EVIDENCE FROM SPACE

Study for the

EUROPEAN SPACE AGENCY

on

USE OF SPACE-DERIVED EARTH OBSERVATION INFORMATION AS EVIDENCE IN JUDICIAL AND ADMINISTRATIVE PROCEEDINGS

AS PART OF ITS SERIES OF STUDIES IN SUPPORT OF ACTIONS TO INTEGRATE NEW DEVELOPMENTS INTO CURRENT EO SERVICES

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FINAL REPORT

EVIDENCE FROM SPACE: USE OF SPACE-DERIVED EARTH OBSERVATION INFORMATION AS EVIDENCE IN JUDICIAL AND ADMINISTRATIVE PROCEEDINGS

REPORT OF THE STUDY COMMISSIONED BY ESA ESRIN

LONDON INSTITUTE OF SPACE POLICY AND LAW

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ABSTRACT

The legal process is concerned with the reliable establishment of facts to enforce laws and to resolve disputes. Among the elements that combine to establish such facts are the surrounding conditions, actions and events. These are introduced as part of the process by information that constitutes evidence. Legal evidence is provided by personal testimony, documents or material objects that establish the relevant facts.

In appropriate circumstances, information obtained by satellite-derived Earth observation (EO) techniques may constitute legal evidence. When compared to information from other sources, it can be more reliable, less costly or easier to obtain. For example, Earth observation satellites can more easily obtain evidence of activities taking place over large or inaccessible geographic areas than that obtained by other means. In some cases, it may constitute the only available evidence. For these and other reasons, a review of the current use of EO information as evidence, and a consideration of ways to increase its future use in the legal context, is timely.

The European Space Agency's European Space Research Institute (ESA ESRIN) commissioned this Study by the London Institute of Space Policy and Law (ISPL). Its aim was to explore past and current use, as well as conditions for the greater use of EO information as evidence in judicial and administrative proceedings. The Study considers some of the issues that arise in such use, draws a number of conclusions and makes certain recommendations to facilitate wider use of EO information as evidence. Broadly, the conclusion reached is that internationally there are no major insurmountable barriers to the use of EO information by courts and administrative tribunals. However, a number of recommended measures may facilitate and encourage its greater use.

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1. EXECUTIVE SUMMARY

This Study[1] explored how space-derived Earth observation information may constitute evidence for use in legal and administrative proceedings. It also examines the means by which its greater use as evidence may be encouraged. This Final Report, including Annexes, records the results of the Study.

An international Study Workshop took place on 5 October 2010, *inter alia* considering two applications, land subsidence claims and enforcement of maritime oil pollution laws. An expansion of the Study was agreed[2] after the Workshop in the light of the progress achieved. Two further applications were then considered in this Study, namely prosecution of humanitarian crimes and water rights civil claims.

The Workshop was a central element of the Study. It forms the subject of an earlier report, *Evidence from Space: Workshop Report*, 5 October 2010.[3] The workshop's outcomes are summarized in this Final Report.

The following are the Study's main findings and recommendations:

1. The Study has confirmed the gap in understanding found in earlier studies between the legal, technical and administrative communities regarding use of Earth observation information;

2. A prime aim must therefore be to engage and inform the legal community and encourage better understanding and exchanges between it and the technical and administrative communities; and

3. The Study has also found that existing standards and procedures do not address the use of space-derived Earth observation information before courts and administrative tribunals.

In addition, this Final Report analyses the salient factors affecting the use of Earth Observation information as evidence. It does so based on the results of research on relevant aspects of the law of evidence in legal and administrative proceedings. This research underpinned the other Study activities including preparation of the Study Workshop.

Annexes to this Final Report include information on relevant standards, expert evidence and EO system capabilities. They also include reports on treatment and use of EO information as evidence in a number of different jurisdictions.

2. GOALS AND STUDY METHODOLOGY

There have been a number of studies that have largely concentrated on the legal, policy and management frameworks within which space-derived Earth observation information

[1] The Study was commissioned by ESA under Contract 4200022802/09/I-AM. A Study Workshop took place on 5 October 2010, *inter alia* considering two applications. An expansion of the Study was agreed after the Workshop in light of the progress achieved.

[2] The extension is covered under the Contract Change Notice No. 1, CCN No: 1500016184.

[3] London Institute of Space Policy and Law (ISPL), *Evidence from Space: Workshop Report*, 5 October 2010, hereafter Annex 1: Workshop Report.

(hereafter referred to as EO information) may be of value as an aid to the enforcement of legal norms.[4] Most have focused on monitoring and the environment.

The present Study aims to explore the nature and characteristics of the information necessary for EO information to qualify as evidence of observed facts and events for use in legal and administrative proceedings.[5] This Study also explores circumstances in which such information has been found inadequate or unusable. Examination of these issues will allow ESA a better appreciation of how far, and under what conditions, information from EO systems can be integrated in legal and administrative procedures and to become an accepted tool.

The present Study examines the factors that affect the admissibility and use of EO information as evidence in judicial and administrative settings. The Study also addresses the conditions that will increase knowledge of the advantages and limitations of EO information as evidence, together with familiarity with its use.

The Study set out to achieve these goals by:

1. Examining applicable evidential rules in selected jurisdictions;

2. Developing case studies in two areas in which EO information has been or can be useful and cost-effective. One relates to land subsidence, the other to maritime oil pollution. These hypothetical scenarios were devised to test the practical utility of EO information as evidence in criminal and civil legal proceedings, having regard also to administrative and regulatory procedures;

3. Submitting these case studies to the rigour of debate in a Workshop[6] composed of legal practitioners, judges, relevant officials, academics, and technical specialists;

4. Studying two further applications in which EO information may be used as evidence. These concern the international prosecution of humanitarian crimes, and civil actions relating to water rights; and

5. Identifying some causes of the limited engagement with EO information by the legal community and its limited familiarity with EO information as evidence.

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4 A number of published evaluations have considered the potential role of satellite monitoring in the legal and regulatory sectors. These include:

a) European Commission, 'APERTURE Final Report' (European Commission, Report ENV4-CT97-437, 2000);

b) NPA Group, 'Applications of Earth Observation to the Legal Sector' (British National Space Centre Sector Studies Programme Report, 2001); and

c) Satellite Monitoring as a Legal Compliance Tool in the Environmental Sector' (AHRC Study, University College London, 2008).

5 The 2001 NPA study considers some similar issues.

6 Annex I: Workshop Report

This methodology enabled assessment of:

a. How space Earth observation tools currently relate to judicial and administrative procedures;

b. How they could do so more widely in the future;

c. How best to engage and inform the legal community and encourage better understanding and exchanges between the legal, technical and administrative communities;

d. Existing standards and procedures; and

e. Proposals for the better use of space-derived information as evidence.

The Workshop identified and explored areas of focus for the Study, and the two case studies provided a framework for discussion of the issues. These are presented in the Workshop Report.[7] This Final Report focuses on the salient factors affecting the use of EO information as evidence, based on the above considerations. Annexes include detailed information on prosecution of humanitarian crimes, water disputes, expert evidence, standards, system capabilities and country reports.

In this Report, *EO* is used throughout to denote space-derived Earth observation. References to *Earth observation information* do not only refer to visual images, but may refer to other types of information, some of which may not be capable of visual representation. In this Report, this phrase refers to space-derived Earth observation material, whether it is a simple visual image or some other kind of data that has been processed into an intelligible form.

The term EO data in this Report refers to the raw digital material before it has been processed into EO information.

3. PRINCIPLES OF THE LAW OF EVIDENCE

To reduce the risk of arriving at erroneous conclusions of fact, legal systems have devised laws of evidence that regulate the manner in which facts are established. These are mainly contained in the rules of *admissibility*. Additional rules qualify the *weight* to be given to specific evidence, and the *standard of proof* governs the degree of certainty required for a decision. In common law jurisdictions,[8] most rules are found in the case law based on judicial decisions. In civil law jurisdictions,[9] the important principles are stated in a code. Most jurisdictions are based largely on one of these traditions, although there are systems comprising elements of both, and some contain elements based on other legal concepts.[10]

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7 Annex 1: Workshop Report, Sections 7 and 8.

8 Common law is the legal tradition that evolved in England from the 11th century. Its principles appear mainly in reported judgments, usually of higher courts, in relation to specific facts arising in disputes adjudicated by the courts. The common law is normally more detailed in its prescriptions than civil law.

9 Civil law is the legal tradition originating in Roman law, further developed in Europe and elsewhere. It is highly systematized and structured, relying on codes embodying declarations of principles.

10 A mixed legal system may exist in a country or a political subdivision of a country, in which the law in force is derived from more than one legal tradition or legal family. An example is the Québec legal system, under which the private law is derived partly from the civil law tradition and partly from the common law tradition. Another example is the Egyptian legal system, in which the private law is derived partly from the civil law tradition and partly from Islamic or other religiously based legal traditions. Religious, tribal and other elements may enter into a legal regime. See William Tetley, Q.C., *Mixed jurisdictions: Common Law vs.*

Whether the rules of evidence derive from case law, statute or code, they govern what may be admitted for judicial consideration and the weight given to the information. For some purposes, the general rules of evidence are supplemented by specific statute. For example, the UK Road Traffic Act provides a specific rule that readings from speed cameras are admissible as proof of driving over the speed limit.[11]

3.1 CHOICE OF REFERENCE LAW FOR THE STUDY

This Study focuses on the most rigorous rules for the presentation of evidence, in order that EO evidence will be admitted for the widest possible range of uses and jurisdictions. As rules of evidence are generally more demanding in judicial proceedings than in administrative cases, the adequacy of EO information will therefore be evaluated by reference to a judicial standard. All laws of evidence, in any type of jurisdiction, have the object of defining how facts may be proven in court or in administrative proceedings. They also influence how certain administrative proceedings, notably investigations, may be conducted.

Common law and civil law jurisdictions differ as to the admission of evidence. Broadly, civil law countries have a more inclusive approach, while common law jurisdictions may take a more exclusionary approach. This is to some extent due to the role of the judge in the respective systems. In the inquisitorial model associated with civil law systems, judges have a major role in uncovering the facts. This tendency is exemplified by the role of the *juge d'instruction* in France, who examines witnesses before pronouncing whether or not the evidential basis exists for a case to go to trial. The judge has wide discretion to admit or reject evidence, and concentrates more on the relevance of evidence than on rules of admissibility.

By contrast, the common law applies stricter rules on admissibility. In the adversarial model associated with common law systems, advocates for the parties take the lead in presenting and testing evidence. The role of the judge is more limited than in civil law jurisdictions. Rules of evidence have evolved within common law systems to ensure that only relevant and probative evidence is admitted.

This Study's approach to the use of EO information in a legal context takes the stricter requirements of the adversarial, common law system as a standard, in addition to focusing on judicial standards rather than administrative. To facilitate maximum chance of acceptance, this Study has therefore chosen to focus on English judicial law, which has highly demanding evidential rules.

3.2 LEGAL AND SCIENTIFIC STANDARDS OF PROOF

For the purposes of this Study, both scientific and legal proof are relevant. There are similarities between them, and arguably, there are differences.[12]

At the Workshop it became apparent that there was some misunderstanding among lawyers and scientists about what constitutes proof in the other discipline. Lawyers expressed the view that science is capable of providing verifiable, indisputable truths, while the legal world deals with more nuanced interpretations. However, scientific proof is not concerned with revealing absolute truth, nor is legal proof concerned with some kind of subjective balance.

Civil Law (Codified and Uncodified), 1999, available at: http://www.cisg.law.pace.edu/cisg/biblio/tetley.html, accessed 11 September 2011.

11 Road Traffic Offenders Act 1988, Sec 20; Statutory Instruments under the Act. See *Halsbury's Laws*, Vol. 40(1), Para 1042.

12 A discussion of legal proof and evidence follows this Section.

The presentation of scientific or highly technical evidence in a court or tribunal may result in misunderstanding, conflict or distortion of the process. In order to avoid these problems, various tests and standards applicable to scientific and legal evidence may be illuminating.[13] It would also be helpful to establish better communication among those involved in legal actions using EO information, and better understanding of what constitutes proof to these different disciplines.

Scientific proof relies on repeatability and falsifiability, and aims, ideally, for irrefutability. There is a range of scientific tests and standards for establishing the validity of a finding, including some for specific purposes. Specific evidential objectives have developed in relation to some types of scientific or technical evidence, and others remain to be developed.[14]

Other factors can affect the assessment of whether evidence is probative. First, the range of evidence available for examination may be narrow. The evidence must then be subjected to statistical analysis to draw a conclusion as to level of certainty and the likelihood of a finding resulting from chance. Second, there may be an element of objective opinion involved, including whether or not there is consensus among scientists in the field. The result may be that the standard of irrefutability is tempered.

There may be a perception that legal standards of proof are somehow fundamentally different. By contrast to scientific proof, legal proof may be concerned with reconstructing and interpreting situations that are rarely repeatable, and often relies on subjective assessment of the probability that such a fact is true, or that an event took place. For instance, the elements leading to the establishment of proof "beyond a reasonable doubt" may not be quantifiable in percentage values.

However, in both legal and scientific settings, a hypothesis must be tested against some defined standard. Statistical extrapolation on the one hand, or 'common sense' on the other, may be applied within the framework of existing knowledge to assist in weighing the evidence. In both cases, the final result will be an evaluation as to whether the evidence proves, or does not prove, the hypothesis.

There are several considerations and recommendations that arise from this comparison. First, in assessing the validity of an item of EO information as evidence, scientific and technical processes and systems are involved. The role of the expert witness is often essential, to assess the validity and reliability of such systems and processes in relation to a specific level of scientific proof. Second, legal practitioners should be better informed about scientific assessments of proof. Third, scientists and lawyers should be better prepared to explain in clear, non-technical language how they assess the validity of evidence.

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13 See, for example, Karl Raimund Popperle, *The Logic of Scientific Discovery* (1959).

14 See Carl Cranor, Kurt Nutting, *Scientific and Legal Standards of Statistical Evidence in Toxic Tort and Discrimination Suits*, Law and Philosophy, 1990, Vol. 9: 115-156.

3.3 Functions of Evidence

Evidence is information that proves a fact. In a legal context, the purposes of information are:

1. To monitor an activity – detection, e.g. environmental changes;
2. To verify a state of affairs – confirmation; e.g. compliance with a Treaty;
3. To establish a fact – proof; e.g. a fraudulent CAP claim.

It is used in different legal contexts:

1. International; e.g. in relation to boundary disputes and territorial claims;
2. Regional; e.g. European Common Agricultural Policy subsidies;
3. National; e.g. Hurricane Katrina insurance claims.

These differing contexts and purposes have to be accommodated in the evidential rules.

3.4 ADMISSIBILITY OF EVIDENCE

Several types of evidence are introduced in legal proceedings in order to establish the facts at issue. These include direct and indirect evidence, testimony, hearsay, documents, real evidence and other relevant material.

Testimony, the statements of witnesses, will in most judicial situations be the primary form of evidence. Documents and other real things generally require proof by witness testimony in some form. For instance, testimony introducing a manuscript letter would confirm the identity of the writer. This proof is significant for the subject of this Study, as much EO information will be in the form of a document. In addition, there are elements of machine production and human intervention to be considered.

Even though various types of evidence may be available in a particular case, there are rules to provide guidance as to what evidence a court may admit, and to ensure the reliability of the evidence that is admitted. The court will decide whether there are any rules that indicate exclusion of the evidence, or whether other factors may make the evidence inadmissible, such as privacy laws or search and seizure rules.

In order for evidence to be admitted in a legal proceeding, it must be relevant to the facts at issue. As it has been observed:

> All evidence which is sufficiently relevant to prove or disprove a fact in issue and which is not excluded by the judge, either by reason of an exclusionary rule of evidence or in the exercise of his discretion, is admissible. In R v Terry[15] it was held that evidence will be admissible if it is relevant *and* such that a jury, properly warned about any defects it might have, could place some weight on it. This is probably best understood...as a recognition that a judge's determination as to whether evidence is sufficiently relevant to be admissible will depend, to some extent, on his or her assessment of its weight."[16]

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15 [2005] 2 Cr App R 118, CA.

16 Adrian Keane, *The Modern Law of Evidence,* Oxford University Press, 2008, p. 20. See also *Halsbury's Laws of England*, Civil Procedure, Vol. 11 (2009) 5th Edition, Para 758.

Some factors that will be considered in deciding on admissibility of EO information are:

1. Authenticity; e.g. that an image is a true representation of the building at issue;

2. Accuracy of the data; e.g. proof that a machine has been properly calibrated;

3. The chain of custody during processing, to show that the source and the end product can be linked; and

4. The people involved in dealings with the data, the applications used, and the business processes and procedures applied to it. This will also help overcome the perception by some that digital data is particularly susceptible to alteration.

Some standards exist in relation to these. However, they are not harmonised or universally applied. Courts may need to rely on expert witnesses to prove authenticity and to interpret specialist technical and scientific information. This is particularly relevant for EO information as evidence.

Some specific characteristics of EO information and their treatment in law are discussed below.[17] In addition, two types of indirect evidence have been relevant to EO information: hearsay and circumstantial evidence.

3.5 HEARSAY EVIDENCE

In civil proceedings, hearsay is a statement made otherwise than by a person while giving oral evidence in the proceedings, that is tendered as evidence of the matters stated.[18] In criminal proceedings, it is "a statement not made in oral evidence in the proceedings that is evidence of any matter stated." At its simplest, hearsay evidence is a statement made by a witness who lacks direct knowledge of the relevant facts or events, and who therefore testifies second-hand.

Hearsay was treated restrictively in English law until relatively recently. However, the Civil Evidence Act 1995 and the Criminal Justice Act 2003 largely abolished the rule against hearsay, instead imposing tests under which hearsay evidence might be admitted.[19]

To be admissible, hearsay evidence must meet one of the following conditions:

1. Statutory provision makes such evidence admissible;
2. The evidence falls within a common law exception to the rule against hearsay;
3. The parties to the proceedings agree; or
4. The court is satisfied that it is in the interests of justice.

Civil law jurisdictions do not make a clear distinction between hearsay and direct evidence. In the context of EO information, because of its electronic or machine-generated nature, particularly when processed by a number of systems and individuals, the evidence may be hearsay.[20] This is significant because the evidence may not be admitted, or if admitted, may carry less weight than direct evidence.

17 See Sections 4 and 5 of this Final Report, and Annex 5: Relevant Standards.

18 *Halsbury's Laws of England*, Vol 11, Para. 808.

19 For a discussion of the English rules of evidence and hearsay see Annex 7.5: UK Report, Section 1.

20 A series of second-hand statements is multiple hearsay, which may be the case with processed data.

Where the EO information is a true record of what is observed by the sensor, such as an optical image, if properly authenticated, the court could treat it as direct evidence. However, if the data from the sensor must be interpreted to be intelligible, it is this interpretation of the original data information that is offered as evidence. This will need to meet the additional requirements for admissibility of hearsay.

3.6 CIRCUMSTANTIAL EVIDENCE

The difference between *circumstantial* and *direct* evidence is that the latter reveals a fact in issue itself, whereas circumstantial evidence only allows inference of a fact. For instance, testimony that person A fired a gun at B, who fell to the ground dead, is direct evidence of person A killing person B. By contrast, testimony that a gunshot was heard from a room, followed immediately by person A coming out the room with a gun and person B being found in room bleeding to death from a gunshot, is only circumstantial evidence of A killing B.

Some EO information will provide circumstantial evidence. For instance, the North Sea Manual on Maritime Oil Pollution Offences[21] states:

> 7.31 Cameras and other forms of remote sensors can be mounted on satellites, and can provide information about areas of the sea where the sea-surface appears to be modified in some way. Skilled interpretation of such information can identify areas where such changes may be the result of spilled oil.
>
> 7.32 However, there is as yet no technique [that] can definitely identify oil slicks at sea from satellite observation.
>
> 7.33 Satellite surveillance is therefore still only a tool for identifying circumstances [that] require more detailed investigation by visual observation or remote sensing. Nevertheless, it is a very useful tool, and one of growing importance for this purpose.

In these circumstances satellite surveillance can provide circumstantial evidence of an oil spill by inference, normally with expert testimony, referred to as “skilled interpretation” in 7.31 above. There will typically need to be corroborative evidence to prove the fact. That evidence could be additional circumstantial evidence, for example aerial or surface data at higher resolutions, or direct evidence, for example testimony from crewmembers that witnessed an operational oil discharge.

An application considered in this Study, where circumstantial evidence can play a significant role, is the use of EO information as evidence of humanitarian crimes.[22] This type of EO information can be useful in such circumstances, where direct ground truth evidence is difficult to obtain and events and facts cannot be readily observed.

3.7 WEIGHT OF EVIDENCE AND STANDARDS OF PROOF

Once evidence has been admitted, all the evidence is weighed as to whether it proves the facts at issue with a level of certainty. This level is lower in civil than in criminal cases. The former is judged *on a balance of probability*, and the latter *beyond a reasonable doubt*. Standards of proof in administrative proceedings, on the other hand, can be less strict than these. The

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21 OSPAR Commission, *North Sea Manual on Maritime Oil Pollution Offences*, Sec. 7.3, Satellite Surveillance, p. 69, http://www.ospar.org/html_documents/ospar/html/north_sea_manual_on_maritime_oil_pollution_offences.pdf, accessed 3 February 2012.

22 See Annex 2: Use of EO in Prosecuting Humanitarian Crimes, Section 6.

International Court of Justice applies a standard that is not rigidly defined. Jurisdictional differences are highlighted in another Report from this Study.[23]

The weight to be given to a particular item of evidence is a matter of fact that will be decided largely on the basis of common sense, the reliability and credibility of the witnesses and exhibits. Frequently, a conclusion on the facts at issue will decide a case one way or another. The burden of proof has no part to play in the resolution of evidential conflicts, although it may determine the outcome of the case if evidence is non-existent or evenly balanced.[24]

4. NATURE OF EO EVIDENCE

EO information is scientific and technical evidence. It has three important evidential qualities in this context. First, it is based on digital data. This means that an untrained person cannot easily discern the connection between the data and the actual event or thing. A hearer of fact may be able to compare two sets of data and see that they are different, but might not appreciate the significance of that difference.

Second, the data will have to be converted into a comprehensible document by some process. It is the processed information that will be offered as evidence, not the original data. As a consequence, EO information may be regarded as hearsay. To be admissible, it will have to meet the specific hearsay requirements of the court. To be probative of the facts at issue, it may be necessary to introduce expert witness testimony or ground truth evidence.

Third, the document will be an electronic record. The collection, transmission, storage, processing and dissemination of EO information are carried out electronically. This presents some evidential considerations, including admissibility and reliability, which will be explored below.

4.1 FACTORS AFFECTING ADMISSIBILITY AND WEIGHT OF EO EVIDENCE

Evidential value of EO information is affected by the procedures by which it is collected, processed and stored. Some of these considerations will also determine the weight that is given to the evidence.

4.1.1 Choice of Technology and Mission

The system used must be appropriate for recording the required information. This will involve assessment of the EO information, additional elements of the system employed, such as other information with which it is combined to produce the evidence, the characteristics of the sensors involved, the techniques to be used, and temporal frequency of observations. In some applications a particular angle of observation may be required. Optical imagery may be desirable, or radar techniques may be more appropriate.

4.1.2 Security

It must be demonstrated that there is a traceable and secure chain of custody. There should be a secure electronic record of the process to which the EO data are subjected, the systems and individuals involved, and where possible, the system should be verified with a qualified electronic certificate.[25]

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23 Annex 1: Workshop Report, Section 5.

24 *Halsbury's Laws of* England, Civil Procedure, Vol 11 (2009) 5th Edition, Para. 766.

25 For example, French law specifies these as requirements for reliability of electronic records; Act No 2000-230 of 13 March 2000, and Decree No. 2001-272.

4.1.3 Consistency in Processing

It will be necessary to show that the raw data that have been subjected to processing will consistently give identical results. The technical sustainability of the operation is thus fundamental to proof of reliability. The methods by which the data are processed must also be validated for the same purpose.

4.1.4 Accuracy and Error Rate

For information to be accurate, it must be a true representation of the phenomena observed, thus ensuring conformity with the observed original. The court or tribunal should be satisfied that potential error or manipulation has been avoided, that is, that the information is precise and free of error, or within an acceptable range of error. The probability of error within the results should be disclosed where possible. For example, in the case of DNA evidence, expert reports include an opinion on the probability or certainty of the result compared with the general population and the specific tests applied to the sample. A similar system of disclosure for specific applications of EO information might be devised.

Calibration is an important element for determining accuracy.[26] Calibration is the process of checking or adjusting the accuracy of an instrument by comparison with a standard or another instrument of known greater accuracy.[27] In the case of an EO sensor, the best method of calibration is to compare the sensor output with the original thing that is sensed, a method known as ground truth. A similar method, which can be based upon a standard, is the comparison of the actual EO data with a suitable theoretical or mathematical model's predictions in order to see how well they match, and the adjustment of its underlying assumptions or equations to achieve a better fit with reality. Such a model may be needed to take account of distortions related to the sensor itself or to physical factors such as atmospheric refraction.

4.1.5 Specific Rules of Evidence

In the absence of any universal legal framework for the use of EO information as judicial evidence,[28] it is necessary to refer to national laws and rules of evidence governing reliability requirements in respect of electronic records. These address the suitability of the system used to create electronic records, which may also be verified by an accepted certification process, or by evidence of calibration or other means.[29] By analogy, such laws and rules relating to electronic records will be applicable to EO information.[30]

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26 Annex 1: Workshop Report, Section 3.3.

27 Halsbury's Laws of England, *Offences and Penalties*, Vol 11, Para 748.

28 But see Annex 5: Relevant Standards.

29 For example, in the UK the principle has been established that evidence of an instrument's reliability required for measuring speed in the context of a road traffic offence need not extend to production of the precise calibration results, provided that the police officer has considered the calibration readings, among other factors, and testifies that the device was reliable: *Greenaway v DPP* [1994] RTR 17, 158 JP 27, DC, at 21 per Buckley J; *Thom v DPP* [1994] RTR 11, 158 JP 414, DC.

30 See Annex 5: Relevant Standards.

4.2 EXPERT WITNESSES

Expert witness testimony is generally fundamental to the introduction of scientific and technical data in courts and tribunals. Given the nature of EO information, the establishment of its reliability and accuracy and its interpretation into intelligible evidence will normally require the testimony of a person with specific expertise. In most cases the court or tribunal will require expert evidence on the system employed and on the processes to which the data is subjected, as well as the interpretation of the resulting information in relation to facts to be proved.[31]

The processes to which EO information is subjected will frequently involve the application of models. Modelling refers to the process of generating a conceptual, frequently mathematical, representation of some phenomenon. A scientific model can provide a collective view of elements that have been broken down to a simpler form.[32] Such models will often be combined with EO information as well as other data, such as climate or socio-economic data, GPS and other records. It will be the role of expert witnesses to explain and assess the validity and rigour of the models involved.

Expert witnesses may be provided by parties to a dispute or action, and may be called by the court or tribunal itself. The expert will be a well-qualified specialist in the subject matter of his testimony and will give his or her opinion on the evidence in issue. The testimony of the expert witness is intended to show a number of things, including the accuracy and reliability of the information being considered. In most cases the expert witness is open to questioning, and other witnesses or expert witnesses may dispute any part of the evidence. It is the court or tribunal that will decide on the validity of the evidence.

The following case is illustrative of the significance of reliability and authentication in relation specifically to electronic data. In *American Express Travel Related Services Company Inc. v. Vee Vinhnee* (2005),[33] American Express was a creditor in a bankruptcy. To document a credit card debt, the company produced computer records, together with a witness to testify about the computer system from which the records came. The court was dissatisfied with the witness and concluded the company had failed to establish the reliability of its computer records. The court rejected the records, and AmEx could not collect the debt.

As an alternative to experts, the court may appoint a Special Master to examine and make certain decisions about technical issues arising in a case. The Special Master, who clarifies complex scientific and technical evidence for the court, will have expertise in the subject matter as well as a good understanding of the court's legal function and procedures.[34] The

31 For a discussion of expert witness requirements see Annex 4: Expert Evidence and EO Systems.

32 Typically a model will refer only to some aspects of the phenomenon in question, and two models of the same phenomenon may be essentially different. Such differences may be due to differing requirements of the model's end users, or to conceptual or aesthetic differences among the modellers and to contingent decisions made during the modelling process. Choice of model is important and will be one of the aspects considered in evaluating the evidence in court.

33 American Express Travel Related Services Inc. v. Vee Vinhnee, 336 B.R. 437 (9th Cir. Dec. 16, 2005) http://www.legalethics.com/include/content/amex012406.pdf. The court essentially required a prima facie showing of measures to safeguard data integrity in relation to paperless electronic records. For a discussion of security of electronic evidence, see Benjamin Wright, *E-Signatures: Are We Building Sufficient Electronic Evidence?,* SANS Institute, Security Laboratory: Cryptography in Business Series, http://www.sans.edu/research/security-laboratory/article/electronic-signature, accessed 17 February 2012.

34 See Cymie Payne, *Mastering the Evidence: Improving Fact Finding by International Courts,* 2011; law.lclark.edu/live/files/10602-414corrected7tojcipaynepdf.

United States Supreme Court has used Masters with specific subject matter expertise primarily in water disputes and boundary cases.[35]

4.3 GROUND TRUTH

In many EO applications, there is commonly a need for ground truth evidence from the relevant location, such as a sample, or a measurement or other record of an on-site observation of events. There can be specific legal requirements for ground truth verification.

To be probative of some facts, high spatial or temporal resolution, specific spectral information or other parameters may be necessary. If these are not provided by the EO information in question, its usefulness is limited. It may only be considered to be of sufficient quality to provide corroborative evidence. In addition, some applications necessarily require ground truth evidence. An EO image of a river showing a distinctive pattern alleged to be pollution will need to be supported by a water sample. Oil spill is another application where there may need to be other supporting evidence, such as identification of the chemical composition of the material, to link it to a specific vessel or its cargo.

The quality of spatial resolution is rapidly improving, but the available detail of visual information may still be considered inadequate in relation to the fact to be proved. For example, cannabis is not always distinguishable by EO from certain other crops.

Other sources of ground truth evidence include web-based local systems using tools for mapping, mobile systems with web cams for documenting changes to structures or land, and GPS optical, infra-red or acoustic techniques.[36]

5. SPECIFIC RULES APPLICABLE TO EO INFORMATION AS EVIDENCE

In addition to the general rules of evidence that permit the admission of EO information into evidence, there are some circumstances where specific rules admit EO evidence. There are also some aspects of its electronic, digital and machine nature that affect its admission.

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35 In exercising its original jurisdiction, the practice of the Supreme Court is to appoint a "Master" to hear the evidence, determine facts, and recommend a decision. This allows the Court to deal with the dispute very much like it does with those that come to it on appeal, for it puts the Court in the posture of reviewing the Master's findings and recommendations in the light of legal arguments made by the opposing parties; http://www.law.cornell.edu/wex/original_jurisdiction. See for example *Louisiana v Mississippi*, 516 US 22 (1995). See *The Original Jurisdiction of the United States Supreme Court*, 11 STAN. L. REV. 665, at app. (1958-1959); Vincent L. McKusick, *Discretionary Gatekeeping: The Supreme Court's Management of Its Original Jurisdiction Docket Since 1961*, 45 ME. L. REV. 185, at app. C (1993).

36 See Andrea Ajmar, Piero Boccardo, Fabio Giulio Tonolo and Carlos Veloso, *Earthquake damage assessment using remote sensing imagery. The Haiti case study,* in *Geoinformation for Disaster and Risk Management: Examples and Best Practices*, Eds. Orhan Altan, Robert Backhaus, Piero Boccardo, Sisi Zlatanova, preface by Margareta Wahlström, Special Representative of the Secretary-General for Disaster Risk Reduction, 2010, Joint Board of Geospatial Information Societies (JB GIS) and United Nations Office for Outer Space Affairs, (UNOOSA) 2010, pp. 31-37. See also Annex 2: Humanitarian Crimes, Section 6.2.1.

5.1 LEGISLATION RELATING TO EO INFORMATION

Specific legislation relating to evidential rules has been surveyed in previous studies.[37] Treaties and legislation[38] specifically mentioning or indicating use of EO information as evidence relate to:

1. Spatial information infrastructures;
2. Arms control and verification;
3. Nuclear proliferation;
4. Natural disasters and humanitarian relief;
5. Restrictions on the resolution of imagery
6. Marine pollution;
7. Claims for agricultural subsidies; and
8. Cadastral mapping and support of agricultural development.

Spatial information infrastructure measures like the INSPIRE Directive,[39] international and national legislation relating to arms control and verification, nuclear proliferation, natural disasters and most elements of humanitarian relief fall outside the scope of this Report. Either they do not rely primarily on civil courts or administrative tribunals for enforcement, or the applicable arrangements do not involve courts or administrative systems for other reasons. There are other forms of information derived from space that fall outside the scope of this Study. Global Positioning System (GPS) data are normally integrated into EO products, but are not considered.

The following are some aspects of legislation that may be relevant to the use of Earth observation information as evidence in some applications or jurisdictions.

5.1.1 Restrictions on the Resolution of Imagery

Military-grade satellite images will potentially be of sufficient quality to provide direct evidence in non-military situations, including applications for legal and administrative or regulatory purposes. For example, monitoring of the 2010 *Deepwater Horizon* incident in the Gulf of Mexico involved extensive use of civilian and military EO information.[40] In such a case, EO observation demonstrating negligence leading to oil pollution could provide valuable evidence in relation to both causation and damages.

However, the laws of some countries restrict the distribution of very high-resolution imagery on national security or other grounds. Access to images of resolutions higher than specified limits is restricted under the laws of some countries, including the US,[41] France, Germany,[42]

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[37] See for example, *APERTURE Final Report*, European Commission, Report ENV4-CT97-437, 2000.

[38] Evidential use of EO information under treaty or legislation has been surveyed in previous studies including the *APERTURE Final Report*, European Commission, Report ENV4-CT97-437, 2000.

[39] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE); at http://inspire.jrc.ec.europa.eu/. The aim of INSPIRE is to help assemble and make available in a common format content relating to EU policies or activities which may have an impact on the environment.

[40] The US National Geospatial-Intelligence Agency (NGA), which is part of the US Department of Defense, has in particular been linked to *Deepwater Horizon* satellite monitoring activities. See *Via Satellite*, August 2010, p.22.

[41] For electro-optical imagery, the US policy involves one resolution limit for imagery that can be marketed generally (currently 0.5 meter) and a second resolution limit for imagery that can be disseminated only with specific authorization to recipients individually authorized by the US government (currently 0.25 meter). See *Leadership in the Remote Sensing Satellite Industry: U.S. Policy & Foreign Competition*, report prepared for U.S. Department of Commerce, NOAA Satellite & Information Service, Commercial Remote

India and Nigeria. Countries differ in what they consider high-resolution satellite imagery and the manner in which they control their distribution. Some impose a strict bar, whereas others subject them to case-by-case review before distribution.[43]

A consequence of these restrictions is that the imagery in question may be made available, but in degraded form. This poses problems for use in legal proceedings. Without evidence of procedures to assure the accuracy of altered military-grade satellite images, notably processing with human agency and the qualities of the system in question, it is likely that the images will be inadmissible as evidence. Evidence of these procedures is by nature often difficult to obtain, particularly as they can be subject to security restrictions.

5.1.2 Marine Pollution

National and international laws on marine pollution, especially by oil, form a major use of EO information in administrative, investigatory and judicial contexts. Part of this Study, the Workshop Case Study II,[44] examined the value and limitations of such evidence. It identified the need for ground truth corroborative evidence in practice, and highlighted some jurisdictional issues.

5.1.3 Claims for Agricultural Subsidies

Monitoring of agricultural subsidy claims is an area where EO surveillance has proved valuable in deterring fraud. While such information is frequently used in administrative investigations, the potential for false positives raises the need for corroborative evidence, including ground truth, samples and aerial photography.[45]

5.1.4 Land Title

Cadastral mapping for land registration and agricultural development, including crop advice, takes place in areas where national legislation promotes the use of EO information for administrative purposes. For example, the Thai Act Promulgating the Land Code 1954, as amended, entrusts the Thai Government's Land Department with issuing most titles to land. The title having the highest weight is the Chanote,[46] which is issued on the basis of EO imagery.

Sensing Licensing Program; http://www.nesdis.noaa.gov/CRSRA/files/NOAA_Report_Northraven_final.pdf, accessed 8 February 2012.

42 See for example, *Act to give Protection against the Security Risk to the Federal Republic of Germany by the Dissemination of High-Grade Earth Remote Sensing Data* (Satellite Data Security Act, (SatDSiG) of 23 November, 2007.

43 Joanne I. Gabrynowicz, *The Land Remote Sensing Laws and Policies of National Governments: A Global Survey*, Prepared for U.S. Department of Commerce NOAA Satellite & Information Service Commercial Remote Sensing Licensing Program, 3 January 2007; http://www.spacelaw.olemiss.edu/resources/pdfs/noaa.pdf.

44 Annex 1: Workshop Report, Section 8.

45 Annex 1: Workshop Report, 2.2.6.

46 This is equivalent to freehold title. For an overview of titles to land in Thailand, see : http://www.samuiforsale.com/knowledge/thailand-land-title-deeds.html.

This scheme, which the European Commission promoted following the 2004 tsunami,[47] currently relies on THEOS[48] and WorldView2[49] imagery with a resolution of better than one metre. The EO imagery is used in conjunction with ground control points and geometric correction. In many cases only EO imagery can provide a detailed and consistent record of land occupation and use before and after the tsunami.

Thailand appears to have been a pioneer in fully embracing satellite imagery for administrative purposes fundamental to the economy. It is particularly suited to a largely agrarian, developing economy with previously informal land possession patterns. The level of accuracy provided in these circumstances is a marked improvement on past information, but it is less suited to urbanized areas. In Europe, aerial imagery has been preferred over that derived from EO, with Bulgaria being an exception in favouring satellite EO data. Bulgaria uses EO data integrated with vector data in GIS databases for management of territories.[50]

5.2 RULES OF EVIDENCE RELATING TO THE NATURE OF EO INFORMATION

5.2.1 Introduction

EO evidence derives from technical and scientific devices, and is by nature electronic, digital and machine-produced. Each facet of EO evidence raises evidential implications, but all modern EO systems are both digital and electronic. Therefore, both aspects are considered here under the general heading of electronic evidence. An aspect of digital information that is separately considered is its perceived vulnerability to undetected alteration. This issue is addressed in relation to the security of the system and the demonstration of a sound chain of custody.[51]

5.2.2 Electronic Nature of Evidence

EO information is based on data that has been electronically collected, recorded and stored. It is digital in form. Electronic or digital evidence can be defined as any probative information stored or transmitted electronically in digital form that a party to a court case may use at trial.[52]

The electronic nature of EO information *per se* does not significantly affect its admissibility as compared to other forms of evidence. However, courts in different jurisdictions may apply different evidential rules. The best prospect for assuring acceptance of information derived from EO systems is to ensure that methods are applied which will meet the requirements for accuracy and reliability under the most stringent current laws of evidence. It is in this respect that the electronic nature of evidence has evidential relevance.[53]

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47 Speech by Niranjan Devaadithya MEP at the ESOA *Briefing on Satellites for Development & Africa*, 09.10.2006, Brussels. For a brief overview of satellite features employed for land management in Thailand, see: http://www.slideshare.net/iskd/accurate-satellite-mapping-for-government-agricultural-management.

48 Thai Earth Observation System, with spatial resolution of 2.5 metres, operated by the Thai Space Agency, Geo-Informatics and Space Technology Development Agency, GISTDA.

49 WorldView-2 has spatial resolution of 0.46 metres, operated by DigitalGlobe.

50 V Vassilev and P Milenov, *Use of Satellite Images and GIS Technologies for the Effective Management of the Territory of Bulgaria,* 1 August 2010, International Multidisciplinary Scientific GeoConference, SGEM, www.space.bas.bg/SENS/Ses2005/r2.pdf.

51 See Sections 3.4 and 4.1.2 of this Final Report.

52 Eoghan Casey, *Digital Evidence and Computer Crime*, Second Edition (2004).

53 See Annex 1: Workshop Report, Section 6.2.

5.2.3 Accuracy

The fact that the means of acquisition and transmission of the EO data is electronic has implications for the fidelity of the resulting information. It is based on an electrical current generated by a sensor. The systems and practices surrounding its acquisition, transmission and storage need to be examined by the court. The digital nature of the system also involves translation of the observed facts into digital data, and back to intelligible information. Facts observed by a sensor may be transformed into EO information, such as an optical image, entirely by the operation of the sensor and standard software programmes. An example of such transformation is optical imagery of structures like buildings. No person is involved in acquisition or processing of the specific image. Absence of a witness to give direct evidence of these facts gives rise to particular legal considerations, such as the application of the hearsay rule.

This process also engages the court in an enquiry as to the integrity of the steps involved. It is essential that the fidelity of the transformation of that signal into comprehensible information is ensured. This requirement has wide application across jurisdictions.

The capabilities and reliability of the system and procedures employed must be shown to produce accurate information about the facts at issue. If not, the evidence will be inadmissible. Evidence about calibration is an important way to prove accuracy of the system.[54] Accuracy may be proved through multiple hearsay statements.[55] The procedures employed must also be shown to assure accuracy by checks for, and correction of, possible errors or distortions, especially as to time, position and the parameters of the facts observed or measured.

If proven accurate, the output from such systems is admissible as direct evidence of a fact.[56] The English Criminal Justice Act 2003, section 129, provides that:

> [W]here a representation of any fact is made otherwise than by a person, but depends for its accuracy on information supplied (directly or indirectly) by a person, the representation is not admissible as evidence of the fact unless it is proved that the information was accurate.

Other jurisdictions have similar provisions, often relating to speed cameras.[57]

5.2.3.1 Calibration

Accuracy can be established by evidence of proper calibration. Conformity with type certification and other standards may also be helpful, as is the case with speed cameras in the UK complying with the Home Office Type Approval process.[58] The presumption of reliability based on type-approval is limited to the particular situation covered by the statute.

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54 For a discussion of calibration see Annex 1: Workshop Report, Section 3.3.

55 A series of second-hand statements is multiple hearsay, which may be the case with processed data.

56 For discussion of English rules of evidence see Annex 7.5: UK Report, Section 1.

57 For example Australia, Canada, France, Switzerland, Germany, Italy, The Netherlands, and several US states.

58 Road Traffic Act 1988.

5.2.4 Authentication of Electronic Evidence

All tribunals are largely concerned with the authenticity and reliability of evidence.[59] Authentication of electronic evidence is a central feature of its admission for use in court and other legal purposes. A legislative review carried out as part of a 2006 study found no direct and explicit references to electronic evidence in the countries covered.[60] However, in all the countries reviewed there are regulations that, in some way, refer to electronic evidence.[61]

To be admissible, a proper foundation must be laid for the presentation of electronic evidence. The evidential rules as to authenticity and reliability must be met. Evidence must be shown to be what it purports to be, that is, it must be authenticated.[62] The methods by which electronic evidence may be authenticated differ from those applicable to other forms of evidence. Otherwise, the general laws and procedural rules of evidence in the relevant jurisdiction will apply to electronic evidence.

The evidence sought by the court to determine authenticity of digital electronic evidence will relate both to technical and organizational attributes. An illustrative case was *In re Vee Vinhnee*,[63] in which American Express, the claimant creditor, failed to collect sums due on a credit card because of its failure to authenticate certain digital records. American Express appealed the verdict, but the decision of the trial judge was affirmed.

In respect of the issues in this trial, Judge Christopher Klein pointed out that:

> [T]he focus is not on the circumstances of the creation of the record, but rather on the circumstances of the preservation of the record during the time it is in the file so as to assure that the document being proffered is the same as the document that originally was created.

In essence, the judge made the point that the issue is "that the record is what it purports to be."

In *Lorraine v Markel American Insurance Co*, Judge Grimm carried out a comprehensive review of the considerations relevant to the admission of electronic evidence.[64] One of the most common grounds on which electronic evidence has been excluded is failure to properly authenticate the evidence.[65]

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59 Note, for example, that in the European Union rules applicable to electronic signatures are harmonised and governed by Directive 1999/93/EC, Art 5.

60 Cybex Study, *The Admissibility of Electronic Evidence in Court: Fighting against High-Tech Crime*, 2006, paper from Third Meeting for WSIS Action Line C5: Building Confidence and Security in the Use of ICTs. http://www.itu.int/osg/csd/cybersecurity/WSIS/3rd_meeting_contributions.html.

61 Examples are the German Criminal Procedure Code, Sec 100c (forms of evidence); Austrian Criminal Procedure Code, Chap XII (interception of telecommunications); Belgian Criminal Code, Secs 210*bis*, 496, 550*bis* and 550*ter* (computer crimes); Netherlands Code of Civil Procedure, Art 152 (forms of evidence); Italy Code of Electronic Government; Indian Information Technology Act 2000, amending evidence law to include electronic evidence; English Civil Procedure Rules; English Criminal Procedure and Investigation Act 1996. See also Paul Motion and Siân Warren, *Electrical Storm on the Horizon*, 54 JLSS 34 (2009 February), http://www.journalonline.co.uk/Magazine/54-2/1006190.aspx.

62 See, for example, US Federal Rules of Evidence, Rule 901.

63 *American Express Travel Related Services Company Inc. v. Vee Vinhnee*, 336 BR 437 (BAP 9th Cir 2005); see also Sec 4.2 of this Final Report.

64 241 FRD 534 (D Md 2007).

65 Keiko L Sugisaka, *Admissibility of E-Evidence in Minnesota: New Problems or Evidence as Usual*, 29 Rev Litig 1, 2 (2009).

The methods of authentication may be:

1. Witness testimony of the method by which the evidence is created (potentially of the sensor operation), transmission, storage and retrieval;

2. Comparison with previously authenticated evidence;

3. Identifying distinctive patterns, content, substance or other distinctive characteristic of the evidence;[66]

4. Description of the methods and processes by which the underlying data is transformed into EO information and evidence of accuracy of the system, perhaps by comparisons with ground truth; or

5. Expert witness testimony of the functionality of the hardware and software involved in acquisition, processing and storage of the information.[67]

There are standards relating to certain of these methods, primarily to the storage of electronic evidence.[68] Conformity to such standards will often permit authentication of electronic evidence.

5.2.4.1 Witness Testimony

Clearly, it will also be necessary to show that the EO information has been appropriately authenticated, to show that it is what it claims to be. Ways to authenticate EO information may include testimony from a witness who took charge of the data or processed it or testimony from an expert witness on whether the information is genuine.

5.2.4.2 Timeframe

A further requirement is that the particular EO information is authentic in terms of the timeframe concerned in the facts at issue. However, under California law, for example, material generated by a computer without human input, such as a timestamp attached to the creation of a document, is presumed to be authentic. This would be relevant in the case of time stamps on EO information that is time-sensitive.

5.2.4.3 Computer Printouts

In some jurisdictions, for example under California law, computer printouts are self-authenticating. This would apply to images generated by an EO system without further human modification. If challenged, it would only be necessary to prove that the system was operating properly.[69]

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66 These may be distinctive numerical identifiers of a file (hash value), or information of the history, tracking or management of the file (metadata); see *Lorraine*, 241 FRD 534, 546-548 (D Md 2007).

67 *Lorraine*, 241 FRD 534, 559 (D Md 2007).

68 See generally Annex 5: Relevant Standards.

69 See Shirley K Watkins and Jin Lew, *Admissibility of Computer Documents at Trial,* October 2007, Plaintiff Magazine, http://www.plaintiffmagazine.com.

There are similar provisions in the UK Police and Criminal Evidence Act 1984:[70]

> 69 Evidence from computer records
>
> (1) In any proceedings, a statement in a document produced by a computer shall not be admissible as evidence of any fact stated therein unless it is shown
>
> > (a) that there are no reasonable grounds for believing that the statement is inaccurate because of improper use of the computer;
> >
> > (b) that at all material times the computer was operating properly, or if not, that any respect in which it was not operating properly or was out of operation was not such as to affect the production of the document or the accuracy of its contents; and
> >
> > (c) that any relevant conditions specified in rules of court under subsection (2) below are satisfied.
>
> (2) Provision may be made by rules of court requiring that in any proceedings where it is desired to give a statement in evidence by virtue of this section such information concerning the statement as may be required by the rules shall be provided in such form and at such time as may be so required.

The House of Lords in *Shepherd*[71] held that the conditions laid down in section 69 must be satisfied in relation to *any* statement in a document produced by a computer, regardless of whether the document contained hearsay or not, thus confirming that the purpose of the section is to ensure the reliability of a computer-generated document offered in evidence against an accused irrespective of whether it contains hearsay or not.

Their Lordships also confirmed in *Shepherd* that the reliability of the operation of the computer for the purposes of section 69 cannot be proven by virtue of the presumption *omnia praesumuntur rite esse acta*[72] but that this condition can be proven either by calling oral evidence or by providing a certificate (subject to the power of the court to require oral evidence), in accordance with Schedule 3 to the 1984 Act.

While ‘a person occupying a responsible position in relation to the operation of the computer’ must sign such a certificate, that is a person with expertise in relation to the computer, the House of Lords took an even more liberal view in relation to oral evidence. Lord Griffiths held that expert evidence will rarely be necessary, but that any person may give oral evidence regarding the operation of the computer who is familiar with the working of the computer and who can provide evidence that the computer is doing its job properly.[73]

Despite this elucidation of section 69 by the House of Lords, it is clear that in 1997 this provision was still creating confusion.

The rules articulated in Shepherd will also apply to civil proceedings. A witness with expertise in the relevant area and information about the system and its qualities will ordinarily provide evidence about the system and processes involved in its operation and the data,

[70] Section 69.

[71] *R v Shepherd*, All ER Review 1993, pp 217–219.

[72] All things are presumed to have been done rightly and in due form.

[73] Sean Doran, John Jackson, *Evidence*, All E Annual Review, 1997, http//www.Lexis Nexis.com, accessed 10 March 2012.

including its handling and storage. A witness may also provide an opinion about whether a particular fact can be established to a specific level of probability, given the circumstances and based on the information offered.

5.2.5 Good Practice Guides

There are a number of codes of practice that set out guidelines for the handling of electronic evidence. Many relate to criminal actions and to guarding the integrity of computer data. These can apply to EO information in appropriate circumstances. Such codes include the *Good Practice Guide for Computer-Based Electronic Evidence* of the Association of Chief Police Officers of the UK, and the Generic Good Practice Guide developed by the International Organisation on Computer Evidence.[74]

5.2.6 Equivalence of Electronic Evidence to Traditional Evidence

In Europe, the majority of judges consider electronic evidence equivalent to traditional evidence and to documentary evidence.[75] It is likely that in Europe and elsewhere the use of electronic digital evidence will become widespread.

English law generally allows the admission of machine-produced evidence.[76] There may be hearsay conditions to be met in some cases, because there is no individual who can give direct evidence of the facts.

It follows that in relation to machine-generated EO information offered as evidence:

a) The data and resulting information in the form presented to a court or administrative body must be proved to be accurate.

b) The particular means of proof will depend on the system in question. For a self-contained, fully automated system, proof from a built-in self-check facility may suffice, if its accuracy can be attested to through evidence of the qualities of the device and the facility. For a system that involves human agency, particularly involving teams of individuals, a rigorous and documented audit, authenticity and monitoring process is likely to be required with respect to the integrity and processing of data, including error correction, so as to ensure the accuracy of the resulting information. This will be in addition to collateral evidence on the system’s qualities.

c) There may be specific substantive legislation that imposes mandatory standards to which such systems must conform. It will be necessary to demonstrate conformation. Some systems will be certified with type approval according to certain standards, which, if met, will demonstrate accuracy.

5.2.7 Rules Applied to Evidence Produced with Human Intervention

The legal system has adapted to the introduction of technology in providing evidence by calling for specific processes to be in place if information derived from them is to be

74 Mark M Pollitt, FBI, *Report on Digital Evidence*, 13th INTERPOL Forensic Science Symposium, Lyon, France, October 16-19 2001. See also UNCITRAL Model Law on Electronic Commerce, http://www.uncitral.org/uncitral/uncitral_texts/electronic_commerce.html.

75 Cybex Study, 2006, pp. 27 – 29.

76 Machine-produced information refers to information that is recorded and processed by a machine, including its firmware and computing capability. The distinction should be made between this kind of machine and what is commonly termed a ‘computer’, which is a machine capable of processing data using application software, operated by a person.

admissible as evidence. Machine-produced information with some element of human intervention may be subject to specific rules. These will have implications for the use of EO information in judicial proceedings, since EO information involves human or human-directed processing of the raw data from sensors.

In some circumstances, an element of human intervention may not affect the value of the evidence. Photographs from a speed camera are admissible, and those that have been merely enlarged by a human technician are potentially admissible, as judges have discretion to admit such evidence, with regard to the value and reliability of the evidence in the interests of justice.[77] By analogy, EO information is not inadmissible as evidence merely because of the presence of an element of human processing alone.

The same rules apply to the introduction of machine-produced EO information with human intervention, as for that without human intervention, but additional requirements apply to ensure that each human intervention does not detract from the accuracy and reliability of the information. These requirements include a secure chain of custody and the application of appropriate accepted processes and models. These additional requirements are complicated by the fact that many individuals may be involved in processing operations, not all of who may feasibly be brought to court to testify and be cross-examined.

A person who is knowledgeable about the methods involved in processing the EO data to generate information must testify as to such things as:

> [S]ystem control procedures, including control of access to the pertinent databases, control of access to the pertinent programs, recording and logging of changes to the data, backup practices, and audit procedures [utilised] to assure the continuing integrity of the records.[78]

Human intervention will often also involve the application of models to the EO data. It is therefore also necessary to validate the models and their operation and suitability for the relevant application. This can be done through expert testimony that the system used is appropriate for recording the required information, that there is a traceable and secure chain of custody, a secured electronic record of the process to which the EO data is subjected, the systems and individuals involved, verified with a qualified electronic certificate,[79] and that the data is the uncorrupted data generated by the sensor, that it was processed in a known way by acceptable methods, and that it produced the result being offered in evidence.

5.2.8 Processing and Integration with Other Types of Information

EO information is frequently subjected to processing and integration with other information. It is necessary to show that the resulting EO information authentically represents the information observed.

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77 Criminal Justice Act 2003, Section 121.

78 See *In re Vinhee*, (9th Cir. BAP, Dec. 16, 2005) 336 B.R. 437, discussed in Section 5.2.4. This case concerned the admissibility of computer records rather than EO information, but the authentication criteria will be largely similar. See generally Jonathan D Frieden & Leigh M Murray, *The Admissibility of Electronic Evidence Under the Federal Rules of Evidence*, Rich JL & Tech 5 (2011). See also 5.4.2.3.

79 For example, French law specifies these as requirements for reliability of electronic records; Act No 2000-230 of 13 March 2000, and Decree No. 2001-272.

5.2.9 Software

All EO systems rely on some level of software programming. If that programming is standard and forms a fixed part of the system, and there is evidence that it is functioning properly, the output will be treated as accurate and reliable. Many documents fall within this category, such as modern telephone bills, readings of the alcohol level in a person's breath, speed camera images, speed radar readings and noise level recordings near airports. They do not require human intervention to process and interpret the information. These are analogous to data from optical EO sensors.

5.3 SUMMARY CONCLUSIONS

There are no substantive legal barriers to the use of EO information as evidence before courts and tribunals or for administrative purposes. In some cases the EO information is treated as direct evidence, probative of a fact in issue. Under other circumstances it can provide circumstantial or other indirect evidence of facts.

As with any evidence, it is necessary to show that the EO information is accurate, authentic and reliable. This requirement may be met through technical and procedural standards. However, due to its complexity and the need to process some of the data into intelligible information, it may be necessary to produce expert confirmation of the adequacy of processes and the likely validity of the information.

Sensors gathering EO data and information are rapidly developing to provide a more detailed and wider range of information. Generally, EO systems cannot provide all the evidence needed for the establishment of a fact in a legal proceeding. However, in many cases EO does provide valuable corroborative evidence confirming other testimony and evidence, and in some cases EO information may be sufficient in itself.

6. SPECIFIC APPLICATIONS OF EO INFORMATION AS EVIDENCE

The Study initially considered two specific applications as Case Studies, namely land subsidence and maritime oil spill. These were chosen because the technical capabilities required for each, and the nature of the facts to be established, differed widely. From a technical perspective, the land subsidence Case Study required analysis of historical data, as well as observations and processing using a specific highly targeted radar technique. The oil spill Case Study relied on frequent contemporaneous observations and systems able to distinguish between oil and look-alikes.[80]

Two additional applications were identified and examined as part of the Study following the Study Workshop, one civil and one criminal as well as international. The selected additional applications were civil disputes relating to water rights, and the prosecution of serious crimes against humanity.[81]

In addition, marine pollution other than oil spills, cadastral mapping and agricultural subsidies are mentioned in the case studies or elsewhere in this Report. Where relevant, some evidential rules will be considered in these contexts.

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[80] See Annex 1: Workshop Report, Section 8.

[81] See Annex 3: Water Disputes, and Annex 2: Humanitarian Crimes.

6.1 LAND SUBSIDENCE: CASE STUDY I

Case Study I was largely based on the *Rovigo Case*[82] in Italy, which concerned identification of the cause of land subsidence in a town and consequent damage to historic buildings. Radar monitoring was chosen as most suitable for this application, as it allows accurate measurement of the distance between the radar sensor and the radar target. It is possible to compare data acquired at different times for the detection of surface deformation, in particular the displacement of individual buildings or structures. This radar data can be subjected to analysis by different techniques. Permanent Scatter Interferometric Synthetic Aperture Radar (PSInSAR)[83] was used, as it is particularly useful in measuring small movements in land surface over time, in some circumstances as small as 1 millimetre.

A hypothetical scenario was constructed concerning damage to a building and its contents, concerning the use of EO information to determine whether excavation on adjoining land had caused the damage.

6.1.1 Facts to be Established and Technology Employed

Case Study I centred on the following facts. Cracks had appeared in a building and its basement due to subsidence. The owner claimed that the adjoining landowner caused the subsidence by excavating the adjoining land. It was necessary to establish whether the excavation was the cause of the subsidence. In order to link the excavation to the subsidence, the claimant documented land movements over a period of time. PSInSAR was specified, but with few reference points. No specific evidence was given in relation to alternative causes of the subsidence.

6.1.2 Usefulness of EO Information as Evidence

Several points were highlighted by Case Study I. The main issues that emerged were:

1. It is necessary to combine the PSInSAR information with other evidence in order to exclude other potential causes of subsidence. It may be necessary to show, for example, that soil conditions did not result in different rates of water absorption in the area of subsidence, which might have been unrelated to the excavation. Additional evidence might include other types of EO information or ground samples of soil humidity.

2. It is necessary to cover a generous area, certainly larger than the area of known subsidence with reference points at which to detect movement. The cause of the subsidence may be at some distance from the visible manifestations of movement.[84] One way to address this is by a careful selection of a sufficient number of reference points, which would demonstrate the unlikelihood of alternative explanations.

3. The availability of adequate historic data is vital in many cases to establish when the movement of land-level reference points took place in the area of interest.

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82 Judgment by Judge Lorenzo Miazzi, Rovigo, 7 June 2002. See Annex 1: Workshop Report, Section 7.

83 Permanent Scatter Interferometric Synthetic Aperture Radar (PSInSAR) is a technique developed and trademarked by the Polytechnic University of Milan. For a description of the technique see Annex 6: EO System Capabilities, Section 3, and Annex 1: Workshop Report, Sections 4.2 and 7.

84 See, for example, John W Bell, Falk Amelung, Allessandro Ferretti, Marco Bianchi, Fabrizio Novali, *Permanent Scatterer InSar Reveals Seasonal and Long-term Aquifer-System Response to Groundwater Pumping and Artificial Recharge,* Water Resources Research, 2008, Vol. 44.

This data will allow comparison of land movement over a period of time both prior to and after the occurrence of the event of interest. In the *Rovigo Case*, such historic data made it possible to show that the land had subsided after excavation on the adjoining land, and not before, thus establishing that the excavation was the cause of the subsidence.

4. Multiple data sets may help to exclude data error. In the *Rovigo Case*, three data sets were obtained from ESA and subjected to two independent processing chains by two different research teams. The identity of the results provided confidence in the evidence.

5. It is important to determine and disclose error rates, and the estimated likelihood of false results. The higher the level of confidence, the more weight the evidence will sustain. In the *Rovigo Case* there were five independent measurements to ensure reliability.

The *Rovigo Case* is a strong example of the value of EO information in determining land movements. There had been many attempts to establish the cause of subsidence, but none had satisfied the court. EO information derived from analysis by PSInSAR made it possible to show that the land had subsided after excavation on the adjoining land and not before. Therefore, it established the excavation as the cause of the subsidence.

6.1.3 Summary Conclusions

One aim of this Study is to facilitate and explore means of engaging professionals involved in the use of EO information as evidence, namely those who are responsible for the production, collection, storage, analysis, interpretation and use of the information. Case Study I demonstrated the value of this approach in promoting dialogue between the technical, legal and administrative communities. It also underlined the widely differing considerations raised by specific types of EO applications and the need for a common language bridging legal and technical issues to facilitate communication between the groups.

6.2 OIL SPILL: CASE STUDY II

Case Study II focused on a multi-national dispute with a number of legal complications. The basic facts of the scenario can be summarised as follows:[85]

A ship registered in one country, owned by a company incorporated in another, discharged oil at night outside the territorial waters of a third country. The ship berthed in a fourth country. Meanwhile oil from a spill caused beaches to be polluted, and fishing to be disrupted, in several countries. There was also a dispute about whether the events occurred within an Exclusive Economic Zone.

The Case Study explored the use of EO information in relation to the potential claims that might be made and prosecutions that could be brought in relation to the incident.

6.2.1 Facts to be Established and Technology Employed

In the event that a case was brought before a court or other legal body relating to the oil spill, several facts would have to be proved:

(a) That a spill occurred, with the time and location identified;

[85] For details of the Oil Spill Case Study see Annex 1, Section 8.

(b) That damage resulted, and if shown, the extent of the damage; and
(c) The source would have to be identified, and alternative causes eliminated.

The EO information presented in the Case Study was SAR,[86] along with optical images from two different satellite systems for the period before, during and after this incident. In addition, Automatic Identification System (AIS)[87] data was presented. These types of information are common to oil pollution monitoring carried out in practice.[88]

6.2.2 Usefulness of EO Information as Evidence

In Workshop discussions about the use of EO information in this Case Study, some problems were identified.

1. While it may be possible to link a discharge of material into the sea to a particular vessel by observing a track left behind or around the vessel, this may not always be the case, particularly in areas of heavy traffic. SAR imagery combined with AIS position data may help to identify a ship suspected of making a spill.

2. Oil can take time to reach the coastline and cause damage to beaches and wildlife. Determination of the chemical composition of the spilled material should be compared to material onboard the ship. If it has already left the area, or taken on new cargo, this may not be possible. Without that chemical analysis, it would be very difficult to link the spill to the ship.

3. It is necessary to show that the material is a prohibited pollutant. EO systems currently detect anomalies in the surface behaviour of the water, but do not yet have the relevant sensors to analyse floating material.[89] Material other than oil, such as algae, can have the same appearance as oil on the surface of the water, and may produce a "false positive" result. The presence of oil at sea may also be confused with algal growths, wind front areas and internal waves. If relying on this technology, corroborative "ground truth" or contextual evidence will probably be required to support satellite evidence. EO evidence of a spill currently needs to be corroborated by vessels in the neighbourhood or by surveillance aeroplanes. On site sampling may also be necessary.

4. EO can provide information about wind speed and surface conditions, which are relevant to the reliability of other EO information. However, the usefulness of SAR readings of the surface is limited to certain wind conditions. Strong winds either disperse the oil, eliminating the surface characteristics associated with oil, or otherwise render the readings unreliable by surface disturbances that make it more difficult to observe the changes caused by the presence of oil.[90]

[86] Synthetic Aperture Radar, see Annex 6 of this Report.

[87] A system used by ships and vessel traffic services (VTS), principally for identifying and locating vessels.

[88] See Annex 1: Workshop Report, Section 3.4.1.

[89] Chemical analysis may be conducted by fluorescence spectroscopy (fluorometry or spectrofluorometry), a type of electromagnetic spectroscopy that analyzes fluorescence from a sample. It uses light, usually ultraviolet light, to excite the electrons in molecules of certain compounds, causing them to emit light of a lower energy, typically visible light. No satellite borne fluorometers have yet been developed.

[90] See Annex 1: Workshop Report, Section 3.4.1.

6.2.3 Summary Conclusions

The advantage provided by EO information is that it can be less costly than surface and aerial observations carried out by coastguard ships or aircraft sent to the location of a suspected spill to obtain visual confirmation and samples. In addition, when ship and aerial monitoring are essential, they may be more efficiently targeted when based on Earth observation information. A significant advantage to EO is that, in some areas, the time from gathering EO information to having it available to expert interpreters is potentially very rapid, even as little as 30 minutes.[91]

Case Study II underlined the value of combining information from EO systems and other space systems, such as those used for AIS. Ground truth or other evidence also remains critical to connect discharged material to a specific vessel and to distinguish between oil and look-alikes such as algae. Current technology merely documents surface characteristics of the water that might be brought about by the presence of oil. This is especially so in adverse wind conditions, until such time as sensor technology is available to identify material discharged from vessels as oil, and to link it to a particular vessel by chemical composition.

6.3 WATER DISPUTES

The application of EO information in civil claims arising from disputes over water is another application considered in this Study. While there are many records of legal cases of water dispute, few specifically mention EO information. However, there is a large body of information about the use of EO information in water administration, planning and adjudication of water rights, much of which will be applicable in legal proceedings. This part of the Study[92] examined types of water disputes, ways in which EO information may help to resolve them, cases where EO information has been introduced, and areas in which it will be applicable in future.

6.3.1 Facts to be Established and Technology Employed

Water disputes involve a range of issues. These include disputes about the quantity and quality of water, its source, for example surface water or aquifer, its point of extraction, the permitted use of the water, and the nature of the right to water.[93] Obtaining meaningful EO information about the relevant factors will often involve the application of models to the data. Complex algorithms have been developed to obtain information from EO data to calculate, for instance, evapotranspiration and biomass production, crop water productivity, regional distribution of measured meteorological variables and ground water conditions, giving information about watersheds where other types of data are scarce or unobtainable.

Unlike the two Case Studies described above, which focus on very specific types of events, water related disputes are varied in nature. A wide range of facts may need to be established. Water disputes may involve detection of a particular volume of water, its condition, or the period and nature of its use. Therefore, a large and varied set of techniques and systems are often used. Some of these are listed in the Water Report.[94] They provide a range of direct and indirect evidence of factors that affect the exercise of water rights, including rainfall, air temperature, soil moisture, ground water abstraction and recharge, water storage, water used

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91 For example, CleanSeaNet data is available to interpreters within 30 minutes of being captured by the relevant satellite. See Annex 1: Workshop Report, Section 8.1.1.

92 Annex 3: Water Disputes.

93 Annex 3: Water Disputes, Section 3.

94 Annex 3: Water Disputes, Section 4 and Appendix C.

for irrigation and stream flow.[95] This underlines how necessary it is to circumscribe carefully the appropriate role of EO techniques.

There are many hydrological models available with a range of spatial scales and physical detail, suitable for a variety of uses. Selection of appropriate models is critical to obtaining accurate results.

Adverse impact on the quality of water by other users may also give rise to a civil claim. EO information can provide evidence of the adverse impact, ranging from pollutants such as algal growth to changes in temperature.[96] There are number of EO techniques that can give evidence in pollution disputes, including systems like Moderate Resolution Imaging Spectroradiometer (MODIS) and fluorescence interferometry.[97]

6.3.2 Usefulness of EO Information as Evidence

EO information is unlikely to provide an adequate measure of water quantity. However, it can provide indirect evidence of the use of water, for instance the irrigation of fields. Techniques are available to estimate water use through assessment of crops.[98] These include measurement of evapotranspiration (ET) from crops, soil condition including moisture, and the extent of crop cover.

Many of these systems involve the use of modelling and the integration of non-EO information such as farm datasets. Therefore, expert evidence and approved systems will be critical to establishing the relevant facts.

Current technology is limited as to detecting water conditions below a certain depth and its findings. Further, these technologies must be supported by good hydrology datasets.[99] It is critical that as EO technology evolves it is calibrated against data collected on the ground.

6.3.3 Summary Conclusions

In a water dispute, a wide variety of facts may need to be established. The range of EO systems capabilities can be well suited to provide the relevant evidence. While no single system will meet all requirements, there are many systems available, which provide EO information that combined with existing data, models and other information can be used as evidence in resolving water disputes.

When used together with GIS and cadastral information, EO systems may be best placed to determine facts in large-scale adjudications of existing water rights. EO is able to provide

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95 Annex 3: Water Disputes, Section 4.2.

96 See Annex 3: Water Disputes, Section 6.

97 See, for example, E. Georgieva, W.S. Heaps, E.M. Middleton, P. K. E. Campbell and L. A. Corp, *Interferometric Sensor for Plant Fluorescence*, in *Remote Sensing and Modelling of Ecosystems for Sustainability VI*, edited by Wei Gao, Thomas J. Jackson, 2009, http://144.206.159.178/FT/CONF/16436764/16436783.pdf; and SELENE (Selenological & Engineering Explorer), Gunter's Space Page, http://space.skyrocket.de/doc_sdat/selene.htm.

98 Bruce A. Lytle, Personal Communication, 28 November 2011. See also Annex 3: Water Disputes, Section 4.4.1.

99 The Hydrological Responsive Unit (HRU) is the smallest unit of water balance computation in some hydrological models. Christopher J. Perry and Julia Bucknall, *Water Resource Assessment in the Arab World: New Analytical Tools for New Challenges*, in *Water in the Arab World: Management Perspectives and Innovations*, Eds. N. Vijay Jagannathan, Ahmed Shawky Mohamed, Alexander Kremer, 2009, The International Bank of Reconstruction and Development/ The World Bank, Middle East and North Africa (MNA) Region, p. 82. (Hereafter *Perry and Bucknall*, 2009.)

wide-scale, cost-effective information that might not otherwise be available about a number of issues, including water quantity and quality.

EO information can also supply corroborative or circumstantial evidence. It is commonly used in combination with other information, including agricultural, watercourse and socio-economic datasets, estimates of evapotranspiration, and hydrological modelling to produce robust tools for a number of applications. In some cases it may be the only practical source of evidence. Where the dispute incorporates a temporal dimension EO information has the capacity to accumulate land change data over a period of time, and can provide historical evidence to establish what changes have occurred over time.

EO information can also be definitive in circumstances where there is alleged unauthorised taking of water by diversion of a watercourse, and is especially useful in large, remote or dangerous areas, reducing the need for costly and time-consuming field investigations.

Reliability and other evidential standards required for the introduction of EO information seem likely to be met in most jurisdictions. To be useful as evidence, EO information is likely to require expert testimony on such issues as interpretation of the information, modelling, calibration, timing, and data processing.

6.4 HUMANITARIAN CRIMES AND WARLORDS

The most serious criminal acts committed against civilian populations including ethnic minorities or other groups of individuals are usually difficult to document. By their nature, these acts and the surrounding events that give rise to them create a hostile environment where it is dangerous for anyone to record the activities on the ground, and they are often committed in remote locations. In these cases, some factors that make EO information preferable to ground observation include:

1. Physical inaccessibility;
2. Climate;
3. Disease such as malaria;
4. Danger from fighting or landmines;
5. Intimidation by criminals, warlords, government, troops or local populations;
6. Poor knowledge of local conditions and limited mapping; and
7. Lack of infrastructure.

In these circumstances, EO information can be of particular value in the detection and prosecution of serious crimes.[100]

6.4.1 Facts to be Established and Technology Employed

As in any criminal prosecution, conviction of a perpetrator of a humanitarian crime such as genocide requires not only proof of the occurrence of events, but also identification and linkage of the events to an alleged perpetrator. In many cases a particular location, such as a palace or camp, can be identified with an alleged criminal defendant through ground truth and witness testimony. While it may be clear that atrocities occurred in a particular area, the linkage of those crimes to the defendant could be established, or corroborated, by EO information tracking movement or build-up of personnel and supplies from or to the alleged criminal's base location.

[100] Annex 2: Humanitarian Crimes.

Often EO information will provide only circumstantial evidence. For example, there may be evidence of movement from a warlord's camp to several villages and the burning of those villages, without identification of the group involved. The strength of the inference that may be drawn from that evidence and its probative value will always depend on both the quality of the information offered and the laws applicable in the trial tribunal.

As indicated in the Humanitarian Crimes Report, if the matter is before the ICC, the dominant consideration is whether the admission of such evidence is helpful to the court in arriving at a just decision.[101] This approach is not far from that in civil jurisdictions and is becoming more prevalent in common law jurisdictions.

Optical, SAR, PSInSAR and infrared EO data can assist establish relevant facts necessary to a successful prosecution. High-resolution optical imagery could provide information about personnel and equipment movements, possibly including the numbers involved, fleeing populations to refugee or IDP[102] camps, the establishment of bases or camps. SAR and PSInSAR could show the destruction or construction of buildings and other structures.

Small changes in the elevation of land may be indicative or evidence of mass graves. PSInSAR can measure changes of as little as 1 millimetre. Nighttime movement of persons and vehicles can be detected using infrared sensors, as can burning of villages and other structures.

Compelling circumstantial evidence may be sufficient to allow of no other reasonable interpretation than that of a commission of a crime.

6.4.2 Usefulness of EO Information as Evidence

The value of EO information in this context can be greater than in many other situations. By their nature, the types of crimes being addressed here are on a larger scale than those against individuals by other individuals. Rather they involve collective action against a group or groups of individuals. EO can therefore capture the scale of the activity on a larger scale than individual incidents observed by witnesses.

EO information offers high quality, accurate information about temporal and spatial relationships.[103] These may be helpful in linking particular parties to specific crimes, by showing the simultaneous presence of certain people and the occurrence of crimes. Such information can also be valuable as corroboration of other evidence where other relevant information is disputed or inadequate.

In areas of conflict or post-conflict, it will be dangerous to collect data on the ground, as in ongoing International Criminal Court (ICC) cases. Evidence may be required relating to very large and potentially cross-border areas of land, or land that is difficult to access, such as mountains or deserts. In some cases spatial data may be lacking about areas that have yet to be thoroughly or recently mapped. In these remote, dangerous and conflict-ridden areas, EO information will have safety and other benefits for those collecting evidence.

In addition, there are temporal benefits. Humanitarian criminal cases often relate to situations that are or were rapidly changing. EO information may speedily provide information

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101 Annex 2: Humanitarian Crimes.

102 IDP means internally displaced person. IDPs are populations moving to safety within the same country. Refugees are persons moving to other countries, usually close to the border with their original country of residence.

103 Annex 6: EO System Capabilities, Section 1.

regarding changes to land, infrastructure and buildings over very large areas of land, where it would not be feasible to gather such information from the ground in the time frame demanded. Advances in technology mean that in many areas EO information may be obtained very quickly. Maps based on EO information can be available within days of an event. Following the 2010 Haiti earthquake, with timely triggering and the lack of cloud cover, EO information was augmented with a combination of web-based local systems using open source tools, mobile systems with web cams and GPS optical imagery.[104] Had there been persistent cloud cover, or some of the conditions that are typical in conflict zones such as Sudan, the multispectral or radar EO information could have been the only tool available.[105]

6.4.3 Summary Conclusions

EO information has been used as part of the investigative and making of cases before the ICC and other tribunals trying the relevant crimes, but it has never been the primary evidence. EO information is potentially more useful than this would seem to indicate, in the prosecution of warlords and other perpetrators of humanitarian crimes. The use of EO information in detecting or monitoring the activities of warring groups illustrates the potential application in the prosecution of these serious crimes. With better understanding of its reliability and greater availability, EO information can become an important, evidential tool in bringing and prosecuting charges against perpetrators of humanitarian crimes.

The legal and other factors affecting the collection and use of EO information as evidence of the relevant acts are explored further in the Humanitarian Crimes Report of this Study.[106]

6.5 CURRENT USE OF EO INFORMATION

Although EO information has been used before courts and tribunals, and for other administrative purposes, much of the available literature relates to monitoring or verification exercises. In many of the cases examined for this Study, EO information has been offered as corroborative rather than primary evidence of the facts in issue. Nevertheless, strong analogies can be drawn between the information gathered for monitoring and verification, and that needed as evidence in the kinds of proceedings discussed in this Report.

Many cases require complex information as evidence. Availability of good EO evidence is a critical issue where vast areas of land, rapidly changing situations, and detailed information are concerned. In some cases very high-resolution (VHR) images may be needed, whereas in others lower resolutions may suffice. In addition, there can be temporal requirements. In rapidly changing situations, EO data with small time-gaps in their archives generated by multiple passes, perhaps even daily, over the relevant location may be needed.

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[104] EO information was provided quickly to the UN World Food Program (WFP), which coordinated the information, and very soon thereafter to the wider community. GeoEye-1 satellite collected colour high-resolution imagery over the capital within a few hours, on 13 January 2010 and again on 16 January. Google made the imagery universally available, without license restriction that might have interfered with the needs of rapid disaster response. Community or participatory mapping systems such as Open Street or Google Map Maker may have scope in some areas to add to the information rapidly, even if it is not the most accurate. See Andrea Ajmar, Piero Boccardo, Fabio Giulio Tonolo and Carlos Veloso, *Earthquake damage assessment using remote sensing imagery. The Haiti case study,* in *Geoinformation for Disaster and Risk Management: Examples and Best Practices*, *supra*, pp. 31-37.

[105] Aimar et. Al., *ibid,* note in their report that the role of radar remote sensing (not only aimed at identifying the main faults by measuring ground displacements) in the post-earthquake damage assessment should be a research priority.

[106] Annex 2: Humanitarian Crimes.

7. PRACTICAL AND LEGAL CONSTRAINTS ON USE OF EO INFORMATION

Among the reasons for the limited use made of EO information, are:

- the relative lack of familiarity with the availability and characteristics of EO information among lawyers and courts;
- the need for greater availability of EO information, with increased acquisitions, broader coverage and more frequent satellite visits to the same locations;[107] and
- the limited access to high spatial resolution information.

The recommendations of this Report will address these issues.

Increased availability of EO information is not of itself sufficient to increase its use in this or other contexts. There must also be easy access to such information. Section 8.4 of this Final Report notes some available EO information resources. Although most providers of EO data and information disclose the services and data they make available,[108] there is no conformity in the information given about their products and services, making it difficult for non-specialists to determine which of a number of alternatives may be most appropriate for their application.[109] There is no single source of information about:

1. EO raw and processed data providers;
2. The nature of EO data and processing available from each provider;
3. Temporal and spatial resolution for each type of data;
4. Geographic and spatial coverage of the data;
5. Agility and accuracy of the data;
6. EO data archives, giving the dates for which each type of data is stored;
7. Price and speed of delivery;
8. Typical applications for each type of data; and
9. Terms and conditions of supply.

Cost considerations and restrictions imposed under legislation, licence or contract, including export control rules, can also limit effective access to EO information.

Satellite operators and service providers typically include standard “as is” clauses in their supply contracts, declining responsibility for the quality of the information. Some regulatory restrictions may limit the resolution that may be obtained.

Depending on the jurisdiction, a number of legal constraints may operate to exclude admission of certain evidence. The grounds for exclusion include privacy, intellectual property rights, trade secrets, principles concerning monitoring foreign activities and resources, and national security.[110] These constraints may arise under treaty or other international act, legislation, export control regulation or data licences.

The issues examined in this section are taken largely from the United States and Europe, where the level of restriction tends to be tightest, with the US being tighter on national security and export control and Europe tighter on privacy. However, they raise issues that may be relevant to the use of EO as evidence in other jurisdictions.

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107 Annex 1: Workshop Report, p.38.

108 See for example, GeoEye-*1 Fact Sheet*, http://launch.geoeye.com/LaunchSite/about/fact_sheet.aspx.

109 Compare, for example, *GeoEye-1 Fact Sheet*, *Sensors Used by WaterWatch*, http://www.waterwatch.nl/tools0/satellites/liss-iii.html, and *Landsat 7*, http://geo.arc.nasa.gov/sge/landsat/l7.html.

110 See Annex 1: Workshop Report, Section 5 and Annex 7: Country Reports.

7.1 PRIVACY

As long as there are appropriate safeguards to notify individuals of the potential use of EO information, or prevent undue interference with private life, such information may be offered in evidence. A case in point is *Uzun v Germany* before the European Court of Human Rights.[111] In that case the Court held that there had been no breach of the right to private life under the European Convention on Human Rights.[112] The Applicant had been the subject of GPS tracking by German authorities, and was charged with acts of terrorism and murder. The Court relied in part on exceptions to the privacy rules applicable to the interests of national security, public safety or the economic wellbeing of the country, for the prevention of disorder or crime.[113]

A factor that is often considered by courts in determining the extent of privacy rights is the assessment of the subject's reasonable expectation. In the case of EO information, the necessity to have a clear line of sight may put it beyond what may be regarded as private. Activities carried out in clear view would not be considered private. One possible exception is the use of technology with a detected spectrum outside the visual range.[114]

Improving technology and changes in social attitudes may also change the concept of privacy. In today's environment, where intimate details are posted on public websites and the Earth can be seen in great detail on Google Earth, expectations of privacy are reduced, at least where this technology is available to the public. However, numerous prosecutions have been pursued against Google for its Street View practices, while some jurisdictions require degradation of any imagery that includes personal information in the form of human faces.[115]

Privacy is only a significant issue with EO information where it can reveal personal information about an identifiable person. In those circumstances, the same rules apply as do to other sources of personal information, including databases.

7.2 SEARCH WITHOUT WARRANT

If EO information is obtained in circumstances that would have needed a warrant if carried out by a terrestrial search, the resulting evidence may be inadmissible. A test that was applied in the US is whether the information is gathered using devices not publicly available.[116]

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111 ECHR, *Case 35623/05*, 2 September 2010; http://cmiskp.echr.coe.int/tkp197/view.asp?item=1&portal=hbkm&action=html&highlight=Uzun%20%7C%20Germany&sessionid=85532889&skin=hudoc-en, accessed 26 January 2012.

112 Article 8.

113 ECHR, Article 8, Para 2.

114 See Ronald J Rychlack, Joanne Irene Gabrynowicz, Rick Crowsey *Legal Certification of Digital Data: The Earth Resources Observation and Science Center Project*, 33 J Space L, 195 (2007) at 210. Compare also the European Convention on Human Rights, Art 8. See also *Colas Est SA v. France*, App. No. 37971/97, Eur. Ct. H.R. (Apr. 16, 2002); *Pretty v United Kingdom* (Application 2346/02), (2002) 35 EHRR 1, [2002] 2 FCR 97, 12 BHRC 149, 66 BMLR 147, [2002] ECHR 2346/02, [2002] All ER (D) 286 (Apr).

115 There is sharp current debate with regulators like the European Commission taking an increasingly tough stance in face of ICT applications compromising privacy and major commercial accumulators of personally identifiable information (PII) like Facebook and Google that treat PII as a commodity.

116 *Oliver v. United States*, 466 U. S. 170 (1984); see also Annex 7.6: Country Reports, US.

In *Kyllo v United States*,[117] where the defendant was suspected of growing marijuana at home, agents used a thermal imaging device to determine if the amount of heat emanating from the house was consistent with the high-intensity lamps typically used for indoor growth of marijuana. On appeal the Supreme Court held:

> Where the Government uses a device that is not in general public use to explore details of a private home that would previously have been unknowable without physical intrusion, the surveillance is a Fourth Amendment "search," and is presumptively unreasonable without a warrant.

This is a changing standard as technology develops and use of sensing devices becomes more commonplace. Other jurisdictions are also less prone than previously to deny the admissibility of evidence obtained in such a manner.

7.3 Intellectual Property and Trade Secrets

There may be circumstances where an installation, its configuration or structure may constitute or disclose a trade secret or be protected as intellectual property. In some cases such rights may present a barrier to the acquisition and presentation of EO information.

A case in point that involved aerial photography of an industrial facility is *Dow Chemical Company v United States*.[118] In addition to arguments based on unlawful search, Dow claimed breaches of trade secret and intellectual property. The Court of Appeals held:

> The fact that state trade secrets law might bar aerial photography by Dow's competitors is irrelevant to the questions presented in this case. Governments do not generally seek to appropriate trade secrets of the private sector, and the right to be free of appropriation of trade secrets is protected by law. State tort law governing unfair competition does not define limits of the Fourth Amendment.

The Court further held:

> Even trade secret laws would not bar all forms of photography of this industrial complex; rather, only photography with intent to use any trade secrets revealed by the photographs may be proscribed. Hence, there is no prohibition of photographs taken by a casual passenger on an airliner, or those taken by a company producing maps for its mapmaking purposes.

It follows that the mere existence of trade secrets or intellectual property rights in the observed subject does not preclude the use of the resulting EO information as evidence.

7.4 National Security

Civil space programs, particularly meteorology and Earth observation science, are increasingly used for national security missions. For example, the objective of the Global Monitoring for Environment and Security (GMES) program is to "support Europe's goals regarding sustainable development and global governance, in support of environmental and security policies, by facilitating and fostering the timely provision of quality data, information, and knowledge."[119]

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117 533 US 27 (2001), http://caselaw.lp.findlaw.com/cgi-bin/getcase.pl?navby=case&court=US&vol=533&invol=27.

118 476 US 227 (*1986*); see also Annex 7.6: Country Reports, US.

119 Global Monitoring for Environment and Security, www.gmes.info.

The military doctrines of a growing number of states emphasize the use of space systems to support national security. This tendency can be seen, for example, in the increasing development of multiuse space systems, combining military and civilian uses, which has led some states to view space assets as critical national security infrastructure.[120]

Although not directly an admissibility issue, the level of resolution can constitute a barrier to the availability of satellite-derived information. Resolution of better than half a metre is currently barred under US munitions control regulations.[121]

There may be other circumstances where EO information discloses sensitive material. It would be open to the government to apply for its exclusion as evidence. If the government relies on information generated using classified techniques or technology, the evidence will also be inadmissible unless properly disclosed and open to challenge.[122]

7.5 UNITED NATIONS PRINCIPLES ON REMOTE SENSING

The United Nations (UN) *Resolution Relating to Remote Sensing of the Earth from Outer Space*[123] has no legal binding force. The Principles cover the operation of EO systems, as well as the raw and processed data.[124] However, some important remote sensing entities, such as ESA and National Oceanic and Atmospheric Administration (NOAA), tend to adhere to the 15 principles contained in the Resolution.

The Principles require that, in conducting EO activities, and where equitable and mutually acceptable, the sensing state is to facilitate participation by the sensed state. The sensing state is also to provide "feasible and practicable" information to other states, particularly the affected state, at their request.[125]

One Principle that may potentially inhibit certain remote sensing activities is that acknowledging the sovereignty of states "over their own wealth and natural resources."[126] However, in its context, this Principle does not prevent remote sensing of a state by another.[127]

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120 Cesar Jaramillo, Ed., *Space Security 2011*, www.spacesecurity.org.

121 The US rules limit the resolution to 0.5m; See International Traffic in Arms Regulations, ITAR, Part 121 – United States Munitions List, *Category* VIII, remote-sensing satellites.

122 *U.S. v Kilgus*, 571 F.2d 508 (9th Cir. 1978): The Defendants were convicted of illegally importing and possessing marijuana with intent to distribute. On appeal, the Court of Appeals held that the forward-looking infrared system (FLIR) can be used for generic identification of objects. The Court found that evidence based on use of Forward Looking Infrared System was inadmissible where defence counsel were precluded from impeaching or rebutting the testimony because most of the necessary technical data were covered by military secrets.

123 General Assembly Resolution 41/65, unanimously adopted 3 December 1986, at http://www.unoosa.org/oosa/en/SpaceLaw/gares/html/gares_41_0065.html, accessed 7 February 2012.

124 Resolution 41/65, Principles V and VI.

125 Resolution 41/65, Principle IX.

126 Resolution 41/65, Principle IV.

127 See for example Principles XII and XIII.

8. CONDITIONS FOR GREATER USE OF EO INFORMATION

8.1 Issues of Law Reform

An important issue arising from this Study is how to assure the legal community of the reliability of EO information.

Rules and procedures are in place to assess the admissibility and reliability of EO information on a case-by-case basis. These have been summarized in this Report. However, this is not an effective way to achieve more widespread acceptance of the use of EO information in judicial and administrative proceedings. Statutes that allow for type approval or the equivalent clearly offer a superior solution in this regard. Although better than a case-by-case approach, such a statutory solution would require an extensive review of legislation and amendment to several statutes.

A more effective approach would be to establish guidelines for meeting the tests of admissibility. It would also be advisable to establish some guidance for the weight to be given to such evidence. This could be done on a country-by-country basis, by an intergovernmental agency or a designated committee of sufficient authority.

Such an approach would necessitate assessments of the qualities of the systems and information provided, against criteria such as those set out in section 3.4 above, for each satellite system and instrument in question. EO information and its handling, including through human agency, must adhere to rigorous audit and documentation, authenticity, chain of custody and monitoring procedures, so as to allow for confidence in its accuracy and reliability. One possible approach would be to entrust these assessments to an existing body such as ISO or other standardization bodies, possibly including ESA in light of its experience with ECSS.

If this can be achieved, EO evidence would then be more widely understood and be more likely to be used in all appropriate circumstances where there is no specific statutory rule prohibiting it or prescribing use of another means. Such a broad degree of acceptance would allow confidence to be built in the value of EO information as evidence, and for assessment of its limitations to be determined over time. Gradual reform of statute law can then take place, where needed and where EO information is not yet accepted.

The workshops to be organized as a result of the present Study can provide a starting point for undertaking the proposed programme of assessments, by gathering people of expertise of sufficient calibre from all the relevant viewpoints, scientific, technical, legal, administrative and managerial.

8.2 CONFIDENCE BUILDING

This and earlier studies have concluded that lawyers, judges and administrators should be made aware of the utility of EO information as evidence in legal and administrative proceedings, in order to build confidence in its use. Although some practical steps have been suggested, not much action has resulted.

The Study Team makes the following recommendations:

1. Events such as workshops, studies and round-table discussions should be arranged where a multidisciplinary group could discuss needs, limitations and general views on EO information and legal requirements.

2. The events should focus on specific applications of EO information as evidence, as each application has different requirements.

3. Where relevant, the multidisciplinary group should initiate drafts of guidelines, rules or criteria relevant to the use of EO information as evidence, including its authenticity and reliability, for the specific application.

4. Organisations with an interest in promoting the use of EO as evidence should provide adequate funding for relevant activities.

5. These events should be organised by an entity independent of those with an interest in promoting specific systems or products.

These events and studies would advance understanding of the issues and their potential solutions, and build confidence in the use of EO information as evidence.

8.3 ACCESS TO EO DATA AND INFORMATION

Other factors that affect the use of EO information are awareness of the range of material that is available, and the ease with which it can be obtained. Awareness should be raised in these areas, including:[128]

1. The nature and characteristics of the data captured, historically and by available systems, stored in various databases. Not all data generated by sensors is captured or stored, so it may not be clear in a given situation whether there is information that may be used, and where to find it. A critical element in overcoming this difficulty is the establishment of a reference database with details of what historic and new data is available and where it may be obtained. It will be essential to make the existence of the database widely known, in order to answer the question of how and where data may be obtained.

2. Such a reference database could also cover the expertise required for the interpretation of specific types of data. This would be of use to legal practitioners and to expert witnesses.

3. In relation to the databases storing actual EO information, it will be advisable to formulate a more coordinated policy about what data is stored, how long it should be stored, and how that may be accomplished.

4. There also need to be coordinated policy about the use and exploitation of the data, how it may be used, to whom it is made available. For instance, a body having EO information about minerals in a country should make it available to the country.

In addition to the creation of a global record of the characteristics of the EO systems used to capture EO data, sufficient bandwidth should also be assured for the capture and communication of the data.

8.4 AVAILABLE RESOURCES

The following are some currently available sources of information about EO systems and their products. None of these provide the centralized reference database proposed here.

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[128] Imagery consultant, Geoffrey Oxlee OBE, also outlined some of these issues during a telephone conversation on 19 January 2012.

8.4.1 CEOS ESA Database

The joint Committee on Earth Observation Satellites (CEOS) and ESA provides an online database containing information on agencies, missions, instruments and measurements related to EO, searchable by agency, mission name and status, instrument name and status, type, waveband, applications, resolution, and level of data access. It is updated annually, based on a survey of CEOS member space agencies, with a print version EO Handbook published approximately every 3 years.

The database is intended to facilitate:

1. Information sharing in support of the coordination of future Earth observation mission, instrument and measurements plans;

2. Earth observation measurement gap analysis, including that performed by the CEOS Systems Engineering Office (SEO);

3. A connection between the Earth observation user community and satellite-operating agencies of CEOS; and

4. Generation of content for the print edition of The Earth Observation Handbook.

The CEOS EO Handbook[129] and database are intended to present the most up-to-date and comprehensive status of the technology and services related to governmental, space-based Earth observation programmes of more than 30 space agencies of the world. Application examples are highlighting the current trends and achievements of space systems to provide user-driven information services. There is a comprehensive list of governmental Earth observation satellite sensors and missions, both current and planned.

However, here is no search function for geographical location, nor is there a general search function, for instance, to look for satellites covering a specific location. In addition, the CEOS database does not cover commercial EO systems or suppliers of processed information.

8.4.2 GMES

The European Global Monitoring for Environment and Security (GMES) initiative is an example of a centralized database of EO data made available to users around the world.[130] It is a joint initiative of the Commission and ESA, intended to bring data and information providers together with users to increase mutual understanding and enhance the availability of environmental and security-related geospatial information.[131]

GMES aims to provide reliable and timely geospatial services related to environment and security issues to support the needs of public policy makers, by coordinating existing systems and producing services of continued guaranteed validity.[132]

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129 ESA, *The Earth Observation Handbook 2010*, http://www.eohandbook.com, accessed 7 February 2012.

130 Donald MacPhail, "*Increasing the Use of Earth Observations in Developing Countries*," 25 Space Policy, 2009 at 6-8.

131 See European Union Satellite Centre (EUSC), http://www.eusc.europa.eu/index.php?option=com_content&task=view&id=10&Itemid=19.

132 At the time of completing this Final Report, the EU had not determined the funding solution for GMES in light of general EU budget cutbacks. The European Commission had proposed to take this flagship space programme out of the EU budget and to make it a responsibility of EU member states.

8.4.3 Other Providers of Services and Resources

Commercial and government entities providing EO services and resources also provide details of services offered and other details. The following are some examples. However, they do not fill the gap identified here and do not offer a central database that is searchable by criteria most useful to users.

8.4.3.1 NASA

NASA provides access to its Earth Observing System (EOS), a coordinated series of polar-orbiting and low inclination satellites for observations of the land surface, biosphere, solid Earth, atmosphere, and oceans. The EOS Project Science Office (EOSPSO) makes programme information and resources available to programme scientists and the public.[133]

8.4.3.2 USGS

The United States Geological Survey (USGS) has established the Remote Sensing Technologies (RST) Project to supply technical expertise and services to the USGS and partners across government, industry, and academia, with focus on satellite sensors' capabilities, reliability, and accuracy. The RST Project works with aerial imaging technology, satellite technology (commercial, government, and foreign), and emerging sensors such as LIDAR (Light Detection and Ranging) and SAR (Synthetic Aperture Radar) to further understand how these technologies can assist science, land management, and civil uses.[134]

8.4.3.3 Independent Resources

Claude Lafleur's Spacecraft Encyclopaedia site lists Earth Remote Sensing Satellites by launch year with details about capabilities. Although not searchable in the same way as the CEOS database, it does provide information about commercial, as well as agency satellites.[135]

The WWW Virtual Library ceased to be maintained after 2007. It provided links to specific organisations, companies, gateways, societies and other information on Remote Sensing.[136]

8.5 IMPACT OF IMPROVING TECHNOLOGY

A significant factor affecting the use of EO information as evidence is the capability and quality of satellite systems. These continue to improve as commercial operators have entered the market alongside government provided EO systems and information, and with technological advances.[137] There is growing access to advanced technologies previously exclusive to the military especially in the US.[138] Commercial systems can achieve a level of performance that may be compared with military requirements or practices save those of highest resolutions. These include features such as regular repetition of observation of target

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133 See http://eospso.gsfc.nasa.gov/index.php, accessed 7 February 2012; C. L. Parkinson, A. Ward, M. D. King (Eds.) *Earth Science Reference Handbook – A Guide to NASA's Earth Science Program and Earth Observing Satellite Missions*, National Aeronautics and Space Administration Washington, D. C., 2006, Available at http://eospso.gsfc.nasa.gov/ftp_docs/2006ReferenceHandbook.pdf

134 See http://calval.cr.usgs.gov/aerial/rst_front_news, accessed 7 February 2012.

135 See http://claudelafleur.qc.ca/Scfam-remotesensing.html, accessed 7 February 2012.

136 See http://virtual.vtt.fi/virtual/space/rsvlib, accessed 7 February 2012.

137 Satellite Imaging Corp., Infoterra and RapidEye are a few examples.

138 Examples are Ikonos and GeoEye, being manufactured by Lockheed Martin, a leading defence contractor with a strong profile in reconnaissance systems.

areas, near vertical observation profiles, access to products being made available reasonably close to real time, and low error rates.

Many older systems do not possess all of these features, and are less valuable to courts in cases of localized incidents over well-defined timeframes. In some cases a system serves a number of different observation requirements that may have a negative impact on some other capabilities, for example, large geographic coverage may reduce the regularity of observations.[139]

Another technological limitation is the spectral bandwidth of the EO system. For example, optical sensors currently use between one and five frequencies for data channels. The number of channels used determines the types of information that can be gathered simultaneously. Hyper-spectral systems, being developed for operational use in the 2020s, will permit 200 channels, generating up to 200 times the volume of the information available from current multi-spectral imaging.[140] This will permit a single instrument to capture data the equivalent of an entire satellite of today.[141]

These developments will increase the usefulness and potential reliance on EO information as evidence in judicial and administrative cases. Other features that can assist in greater use of EO information are mission design and operational changes for specific applications, such as regular repetition of observations over particular areas, treatment of the data within a reasonable time and availability at a reasonable cost.

9. RECOMMENDATIONS

The best prospect for assuring acceptance of information derived from EO systems is to ensure that methods are applied which will meet the requirements for accuracy and reliability under the current laws of evidence.

Throughout this Study and in this Report a number of suggestions have been made in order to promote the greater use of EO information as evidence. To summarise, we recommend:

1. Holding frequent workshops and round-table discussions between all relevant professionals, including lawyers, judges, administrators, experts involved in the design, operation and management of EO systems, users and providers of EO data and information;

2. Discussions between the relevant groups should address legal and technical requirements, matters covered in Sections 3.4 and 8.1 above, and include application-specific sessions;

3. Establishment of an EO data and information reference database that is publicly accessible and searchable to include details of providers, the characteristics, nature and history of the data or information available, ideally with prices;

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[139] See, for example, Envisat.

[140] A multi-spectral image is one that captures image data at specific frequencies across the electromagnetic spectrum. The wavelengths may be separated by filters or by the use of instruments that are sensitive to particular wavelengths, including light from frequencies beyond the visible light range, such as infrared. Hyper-spectral missions are planned within GMES, (with Sentinel satellites), but will require demonstration before operational use can be fully implemented.

[141] Such data flow will be ten to twenty times greater than Envisat. For example, current technologies cannot detect types of fertilizer in a field or whether a discharge in the sea is oil pollution. In future, such detection may be possible through the combination of information that hyper-spectral sensing allows.

4. As Courts require the best available evidence in terms of observation features such as angle, repetition, spectral resolution, processing and presentation, a system of certification will assist EO information meet the potentially demanding and varied requirements of courts in establishing facts and events. If elaborated, such certification could meet the information needs of diverse users. Cooperation with standards bodies such as the ISO to ensure appropriate criteria for the capture, storage, dissemination, processing and interpretation of EO data, including clear identification of the distinct types of expert and the roles of such experts;[142]

5. A specific examination of two or more satellite systems with the aim of developing a certification approach would be a useful area for further study;

6. Establishment of criteria and qualifications to which expert witnesses conform, both in relation to the systems used and the processes employed;

7. Consideration of the merits of engaging Special Masters[143] to make findings on technical issues and facts and of establishing the qualification criteria for such Special Masters;

8. Creation of standard terminology across the sector and a common glossary of terms to ensure the level and quality of communication between the various disciplines engaged in EO information;

9. Provision of sufficient spectrum bandwidth to accommodate data collection and transmission of more and higher resolution EO information;

10. Examination of guidelines, rules and procedures to allow legal community and courts access to relevant imagery and other EO information, under controlled conditions, that are otherwise restricted; and

11. Investigation of the economics of EO information use and potential benefits.

Some of these recommendations have been made in other studies. We strongly urge ESA to give serious consideration to implementing these measures. They will benefit both the providers and users of EO information beyond the specific focus of this Study.

Additional areas of study and research were also identified in the Workshop Report. We again commend them to ESA.[144]

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[142] In developing any criteria applicable to experts and their testimony, regard should be had to the rules articulated in the *Daubert* case, and recommendations of the Law Commission of England and Wales, *Expert Evidence In Criminal Proceedings in England and Wales*, 21 March 2011, (Law Com No 325), http://www.justice.gov.uk/lawcommission/docs/lc325_Expert_Evidence_Report.pdf, accessed 15 February 2012.

[143] See Section 4.2 of this Final Report.

[144] Annex 1: Workshop Report, Part II.

10. CONCLUSIONS

This Study has found that although there are differences among jurisdictions in the rules and laws governing evidence, they do not present any insurmountable barriers to the use of EO information as evidence. Even by the stricter rules of English law, under appropriate conditions EO information can be shown to be both admissible and of value as evidence.

The case study approach applied in this Study against the background of a focused examination of the laws of evidence has explored both the adequacy of EO data, including the information derived from it, for purposes of legal and administrative proceedings, and the issues of law reform that are needed to encourage greater acceptance of EO information as evidence.

The Case Studies themselves provide a basis for assessing the need for and effectiveness of exploring use of EO information as evidence in relation to specific applications. This approach also facilitates extending inquiry into other fields that have not been prioritized in this Study.

Ways have been indicated to bring about the legal principles and structure necessary to encourage greater use of EO information as evidence. These extend to authoritative assessments and process requirements, which can best be elaborated through discussion between suitable representatives of the relevant communities of providers and users.

Clearly, further studies need to be conducted to identify and propose solutions to the many outstanding issues, including the development of standards and examination of the technical capabilities and legal frameworks necessary for the use of EO information as evidence for specific applications.

However, these studies should be aimed at ensuring the widespread routine use of EO information with a uniform approach across jurisdictions. It is not intended to suggest that there are technical or legal barriers to the use of EO information as evidence in cases where it is available, relevant and reliable. On the contrary, this Study has found that under current conditions much greater use can be made of EO information to provide evidence in judicial and administrative proceedings.

ANNEX 1

WORKSHOP REPORT

TABLE OF CONTENTS

PART I: THE WORKSHOP

1. STUDY OUTLINE, WORKSHOP DESCRIPTION AND AIMS

1.1 THE STUDY: USE OF SATELLITE-DERIVED EARTH OBSERVATION INFORMATION

Satellite-derived Earth Observation (EO) information is widely used to detect and to monitor a range of activities. Many uses relate to environmental conditions. EO services have developed to better meet these needs and are deployed in observation of emissions, oil pollution, deforestation, land movement, use of agricultural land, geological and other changes over time and many other conditions and activities.

Satellite EO information is not limited to traditional imagery, but includes a wide range of data, not all of which are visual images. For example, InSAR (Interferometric Synthetic Aperture Radar) systems use reflected radar signals to make highly precise measurements of differences in the levels of land surface, to detect movements of less than one centimetre. The radar data is not itself an image, but is processed to produce a visual representation.

There are many advantages of EO information in the context of administrative and judicial proceedings. These include:

1. Providing a potential source of geographic evidence allowing for a flexible and robust response to geographical questions;

2. Improved quality and accuracy of information about temporal and spatial relationships;

3. Cost savings in gathering evidence;

4. Improved chances of prevailing in litigation; and

5. Improved implementation and enforcement of legal standards.

As EO satellite systems grow in sophistication and as their sensor resolutions improve, so does the utility of EO information as evidence.

1.2 OBJECTIVES OF THE STUDY

The ESA-ISPL Study[1] explores the conditions necessary for satellite-derived EO information to be used as evidence in judicial and administrative proceedings in different jurisdictions. The Study has three objectives:

1. To inform the legal community about the potential uses of satellite EO information as evidence;

2. To explore the technical capabilities of EO satellite systems to meet legal needs; and

3. To identify legal and technical areas requiring further development or changes.

The Project Workshop is an important part of achieving these objectives.

[1] This Project is a study conducted by the London Institute of Space Policy and Law, (ISPL), commissioned and funded by the European Space Agency, (ESA).

1.3 METHODOLOGY OF THE WORKSHOP

To inform the legal community and identify issues that need to be addressed, the Workshop engaged technical experts concerned with the production of EO information, as well as lawyers and administrators who use it in court and before tribunals.

The Workshop included:

1. Presentation of legal issues, covering decisions and findings in different jurisdictions;

2. Description of systems' technical capabilities and shortcomings; and

3. Discussion of the two Case Studies on land subsidence and oil pollution.

Presentations covered the legal and technical features. Well-informed participants from the legal, administrative and technical communities discussed operational, processing and evidential aspects of satellite-derived EO information. They raised many clarifying questions and discussed the issues that arose. The arguments presented in the Case Studies were challenged, revealing strength and weaknesses in the law and in the collection and processing of the EO information.

Through this methodology, the Workshop threw light on:

1. How satellite Earth observation tools are used in judicial and administrative procedures now; and

2. Some aspects of how they could be better used in the future.

It gave insight into actions needed to make satellite EO information more readily admissible as evidence. These will be explored further in this Report and in the final phase of the Project.

1.4 INTRODUCTION TO THE WORKSHOP[2]

1.4.1 Interests of ESA in the Workshop

The European Space Agency develops scientific technological systems, and puts in place operational systems to derive the utility from those technologies. Among them is earth observation, the focus of this Workshop. Typically the development cycle takes 25 to 30 years.

ESA's program is very much concerned with core science and technology, but also with engaging communities that can derive those benefits. That is the reason for this Study, why ESA is very pleased to be here and to have seen the Institute for Space Policy and Law bring together leaders in science, technology and legal practice.

1.4.2 Overview of the Study

Three very notable studies on this topic mainly concerned monitoring activity, as opposed to investigating ways in which remotely sensed information could be used as evidence. The Study by the Institute is to examine the criteria and conditions for evidential use of EO information.

[2] Introduction by Mark Doherty, ESA.

1.4.3 Background Material for the Workshop Sessions

In preparation for the Workshop, summaries of matters to be covered, and two Case Study scenarios, were sent to participants. These and the Workshop Programme[3] provide a brief summary of the structure of the Workshop and of the issues covered.

Each session is covered in this Annex, including its background material, presentation slides in most cases, a summary of the presentation, and the discussion that followed. Questions raised in the course of the Workshop, issued identified, possibilities for further action and additional issues to be examined are set out in Part II of this Workshop Report.

2. RULES OF EVIDENCE AND METHODOLOGY[4]

2.1 INTRODUCTION

To establish some common points of reference and provide a framework for some of the non-legal participants, the first session addressed rules of evidence. The presentation also covered some specific aspects of evidence relevant to EO information, and some rules that govern its use in judicial and administrative settings. Hearsay was considered, as were authenticity and reliability. The aim was to facilitate debate on how satellite-derived EO information may satisfy these rules, and what evidential issues arise because of its nature.

This presentation also gave a brief description of the matters investigated and the project methodology. Its primary objective was to seek the views of participants on issues that arise in relation to the use of satellite-derived information as evidence.

2.2 BACKGROUND MATERIAL ON EVIDENTIAL ISSUES

2.2.1 Nature of Evidence

Evidence is the information that proves a fact. In a legal context, satellite-derived information is used for one or more purposes:

1. To monitor an activity – detection, e.g. environmental changes;
2. To verify a state of affairs – confirmation; e.g. compliance with a Treaty;
3. To establish a fact – proof; e.g. a fraudulent CAP claim.

It is used in different legal contexts:

1. International; e.g. Boundary disputes and territorial claims;
2. Regional; e.g. European Common Agricultural Policy;
3. National; e.g. Hurricane Katrina insurance claims.

2.2.2 Requirements for Evidence

From a legal perspective evidence must be *admissible* and *probative* of the fact at issue. The manner and standard of proof required will differ according to the legal context in which

[3] See Annex 9: Workshop Program, Presenters, Moderators, Rapporteurs, Attendance.

[4] Presented by Professor Kevin Madders, ISPL Faculty.

evidence is offered. Distinction is also made between *public*, *civil* and *criminal* law. Jurisdictional differences are highlighted in another paper.

2.2.3 Reliability

To be admissible, evidence must be reliable. The court must be satisfied that it is what it purports to be. Aspects of reliability are:

1. Authenticity; e.g. that an image is a true representation of the building at issue;

2. Accuracy of the data; e.g. proof that a machine has been properly calibrated;

3. The chain of custody to that data; the chain of custody through processing, to show that the source and the end product can be linked; and

4. The people involved, the applications, the business processes and the procedures applied to it. Digital data is perceived by some to be particularly susceptible to alteration.

To illustrate reliability and authentication of data in relation to the legal process, the following case is useful: *In re Vee Vinhnee, debtor, American Express Travel Related Services Company Inc. v. Vee Vinhnee* (2005). The court excluded corporate records of American Express for lack of sufficient authentication.

2.2.4 Standard of Proof

Once admitted, evidence is judged on whether it establishes the fact at issue with a level of certainty. This level is lower in civil than in criminal cases. The former is judged 'on a balance of probability', and the latter 'beyond a reasonable doubt'. Standards in public (administrative) proceedings are less strict than these. The International Court of Justice applies a less rigidly defined standard.

Some standards exist for the authentication process. However, these are not harmonized or universally applied. In addition, courts may need to rely on expert witnesses to prove authenticity and to interpret specialist technical and scientific information.

There are other factors that may make the evidence inadmissible, such as privacy laws and search and seizure rules.

2.2.5 Nature of Satellite-derived Evidence

Satellite-derived information is scientific and technical evidence. It has two important evidential aspects in this context: its digital nature, which might make changes difficult to detect; and the need to process it to create intelligible information. It is the processed information that is offered as evidence, not the original data.

As a consequence, satellite-derived information may be regarded as "hearsay." In some jurisdictions hearsay is admissible subject to specific conditions.

2.2.6 Ground Truth Requirements

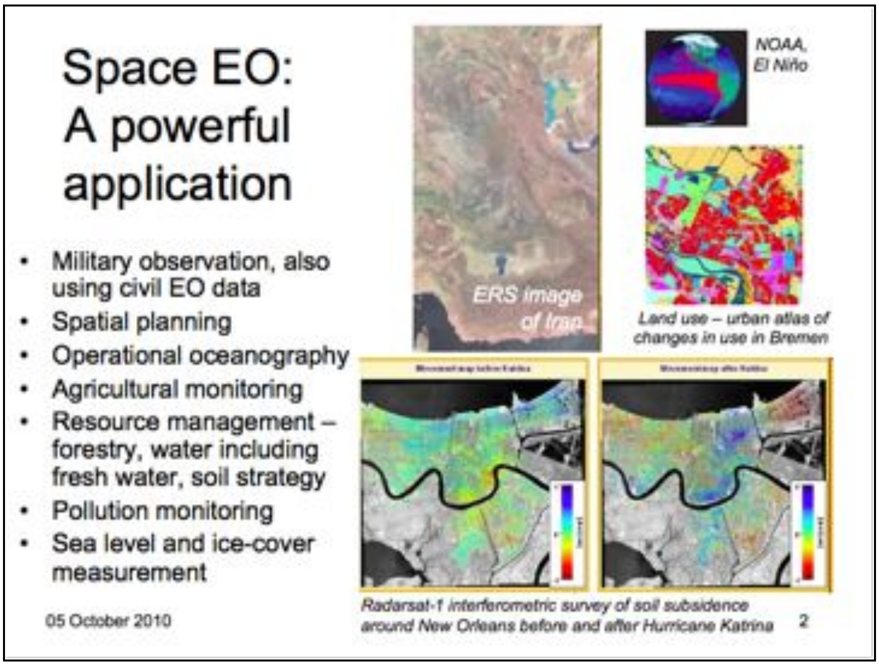
Technical aspects such as resolution or inadequacy of information may limit the usefulness of satellite-derived information to a monitoring or detection function. It may be of sufficient quality only to provide corroborative evidence. This would raise the need for 'ground truth' evidence from the relevant location, a record of an on-site observation of events. In some cases there are specific legal requirements for ground truth verification.

Resolution is rapidly improving, but the detail of visual information may still be considered inadequate in relation to the fact to be proved. For example, cannabis is not always distinguishable from certain other crops. Oil spill is another case where there may need to be other supporting offered in evidence, such as identification of specific chemical composition related to the vessel or its cargo.

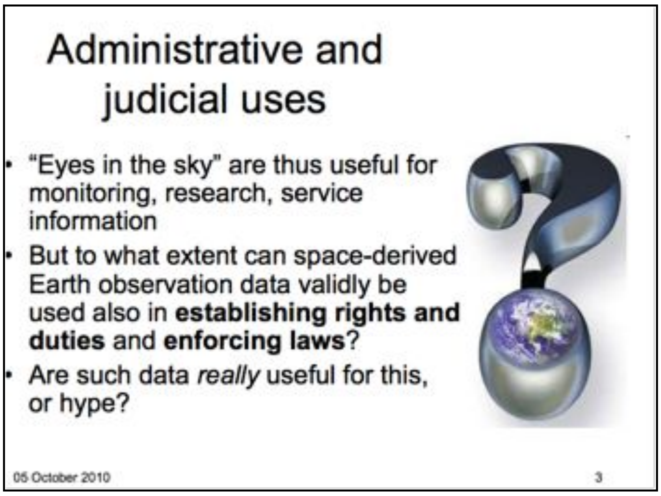
2.2.7 Expert Witnesses

In most cases satellite-derived information requires expert interpretation and validation. The normal rules for admission of expert witness testimony will apply.

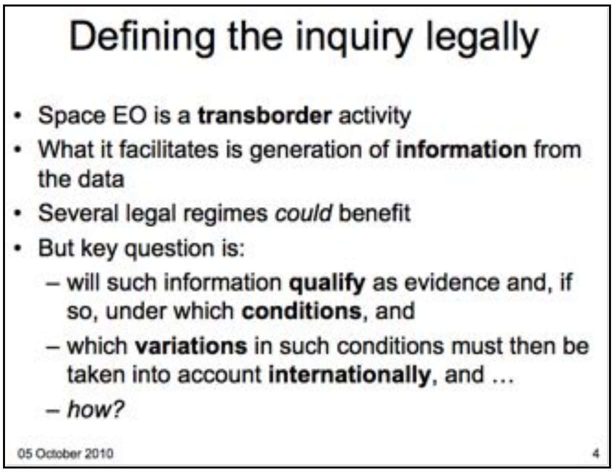
2.3 PRESENTATION



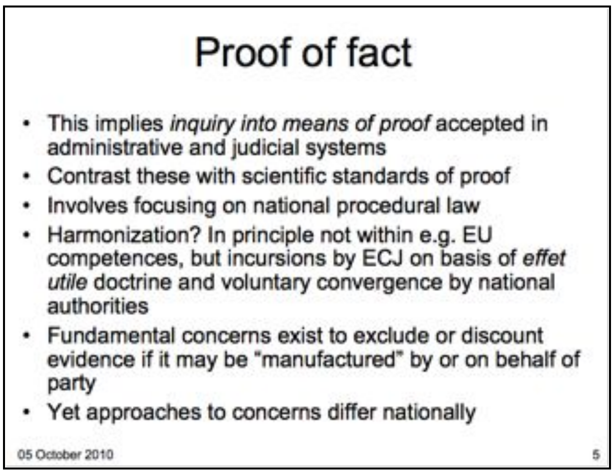
There are a variety of earth observation modes and uses. The information can provide evidence in a number of areas, including land use, soil subsidence, sea temperature, and military observation. GMES The European successor to the Galileo program is very important in itself, and in driving fresh platforms and uses.



This project examines administrative and judicial uses of satellite-derived information. It addresses the extent to which space-derived data can validly be used as evidence in establishing rights and duties, and enforcing laws.

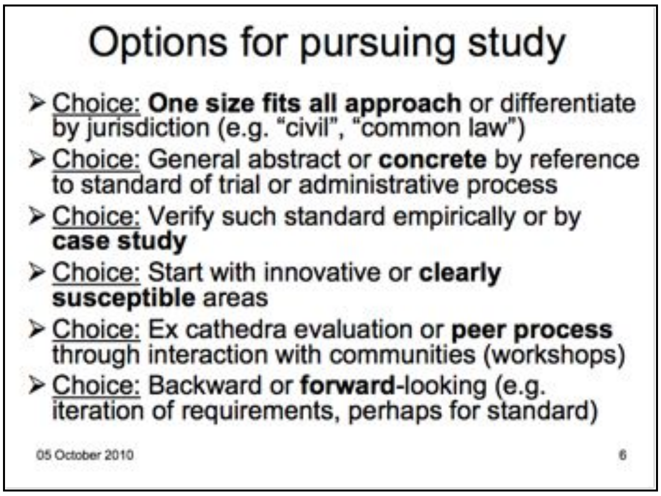


Satellite-derived information has the benefit of being trans-border, but that also raises issues of jurisdiction. There are also issues of validity: what kinds of information will be useful for tribunals and administrations. In addition, a distinction may need to be drawn between "proof" as defined by lawyers and by scientists.



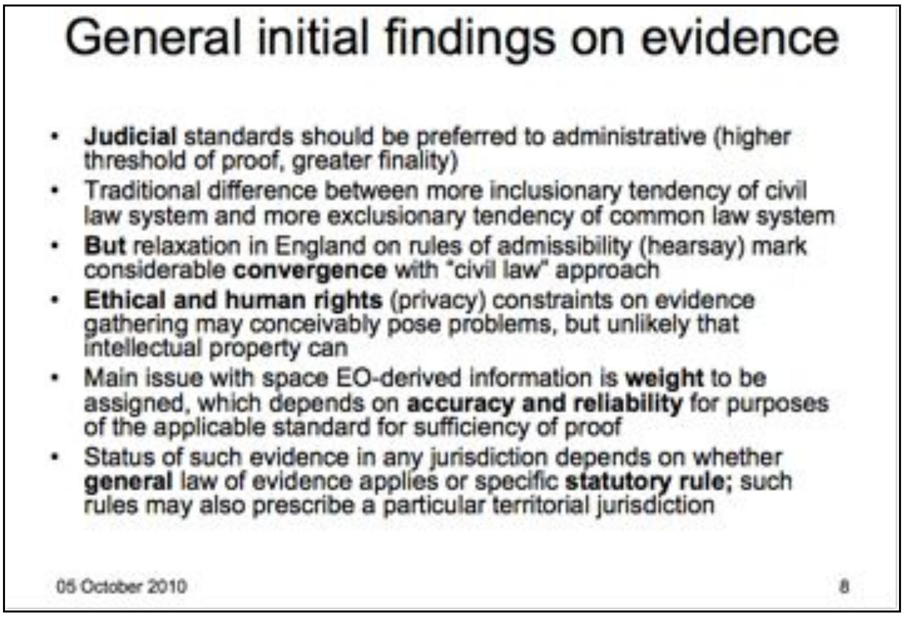
Scientific proof is reached on the basis of irrefutability, repeatability, objective states and deterministic probability, whereas there is a high degree of subjective evaluation in legal evidence.

While there has been a great deal of voluntary convergence internationally, national procedural laws have not been entirely harmonised. There are differences in approaches to reliability of evidence, processing and safeguards. One of the aims of this Study is to determine what, and how important, those differences are. With increasing ubiquity and confidence in technology, it is clearly necessary to consider its use, barriers to its use and protections that may be needed.



The study looks at abstract as well as concrete issues in the administrative and legal arena, to examine ways to achieve greater acceptability and use of satellite-derived information as evidence. It will consider whether future approaches should be tailored to different jurisdictions, or be more universal; what role standards, guidelines and legislative reform might play.

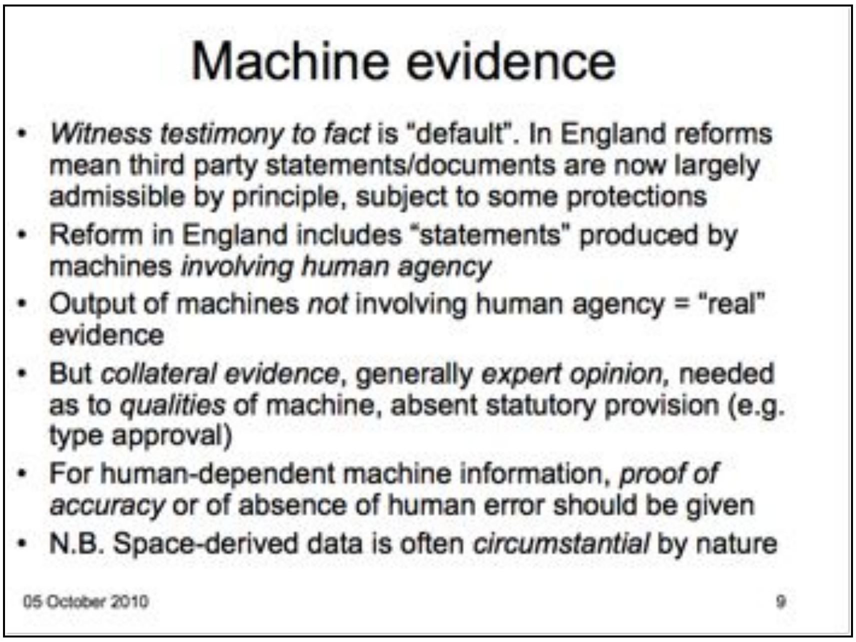
The Workshop will use presentations on land subsidence and oil pollution. Variations in approach between jurisdictions, particularly the discretion that can be used to admit evidence, will be addressed.



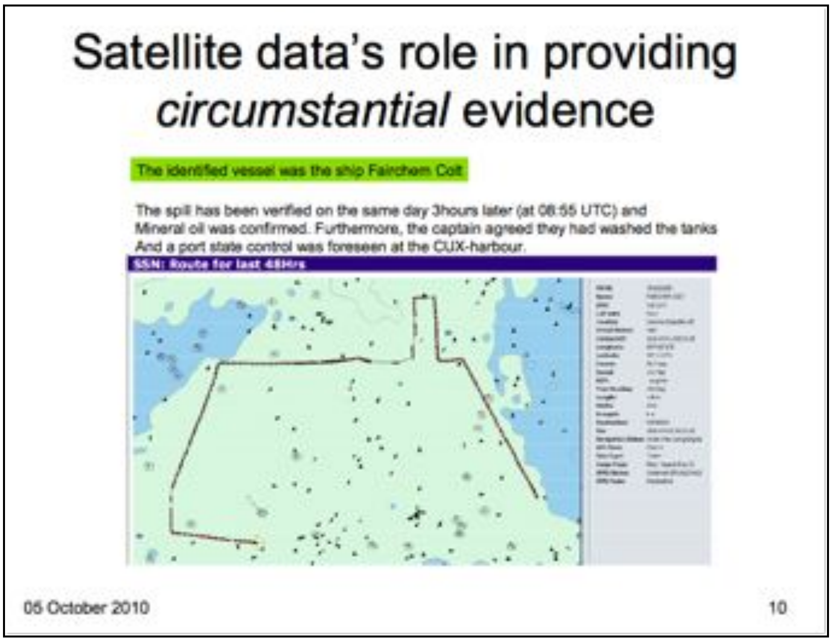
It was felt that the higher standard of proof applied in courts, as opposed to administrative tribunals, would be preferable. The level of certainty to which a fact is established is higher in court than before administrative tribunals. Similarly, selecting the most restrictive jurisdiction results in the higher requirement.

To this end English law was chosen as the benchmark, for its relatively strict exclusionary rules regarding admissibility.

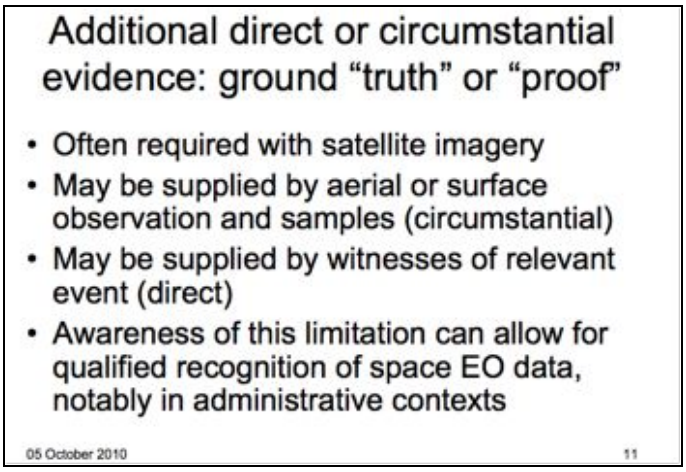
The weight given to evidence based on satellite-derived information will depend on its accuracy and reliability. Statutory rules on admission, and conditions to be met by such evidence, can be of benefit. Examples of such rules are found in analogous areas such as speed cameras, where type approval specifications exist. Whether such rules are relevant or desirable for these applications will be discussed.



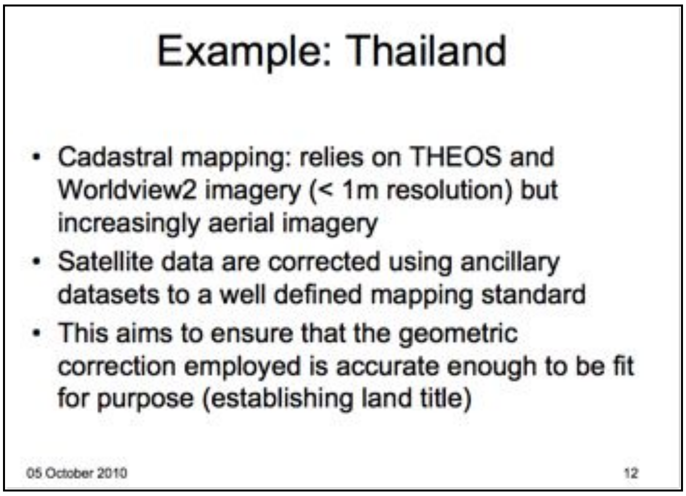
In relation to machine-generated evidence, in the literature, and particularly the 2001 study by BIICL and NPA, it is said that where satellite data is involved, expert opinion is always required. This is relevant to cost and length of proceedings. There is a need to examine what approaches to the proof of accuracy may be appropriate.



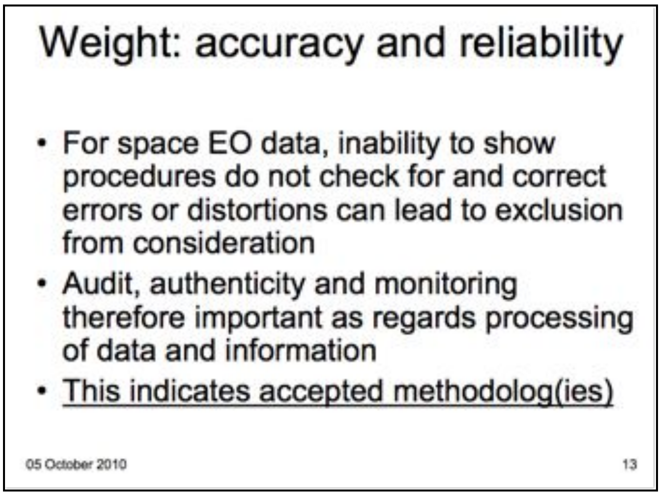
Space data is generally circumstantial rather than direct. It is indicative of an inference to be drawn.



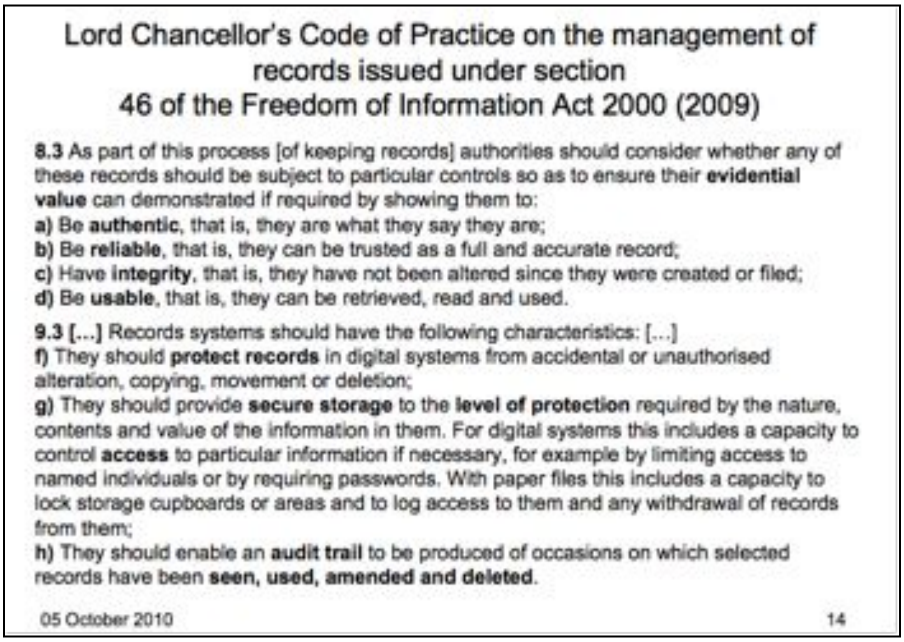
Other corroborative evidence or ground truth, perhaps in the form of extra observation, may confirm the inference drawn from the circumstantial evidence provided by satellite.



In the example of Thailand, satellite data was not sufficient to establish land title. Ground control point verification and geometric correction were also required.



Reliable, calibrated systems are needed to give sufficient accuracy and weight to evidence. Otherwise the information may be inadmissible, or may lack probative value. Audit, authenticity and monitoring are important.



There are codes of practice, guidelines and rules to ensure a good audit trail, and reliability of information.

Guidance might be in the form of legislation, a standard, voluntary standard, or some other statement that is applicable. Existing standards have relevance but are not specifically on point. The Study and this Workshop explore these options and related issues.

2.4 DISCUSSION

C***omment***: The relevant characteristic of satellite-derived EO information is that it is electronic. Therefore, the issues are the same as for any electronic evidence. Further, lawyers and judges do not understand electronic evidence.

Response: The quality of expert evidence can be critical. Courts can err by relying on their own judgment in the face of expert evidence. This is further examined when considering the jurisdictional issues in the Netherlands.

3. SYSTEMS CAPABILITIES

3.1 INTRODUCTION

Three presentations were given, each relating to a different application. They covered technical capabilities, including processing techniques for satellite data.

The first presentation focused on sensors and processing techniques in general, and for land motion measurement in particular. The techniques used and the capabilities of systems measuring land motion present an interesting application. The data collection systems are not novel, and much of the information used can date back several years. The innovation is the development of a technique for processing the data that can measure very small movement in land surface levels by reference to selected points. Issues relating to standards, reliability and accuracy were mentioned. The need for better understanding and greater communication between lawyers and technicians, scientists and administrators was highlighted, along with calibration and factors relevant to the combination of earth observation data with other information, such as geographic and time. Modelling and its impact on the information generated were addressed.

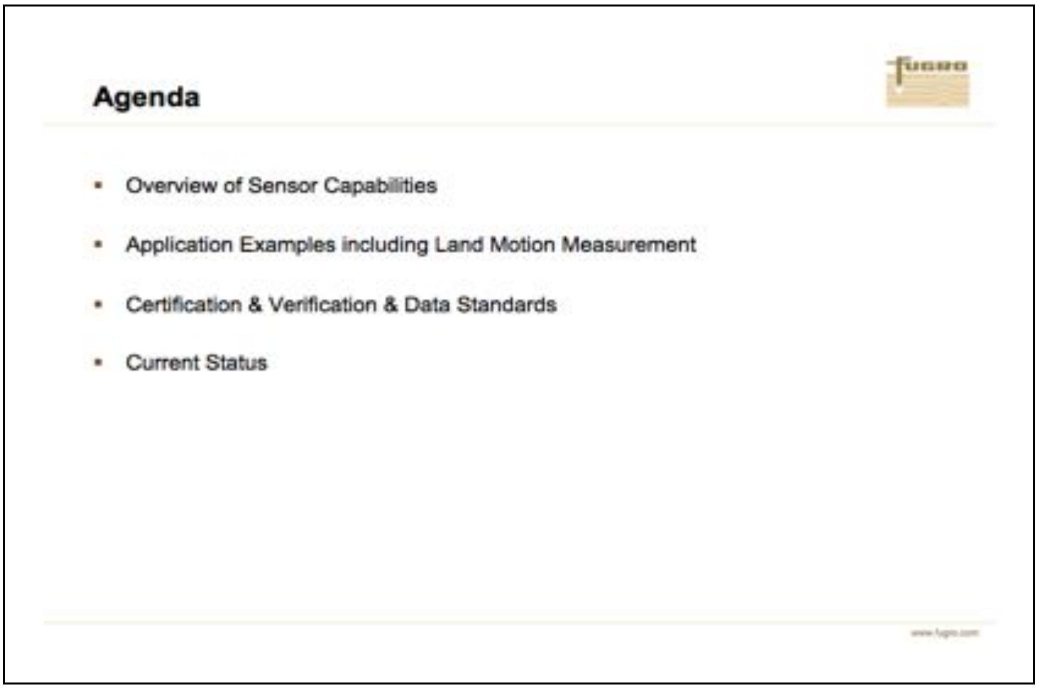
An important evidential facet of sensors is that the data generated be accurate. To that end, systems need to behave predictably and consistently. There is, therefore, a need for calibration and verification of system performance. This was addressed in the second presentation in the session. Even where systems can be relied on to provide data accurately and reliably, there is a further requirement to be met. To be of evidential value, the information must relate to the specific matter being investigated. It is therefore necessary to show that the information relates to the factors that are at issue, and can be relied on for that purpose.

The third presentation explored this aspect of satellite systems capabilities, taking oil spill detection and polluter identification as the reference point. It covered the techniques used to monitor and identify polluters. The impact of environmental factors on satellite observation systems was considered.

The discussion following this session is reported in Section 3.5.

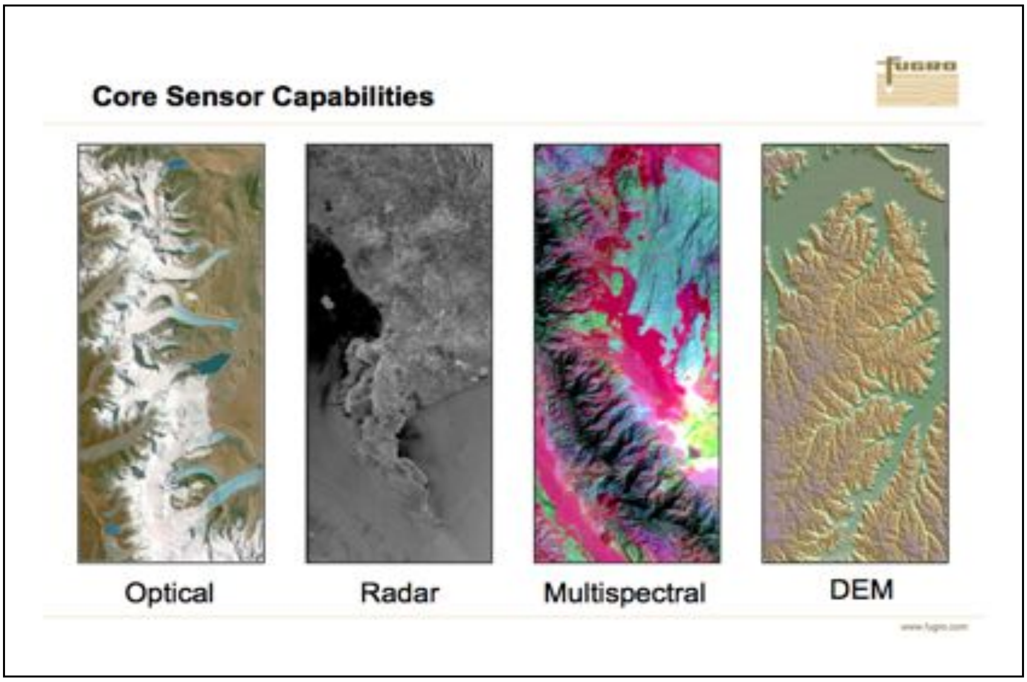
3.2 SATELLITE CAPABILITIES FOR LAND MOTION MEASUREMENT:[5] PRESENTATION

Satellite sensor capabilities were reviewed for land motion measurement and some other applications.

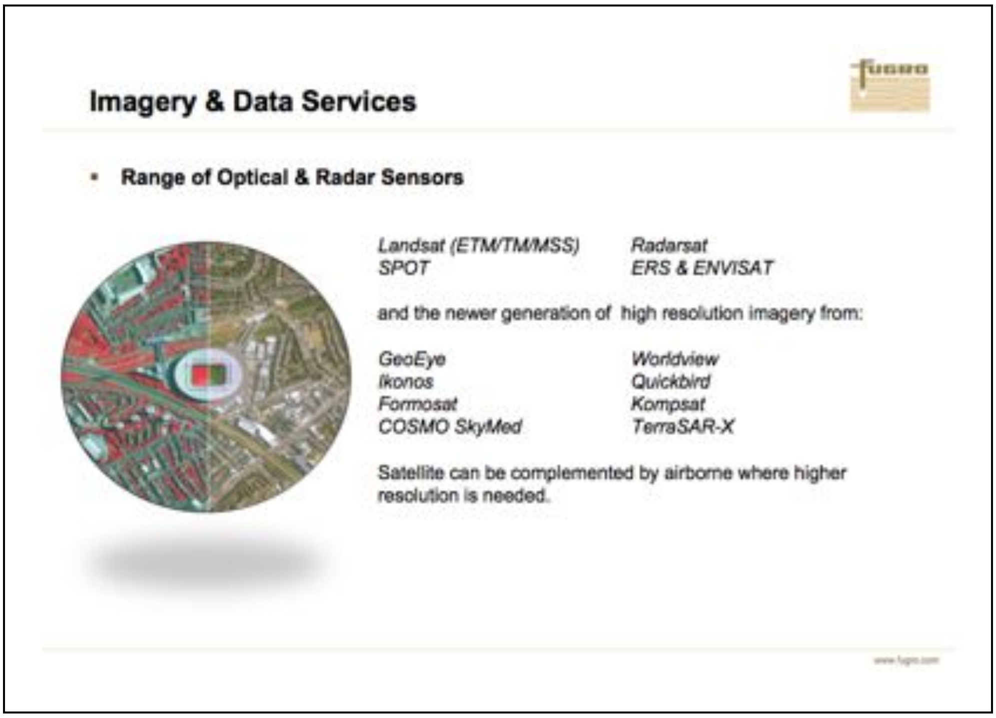


It explores certification, verification and data standards, and issues relating to terminology and communication between scientists, technologists, academics and lawyers. Some lawyers view satellite data as electronic evidence, others as simply hearsay or circumstantial. The technical community needs to understand the procedural issues and the needs of the legal community.

[5] Presented by David Morten, Fugro NPA.



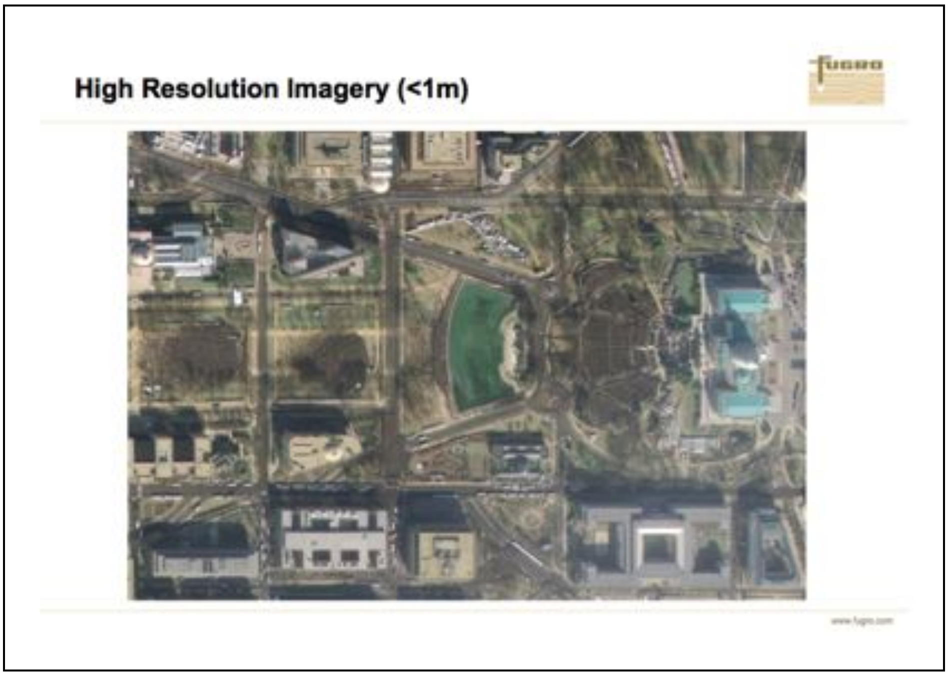
There is a distinction between optical data, representing a visual image of the subject, and more complex radar data, which needs processing into a visual image. Other aspects include recording phase, change of signal phase, and the amplitude of the signal. A range of multi-spectral sensors are also used over a broad range of the electromagnetic spectrum to provide much more information, for example in the near infrared for detecting vegetation and other material and conditions. In addition, multiple passes can provide elevation models.

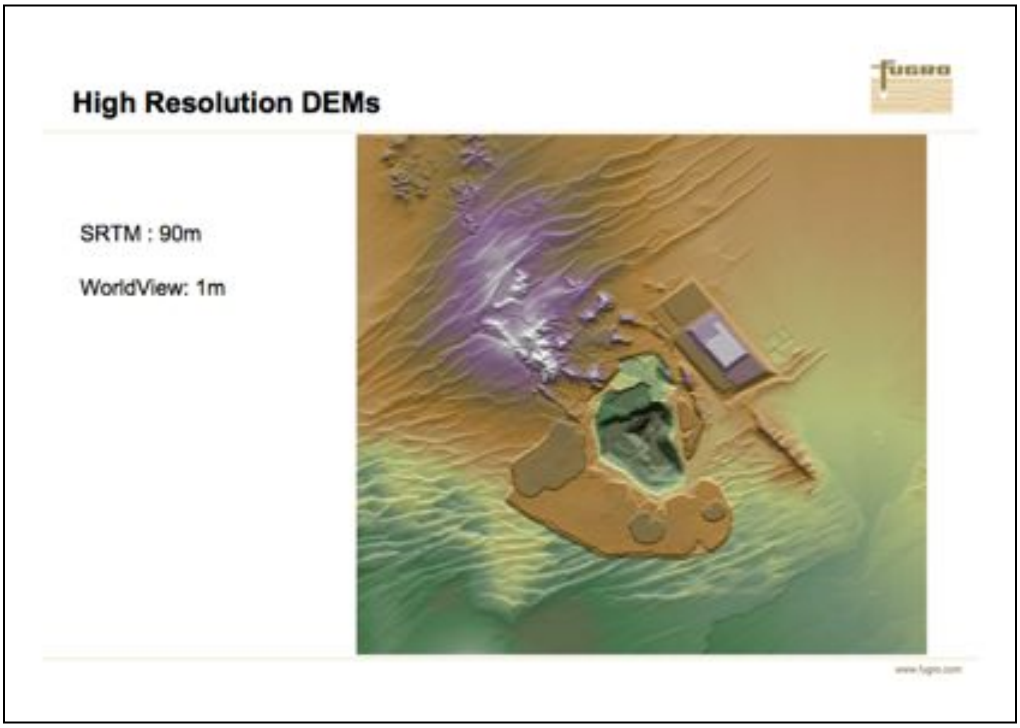


The range of sensors is maturing. Well-known traditional sensors on systems such as LandSat, RadarSat, the ESA ERS, ENVISAT, and Spot typically range in the 30 metre to 10 metre range of resolution. In the last 10 years or so, a large number of newer generation satellites have created constellations such as COSMO SkyMed, with 3 satellites, and a 4th one is on the way. These will improve the temporal separation between the data and the acquisitions.

Not all satellite missions have the same scientific and archive base. Time gaps in archives may reduce their usefulness as evidence. With increasing acquisitions, coverage and daily re-visits the position is improving. But the historic problem remains.

High-resolution satellites orbiting 740 kilometres up, and resolutions of less than one metre, can detect numbers of people in a crowd and make estimates of attendance at an event. Movements of refugees, troops or vehicles can be observed.



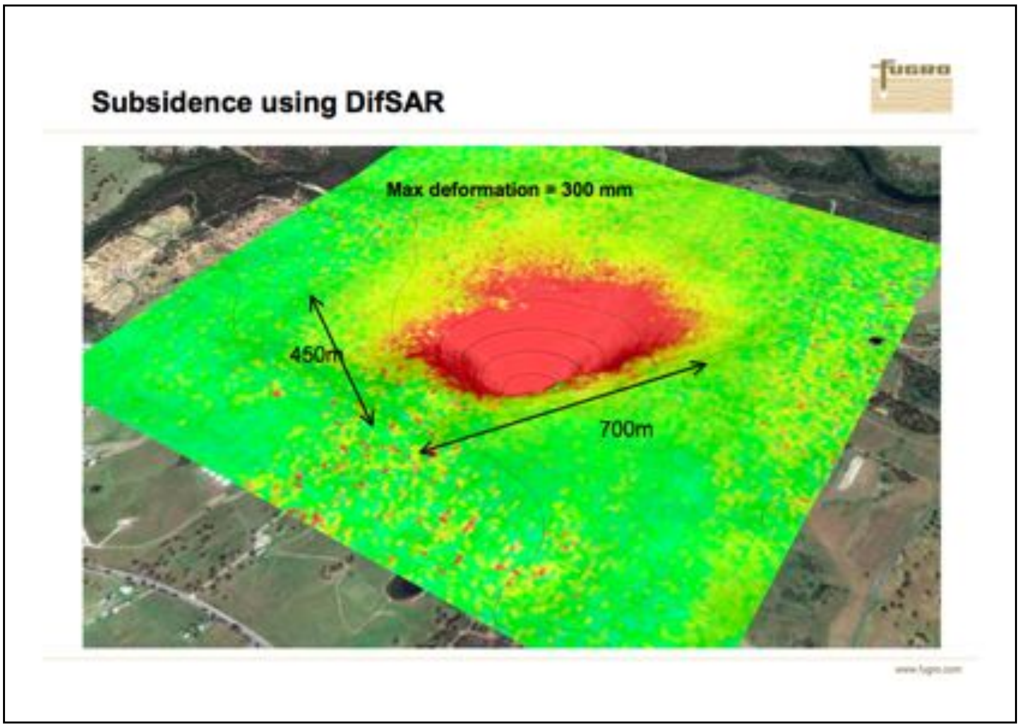


1 metre DEMs can now be created using DigitalGlobe and GeoEye satellites.

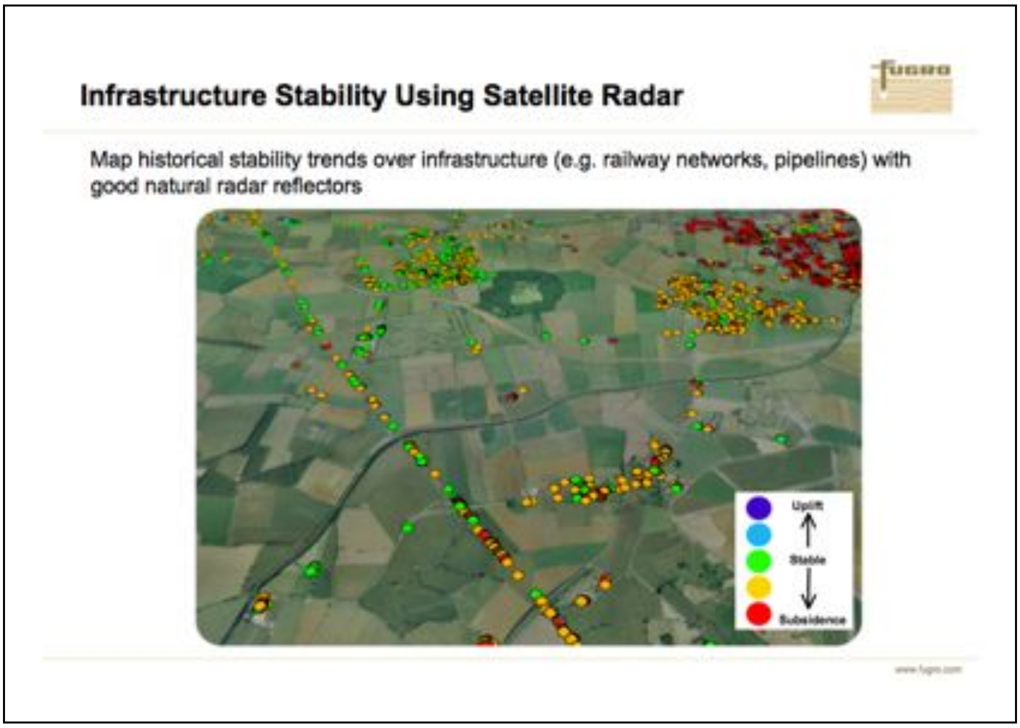
Earth observation satellites can provide considerable information about ground motion and subsidence tectonic movement, as well as site development, environmental factors, site clearance, and other changes. Such observations are useful in boundary disputes and coastlines changes. Satellite data has been used in damage assessments in insurance claims, pollution monitoring, and humanitarian aid.

To detect and measure land motion as low as one millimetre, a pair of scenes and an elevation model are used.

With a time series of data over a particular target, using more precise reflecting points, individual buildings and features can be monitored. The above InSAR images of oil tanks in a storage reservoir enable monitoring of the stability of the whole infrastructure. The buildings act as reflectors. A passive corner reflective device reflects the radar signal, and an active device, a transponder, helps measure small changes in movement.

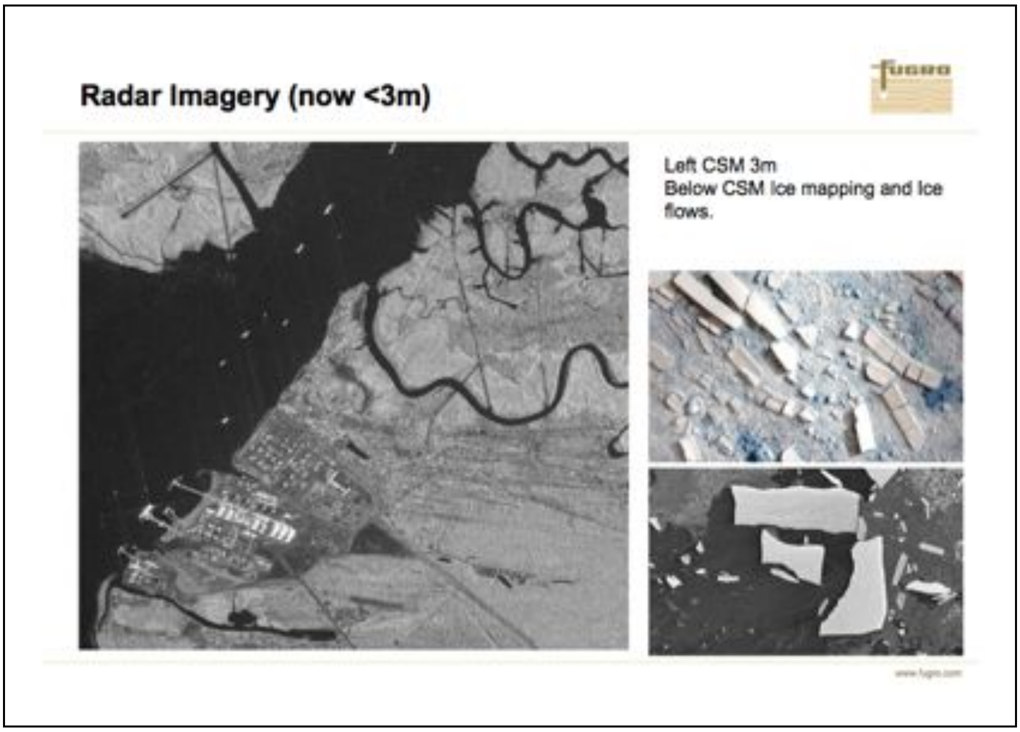


Radar imagery that may not be intuitively understood is transformed into an image, for use as a depiction of the damage and impact being observed. To be useful as evidence, it is necessary to understand how radar data from acquired scenes are processed to derive a motion image that may result in a claim.

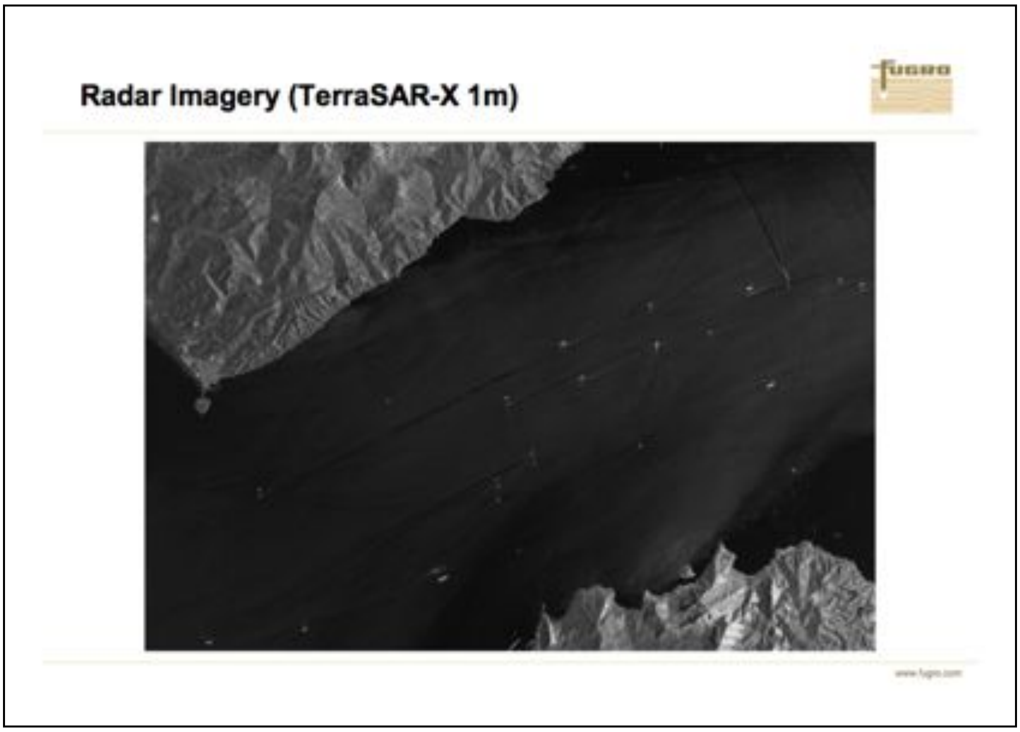


This image using the persistent scatterer radar technique shows a linear feature, possibly a railway line, road or other infrastructure, and a trend of subsidence in the direction of the bottom of the image. The top right-hand corner of the image also shows an area affected by mining subsidence.

An illustration of a landslide, with corner reflectors.

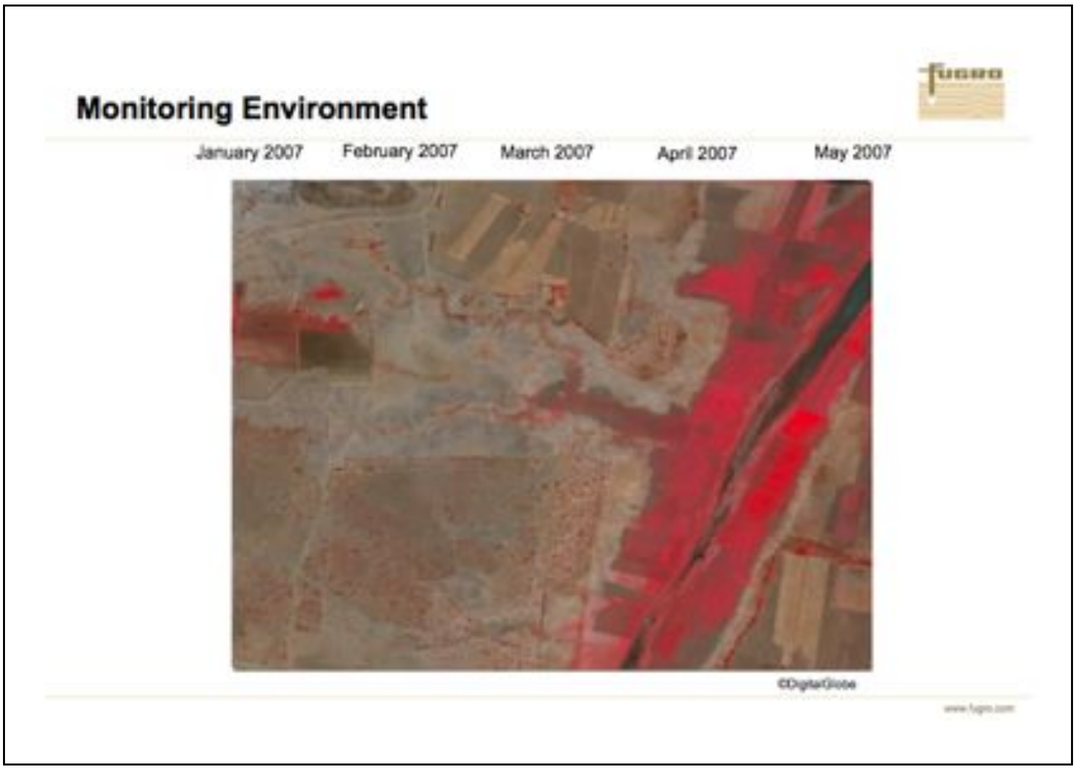


These images illustrate advances in radar from lower-resolution radar imagery, with high-resolution radar, less than 3 metres, able to pick out ships, ports and activities within those ports. Using long-track interferometry, movements between two satellites can be measured to give information about the direction of the ship. The combination of satellite imagery with other sources, such as AIS transponder information, provides a large amount of information for pollution monitoring.

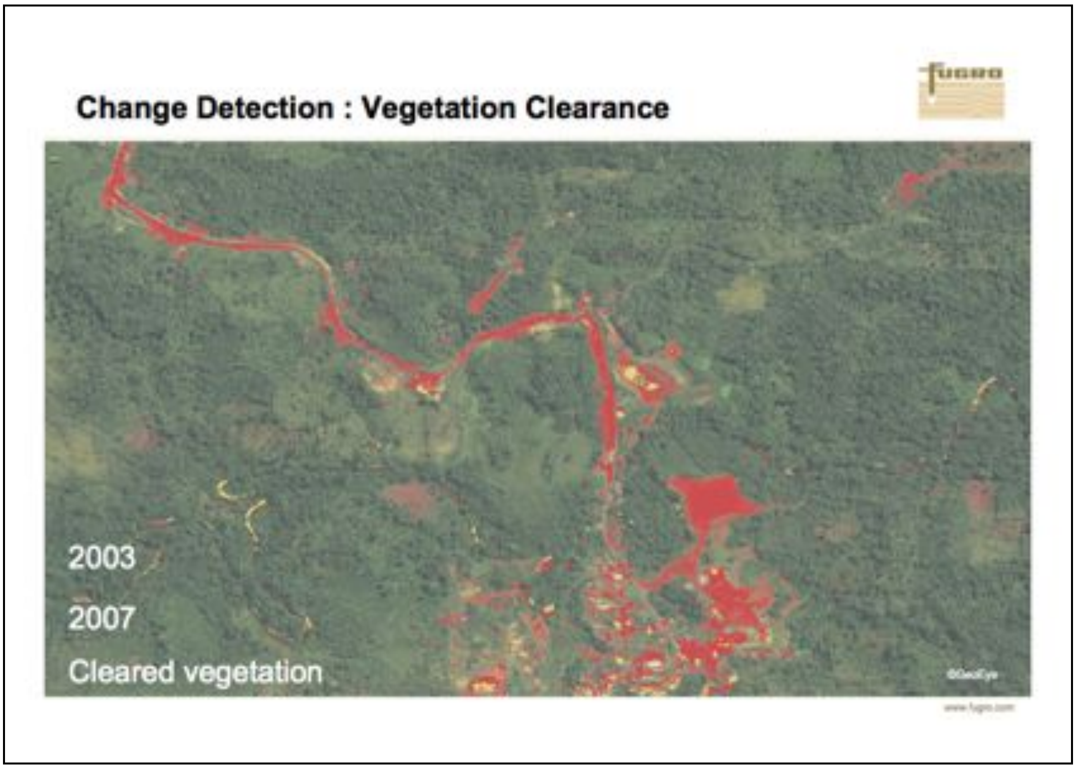


1 metre resolution of the Straits of Gibraltar reveals ship movement.

This image illustrates satellite data capability to show movement or change in a development site.



In terms of monitoring the environment, a time series can show changes, such as increasing vegetation in fields.

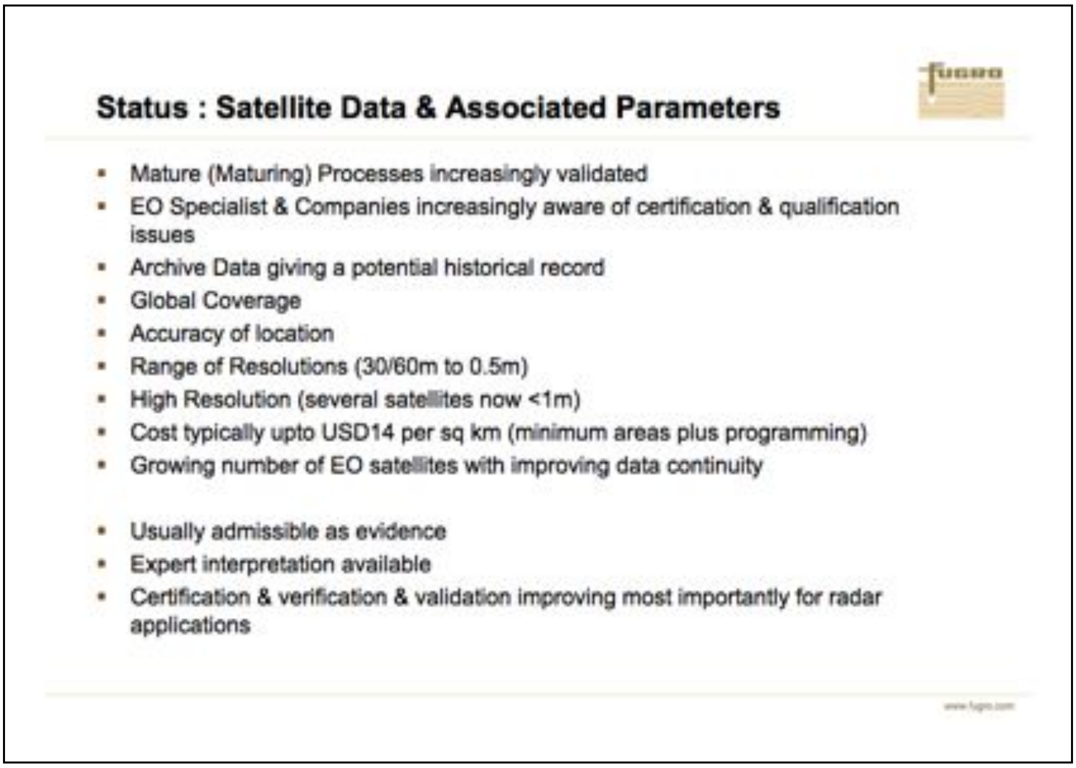


Another image of change detection, this time clearance.

In an insurance example, high-resolution imagery shows buildings and the extent of damage.

Questions are raised about certification and data qualification. Should an EO company producing data and products try to certify its management systems in terms of ISO standards? Should it focus on the credentials, qualifications and reputations of the people acting as expert witnesses? Should it validate and verify the techniques used as being 'accepted'? Advances in the way lawyers view "electronic" evidence may overtake such questions, and whether this evidence is viewed as circumstantial or hearsay.

Most data used by EO companies come from government sources but some are from commercial companies. The data is supplied with no 'fitness of purpose', no warranty, and no guarantee. The above liability limitation provision is typical for most satellite data supplied.



EO products can take 30 years to come to fruition. These are a maturing set of processes. These processes are increasingly validated. For example, in the case of optical imagery, some of the simpler radar-processing techniques are generally accepted. EO companies are increasingly aware, and certainly the four companies involved in very fine radar processing for ground movement in GMES projects are aware, of the desirability of certification, including ISO 9001 certification, and validation of processes.

Satellite data provides global coverage with good accuracy. Most satellites are very well calibrated. Resolution is good, less than 1 metre. Costs vary, with some systems providing free data from the governmental and scientific communities. Commercial satellites must try to give a return to shareholders.

There are some questions about the admissibility of the data, and the form it has to take. It seems to be usually admissible, but this could be clarified for the value-adding EO community as a whole. Expert interpretation is widely available, but good communication and access are vital. Certification, verification and validation are key issues, particularly in radar.

3.3 CALIBRATION AND SYSTEM RELIABILITY[6]

3.3.1 Background Material

Environmental Science and its applications are evolving rapidly as we move from description of the environment to prediction, which inevitably involve errors. There are three technological catalysts of the change, advanced computation, global observations, particularly from satellites, and the computational and mathematical facilities to compare and evaluate the models with the observations. Making predictions changes how the observations are used, but the methods used allow the role of observations to be quantified, along with the errors in the resultant predictions.

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[6] This section is based on material provided by Professor Robert Gurney, NERC, Reading University.

Some of the best-known examples of prediction are in weather forecasting and forecasting the consequences of extreme weather, such as flooding. These problems are usually classed as initial value problems, where a set of observations is used to set the initial state of a model, which is then allowed to evolve. Models are now often run many times, with slightly different initial conditions, to get estimates of the error growth in the model over time. Comparing the predictions with observations after the event also assesses predictions. A more recent method is data assimilation, where observations are fed into the predictive model as they are received, so that the initial and predicted fields are blended products of observations and models. These methods allow the worth of observations to be assessed, in addition to the predictions themselves. Methods of data assimilation, originally developed in control engineering, are now very common in atmospheric science, becoming more common in ocean sciences, and increasingly into the science at the land surface, including flood modelling and prediction.

A second type of prediction is so-called boundary-value prediction. Here, boundary conditions are observed, or fixed, and a model is allowed to evolve. Climate prediction is an example of this type. The model gives the general statistical description of a change with a change in boundary conditions, such as a change in greenhouse gas concentrations, but prediction of this type cannot describe the exact evolution in time of processes. This can lead to controversy, and it is important to understand the uncertainties involved in this type of prediction. Observations are again important, to set boundary conditions, and to allow comparisons between the general statistical performance of models and the general statistical description derived from the observations.

Both types of prediction have been evolving fast with better computing power, so that more processes can be modelled explicitly, and not approximated because they cannot be modelled. However, there is still controversy, both in the modelling approximations which remain and in the observations, as many of these are derived, particularly from Earth observation, and can themselves contain artefacts. The International Space Innovation Centre at Harwell, newly initiated by the UK Government, will allow the UK to investigate these observed field errors in more depth and breadth than was previously possible in the UK.

The use of observations will be illustrated by some examples. First, a key driver for weather and climate models is a good knowledge of the radiation that drives the global atmosphere and ocean system. We can now also observe this. Detailed comparisons show that the two agree to 1 – 2%, except in areas such as the Sahara where there is a lot of dust that is not well modelled. Second, the errors of weather forecast models at forecasting severe storm tracks will be shown to illustrate the growth in forecast errors in time, and to show that some predicted quantities, such as storm tracks, are better predicted than their intensity and timing.

The analysis also shows the effect of adding or removing different observation fields. Third, a comparison between observed and modelled Northern hemisphere snow fields shows that while the amounts of snow are similar, they are distributed quite differently in weather and climate models, both of which differ from observations. Finally, the ways observations are being used to improve flood models will be shown.

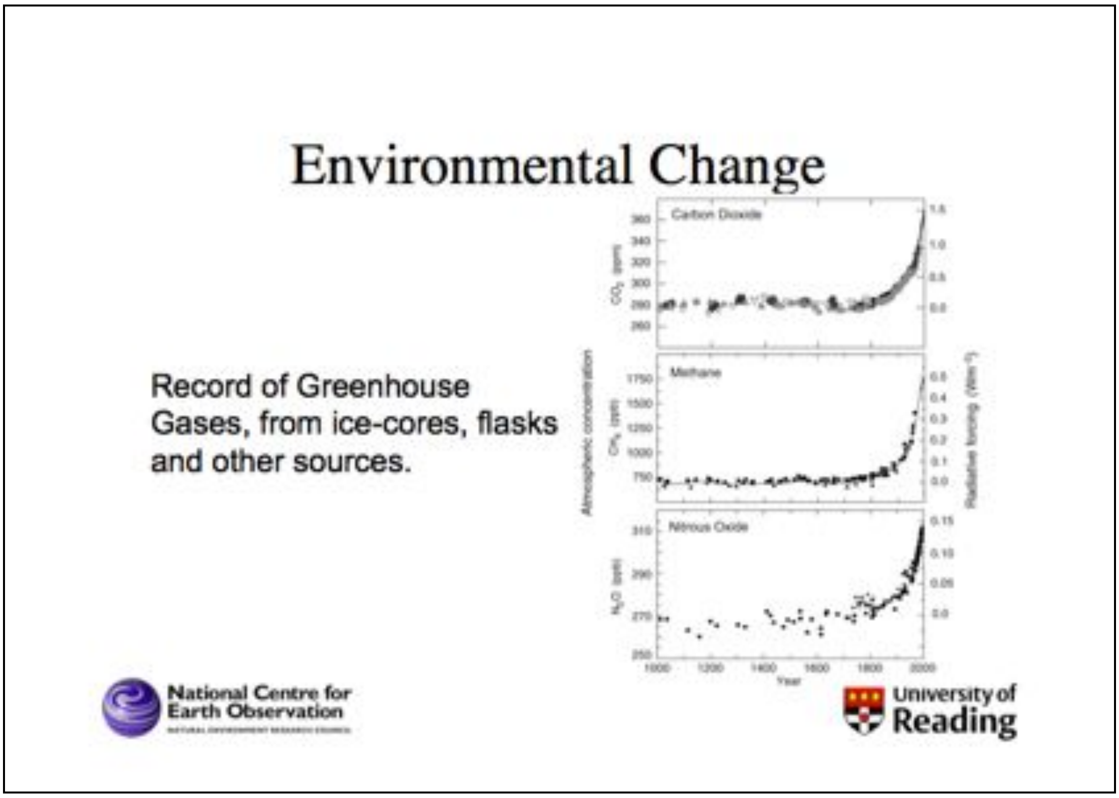
The uncertainties increase though these examples, while the economic impact also increases. How do we handle uncertainty where there are economic benefits and therefore potentially actionable advice? The evidence from space is consistent in time and in space, but needs interpretation that introduces error. How do we handle this evidence in the presence of error?

3.3.2 Presentation[7]

To examine aspects of calibration and system reliability, as well as the processing methods involved in satellite-derived information, this presentation focused on environmental and weather systems. These present some of the more challenging problems.

Environmental science is changing immensely fast. There are three catalysts for this. It is possible to bring together lots of observations, globally and regionally. These observations, particularly earth observation but other sorts of information as well, may be combined.

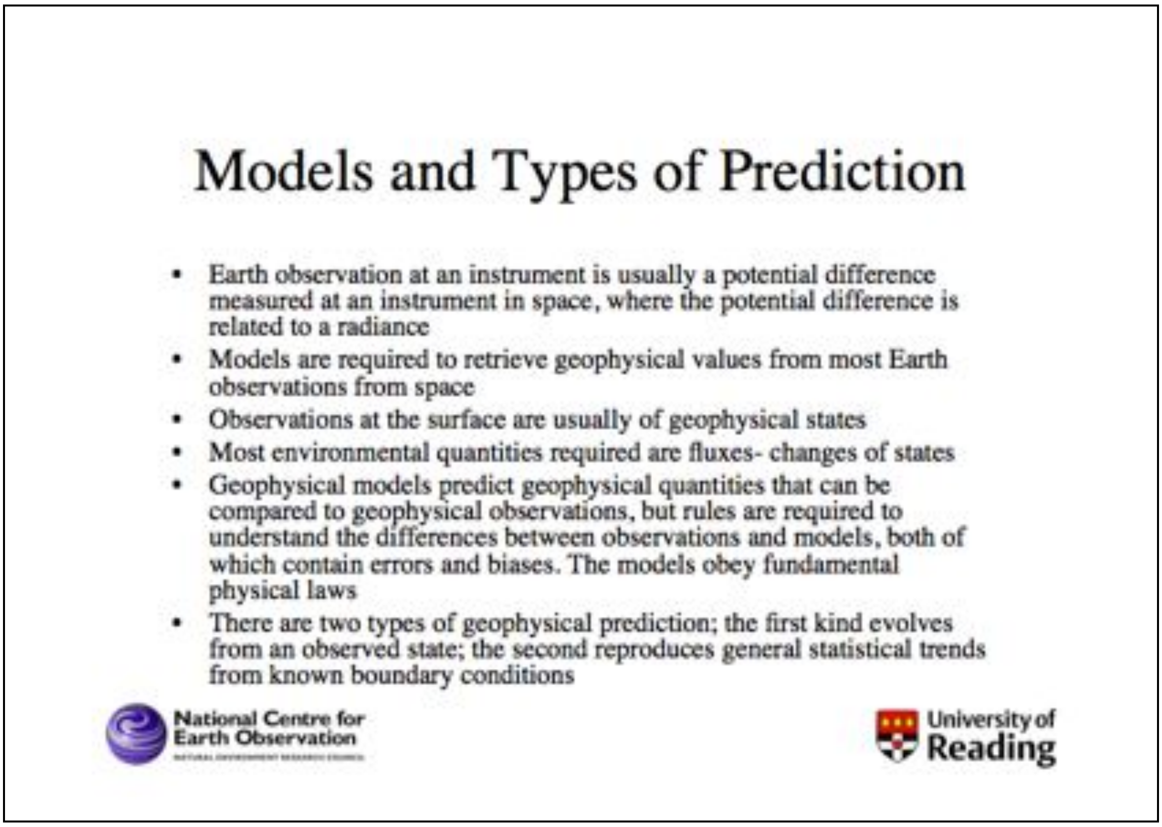
It is possible to solve very large sets of partial differential equations on large computers, for modelling the whole earth and bringing all this information together. Earth observation of any kind is very rarely used on its own, whether from space or any other source. It is put in context with other information.



This well-known set of data from the last 1,000 years shows the concentrations of 3 major greenhouse gases that are well mixed. This is more controversial than one might think, because it includes information from many different sources.

Obviously this data is not from remote sensing, but from other sources. There is a lot of information about calibration, differences in time, and so on, involving a lot of interpretation even in something as well known as this.

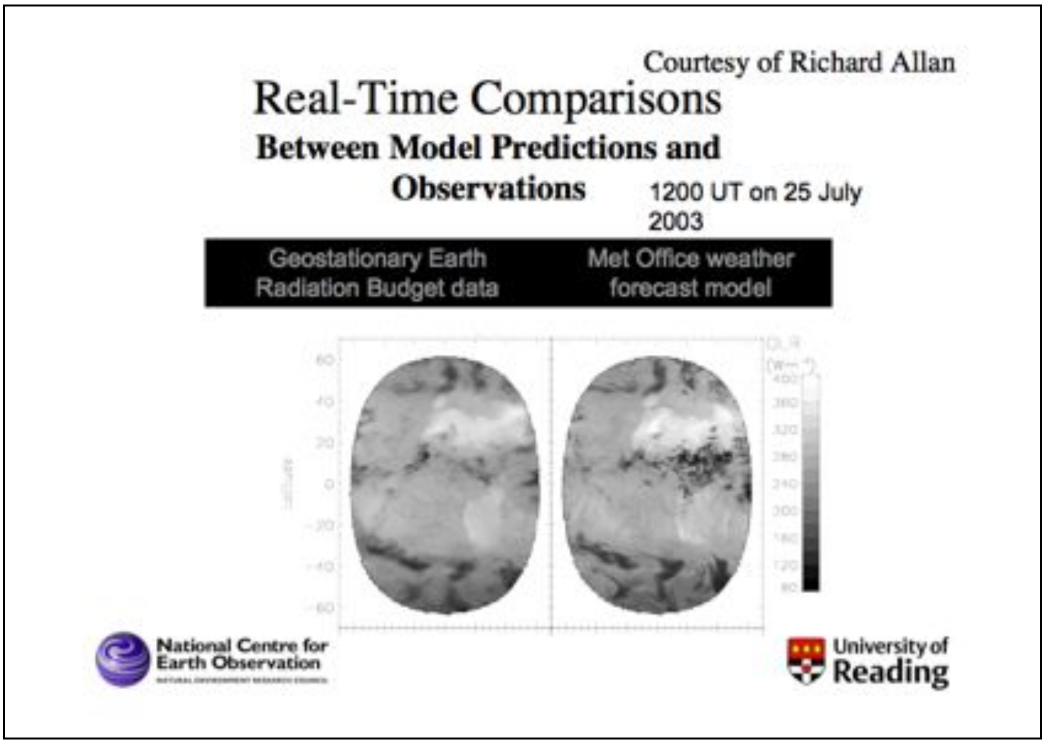
[7] Presented by Professor Robert Gurney, Reading University.



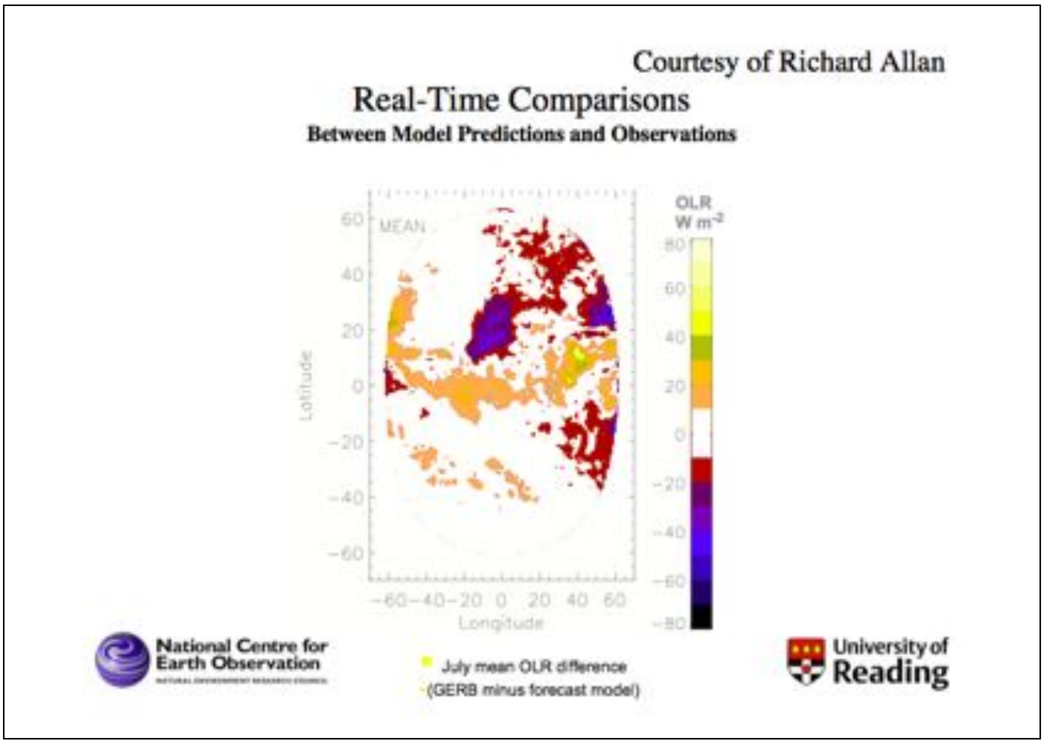
Earth observation data is almost always a voltage out of an instrument. A model is needed to convert it into a geophysical quantity, so that there is the need for expert opinion whether in the legal sense or not. Geophysical models of the planet, the climate and the weather are large, and include many different processes.

These systems combine models and observations; it is very rare to have only an observation. Usually some geophysical state is observed, and a change measured, usually a small difference between two large numbers. Errors are a concern.

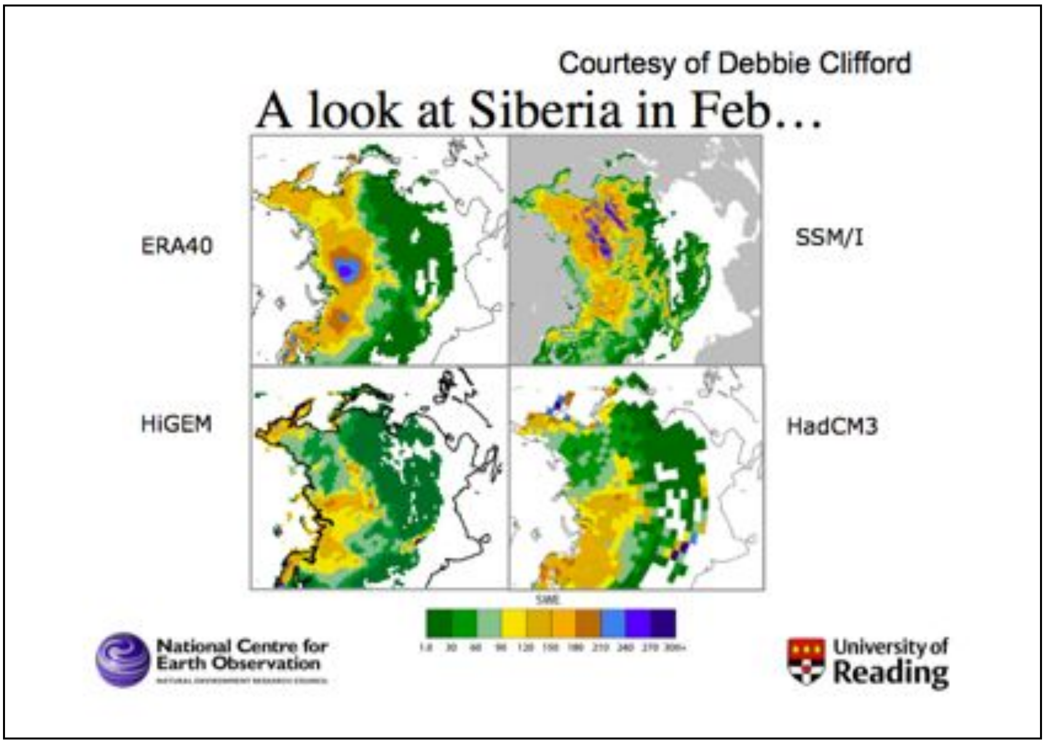
There are two kinds of prediction. One starts with a set of the measurements of the state of a process, and evolves in time. The other uses climate, with known boundary conditions, and evolves within those, but not to predict the exact state.



This classic image shows radiation over Africa, in 2003. The left is an actual observation; correct to about 3 watts a square metre, showing the outline of Africa. The right is a prediction at exactly the same time from a UK Met Office numerical weather forecast. The comparisons can be used to determine errors in the models.

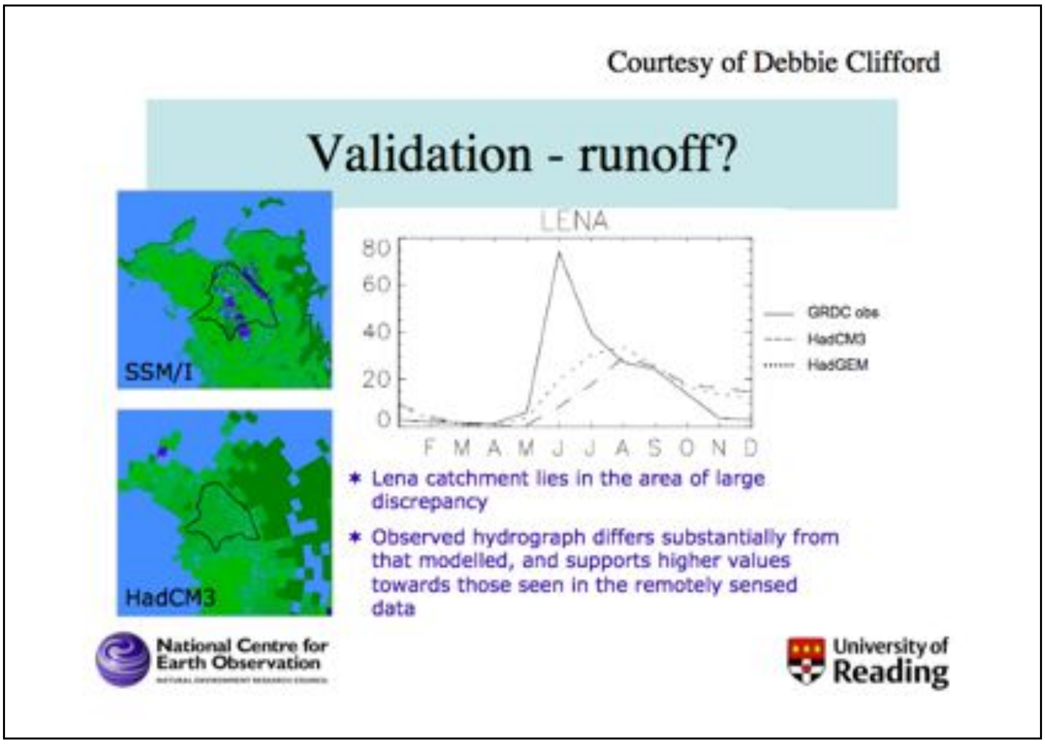


Here is an average over about 5 years, of the differences of the outgoing radiation observed and modelled. The differences are extremely small except over the northwest Sahara, where atmospheric dust is present.

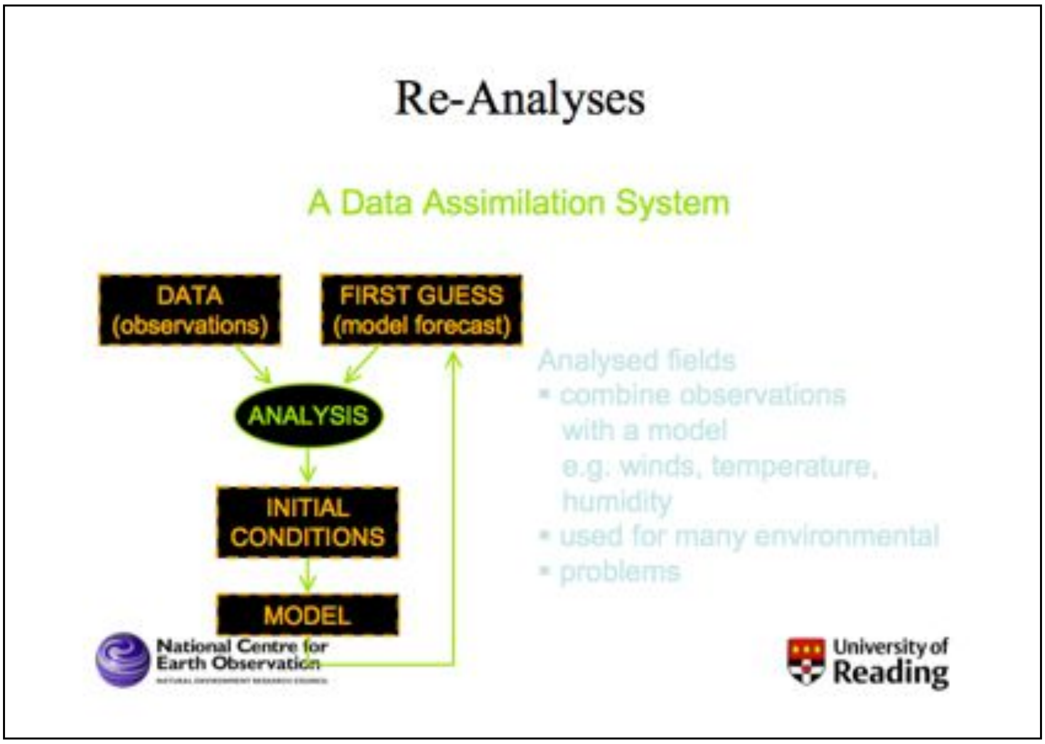


Snow is economically important for a number of reasons. This is Siberia. The top left is the European Weather Centre estimate, in average February levels over many years. The bottom two are from climate models. The top right is from the NOA satellite series over about a 40-year period.

There are large differences between the model based on the satellite data, and conventional observations combined with a weather forecast model. Much more information is required in addition to the satellite data in order to interpret the data. The challenge is to design information systems able to capture enough information to be able to understand those differences.

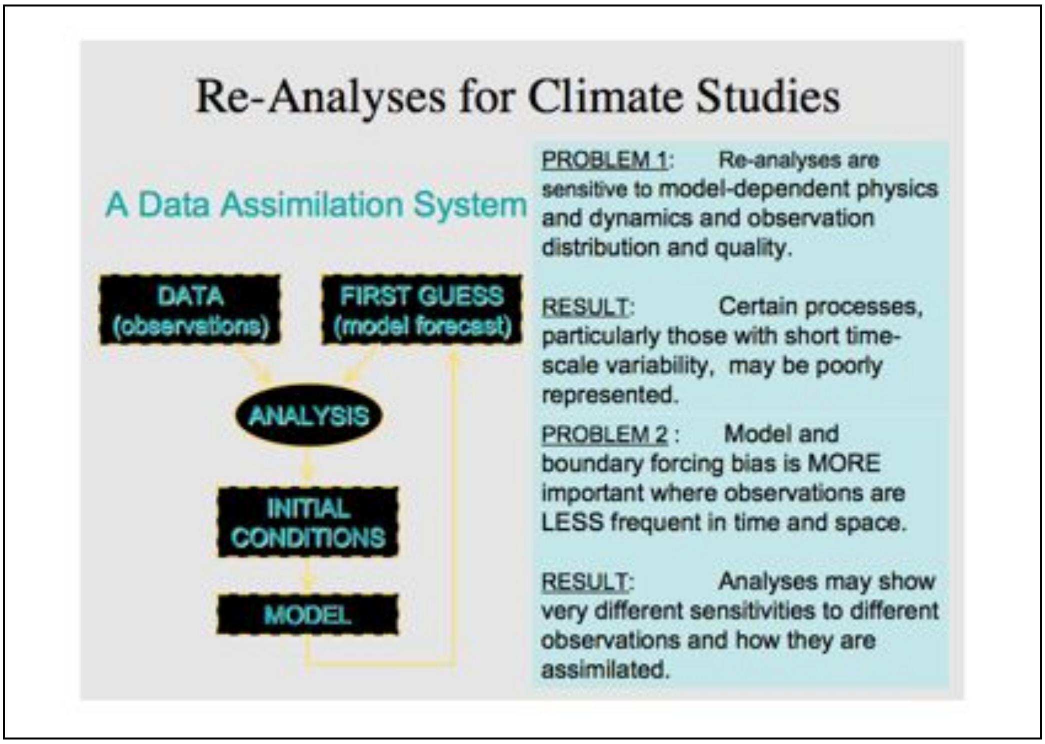


This is a catchment in eastern Siberia, with satellite data and climate model information. The solid line in the graph is the actual runoff from the catchment. The dotted and dashed lines show information from two different models. It is evident that the climate models are probably wrong in this area, and more information is needed to understand why.



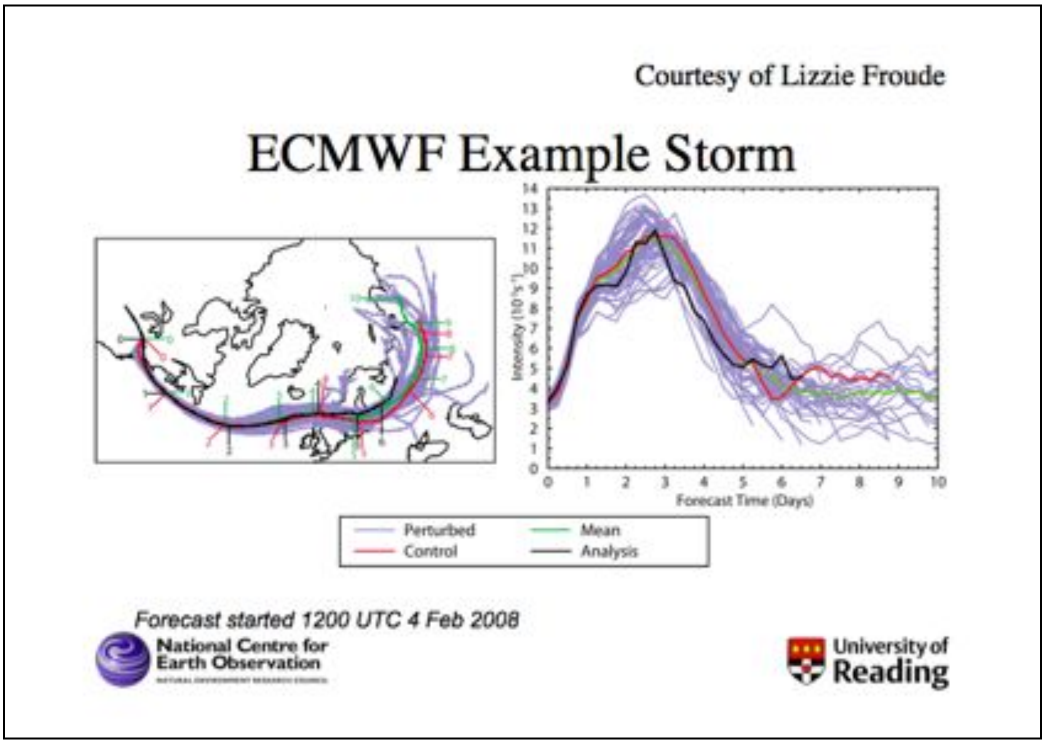
The process called data assimilation brings together observations and models. These have a lot of processes built in – conservation of energy, mass and momentum – which are true. And the observations have errors. The analysis combines the two statistically, to get a best state of the atmosphere, the ocean, and the land surface.

With this system, it is possible to work out the value of any particular piece of information, to identify errors, reduction errors that are being brought in by particular sorts of information, and also to run experiments by removing certain sorts of information and seeing the differences.



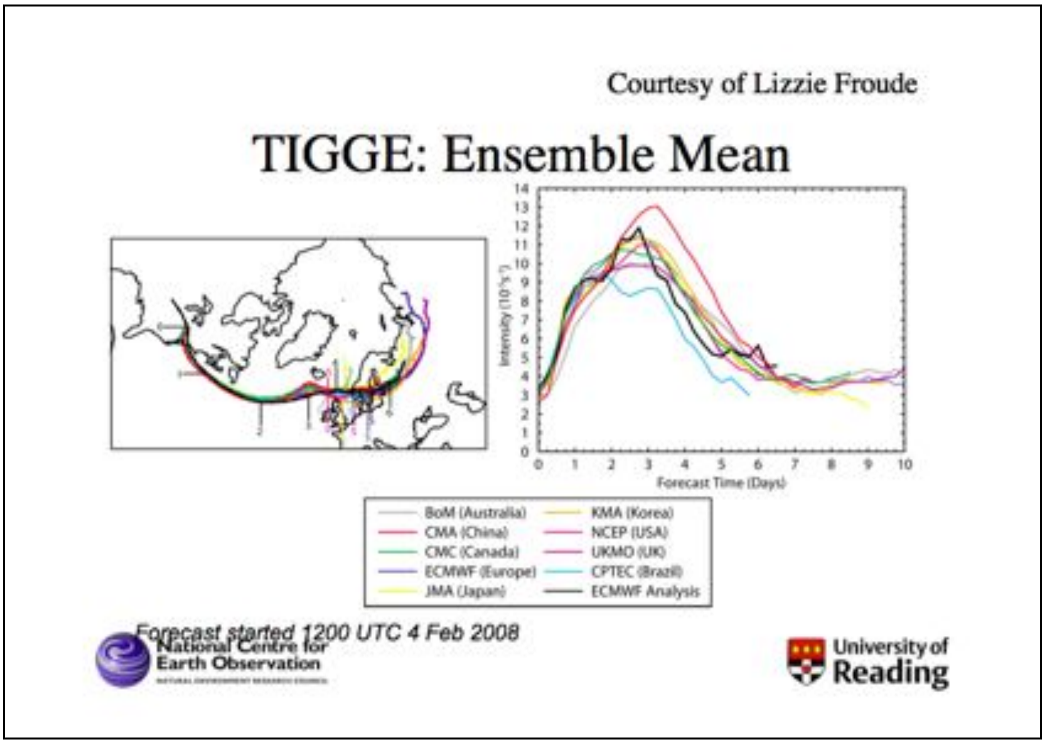
There are two problems. First, the re-analyses are sensitive to the exact models used. Certain processes are not well observed or modelled. For instance, if satellites always come across at noon and 6 pm, and it mainly rains at 4 pm, the rainfall estimate is biased.

The second problem is that where there are fewer observations in space and time, the bias becomes more important. The analyses may show different sensitivities to different observations and how they get assimilated.



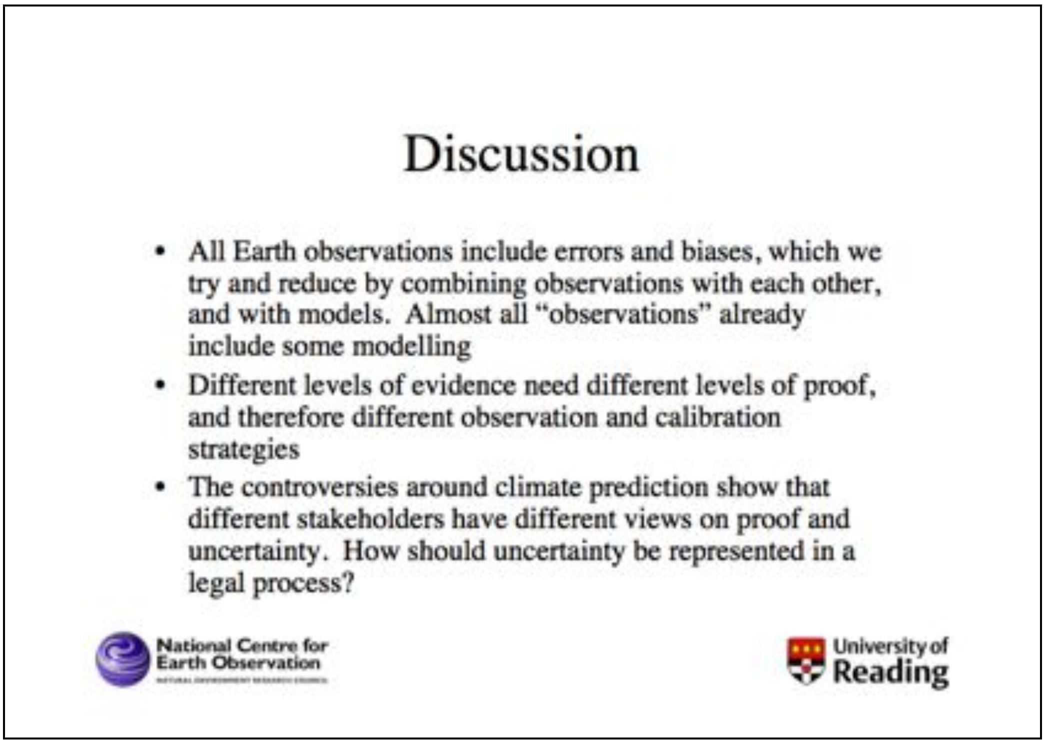
The first example of weather forecasting is from the European Weather Centre. The models are run many times. Errors are investigated by running the model with slightly different physics each time. A good estimate of errors can be produced in many different processes. This is routinely done in weather forecasting, but also in other areas including ocean modelling, ice modelling, land surface flood modelling. The purple is the spread of 50 different models run with slightly different conditions, and the errors increase in time.

On the right is a graph of intensity, on the left is the track over the number of days after the initial forecast. In this example the model reproduces the storm track quite well, but the model is running too slowly, and it is probably not sufficiently intense in many cases.



It is possible to observe many storms to get average statistics, and to look across different models. These models from many countries are compared with the actual observation (in black), and the models in the different colours. They all get the storm tracks pretty well, but the intensities rather wrong.

As a legal example, if an oil rig is destroyed in a large storm, it matters which model has been used in the analysis as to whether the warning is right, as well as what observations are used. System design and calibration, error reporting and ground design system, have significant impact on the adequacy of information collected to understand what happens.



All observation data, whether from space or not, include errors and biases. These must be reduced by combining different kinds of information together, and with models. Almost all so-called 'observations' implicitly include some modelling, to get from a voltage on the back of an instrument to a geophysical quantity that can be useful.

In the controversies in the climate community, as well as in more formal legal senses, different levels of evidence need different levels of proof, and there are different calibration strategies to adopt. The scientific community may need to examine issues of calibration in this regard.

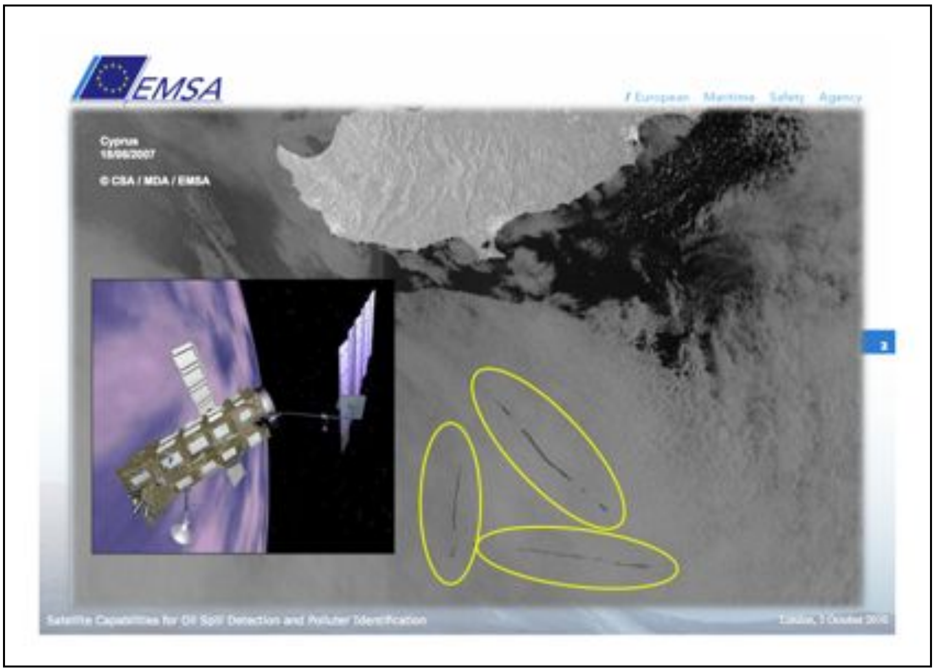
In climate prediction, different stakeholders have very different views on proof and on uncertainty, even on the same problem. How should uncertainty be represented for legal purposes?

3.4 SATELLITE CAPABILITIES FOR OIL SPILL DETECTION AND POLLUTER IDENTIFICATION[8]

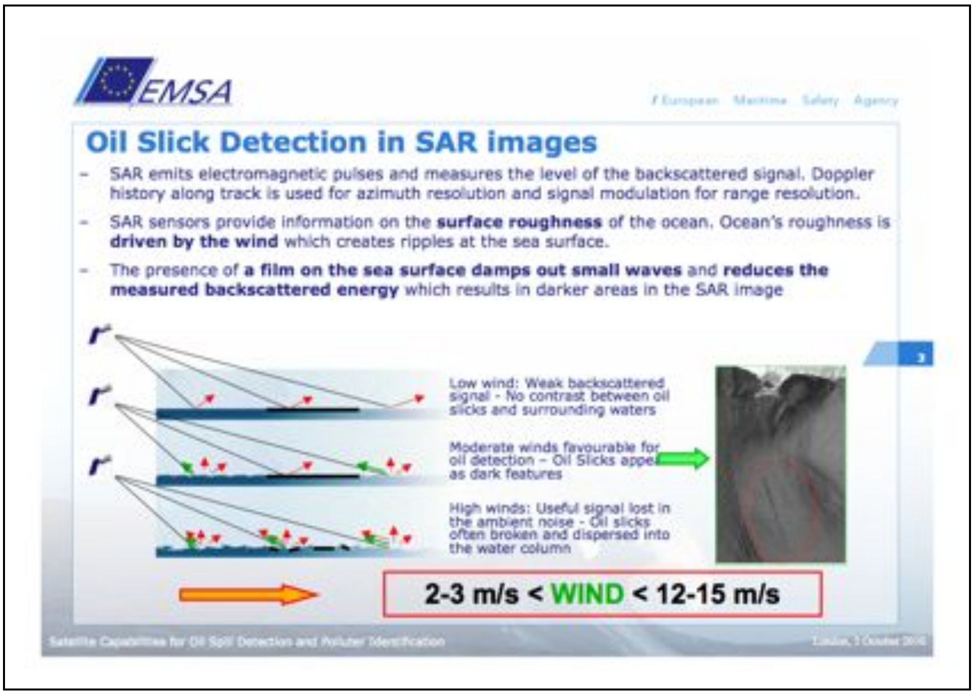
This presentation concerns operational surveys to detect oil spills since 2007, by the European Maritime Safety Agency.

[8] Presented by Marc Journel, EMSA.

3.4.1 Presentation

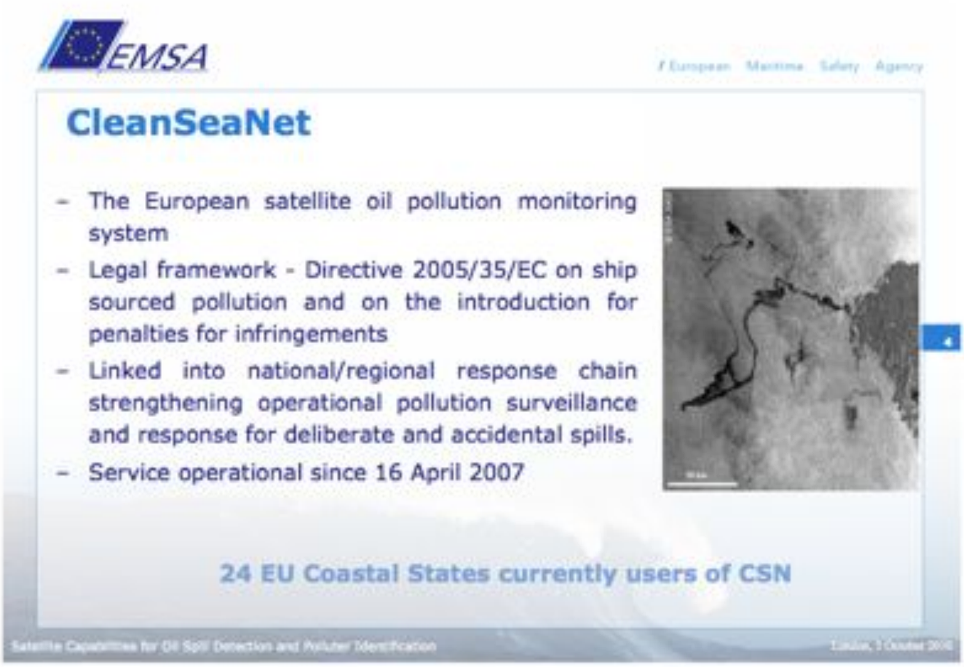


From the 1980s, the Member States wanted to monitor oil pollution at sea. They developed air and sea tools. Satellite observation dates from the mid-90s with the launch of ERS2 and RadarSat1 satellites, although few countries used SAR (Synthetic Aperture Radar) to detect oil spills.

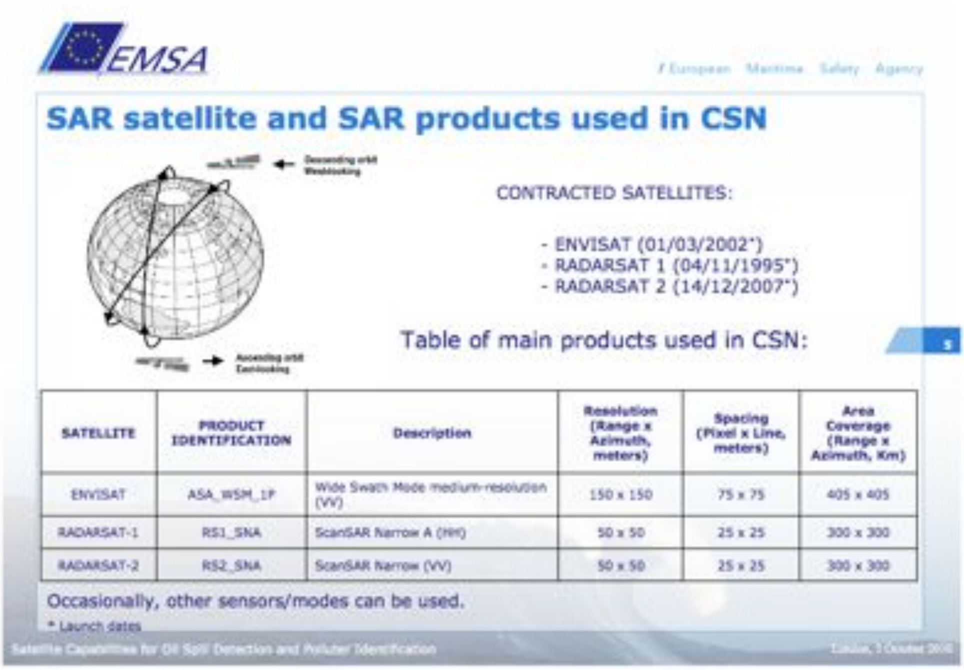


SAR emits a signal that is back-scattered to the emitter. The level of this back-scatter signal is measured. If there is no wind on the sea surface, there will be no waves and no signal coming back to the radar. If there is slight wind, there is a signal. An oil spill will smooth the sea surface, and the signal will not come back. Oil spills will appear as black features on SAR images.

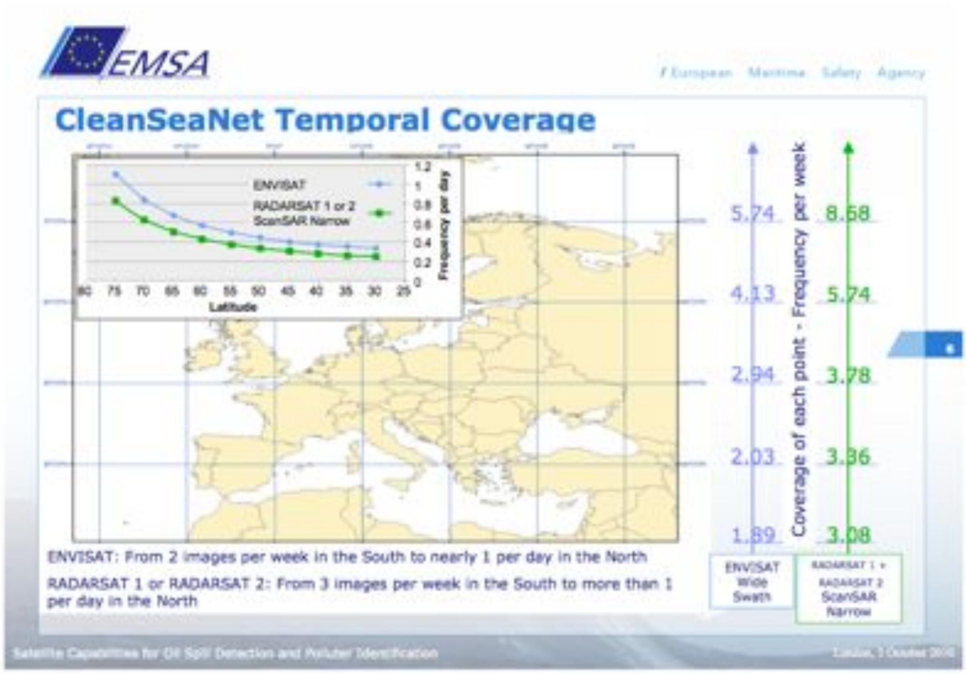
In high wind, the signal is lost, and the oil slick gets broken and weathered by the natural dispersal of the water column. As an estimate, oil slick detection is done using SAR images in good wind conditions, between 2 and 3 metres per second and up to 12-15 m/s.



Directive 2005/35/EC tasked the Agency to develop and operate oil pollution detection and monitoring service. As a monitoring tool it is linked to the surveillance systems of the Member States.



Currently there are 24 coastal States using the service which is based on ENVISAT, RADARSAT-1, RADARSAT-2 radar satellite images. High resolution is not required for oil spill detection. Therefore, satellite images present the advantage to monitor wide sea areas. Aircraft would probably be more cost effective in small areas.



Radar Satellite can monitor up to 400 kilometres wide strips looking for oil spills. An ENVISAT image covers up to 400 x 400 kilometres, and even longer, and RADARSAT covers something like 300 x 300 kilometres in one image. Satellite constraints limit temporal coverage. These polar orbiting satellites pass more often over the poles than the equator. There may be 5 images per week in the Mediterranean, with 3 satellites, but about 14 images per week in northern Norway.

Time is a crucial element to deal with illegal discharges. CleanSeaNet is a near real time service. There is less than 30 minutes between acquisition of data by the satellite, and delivery of the alert to the Member States that a possible spill may have been detected.

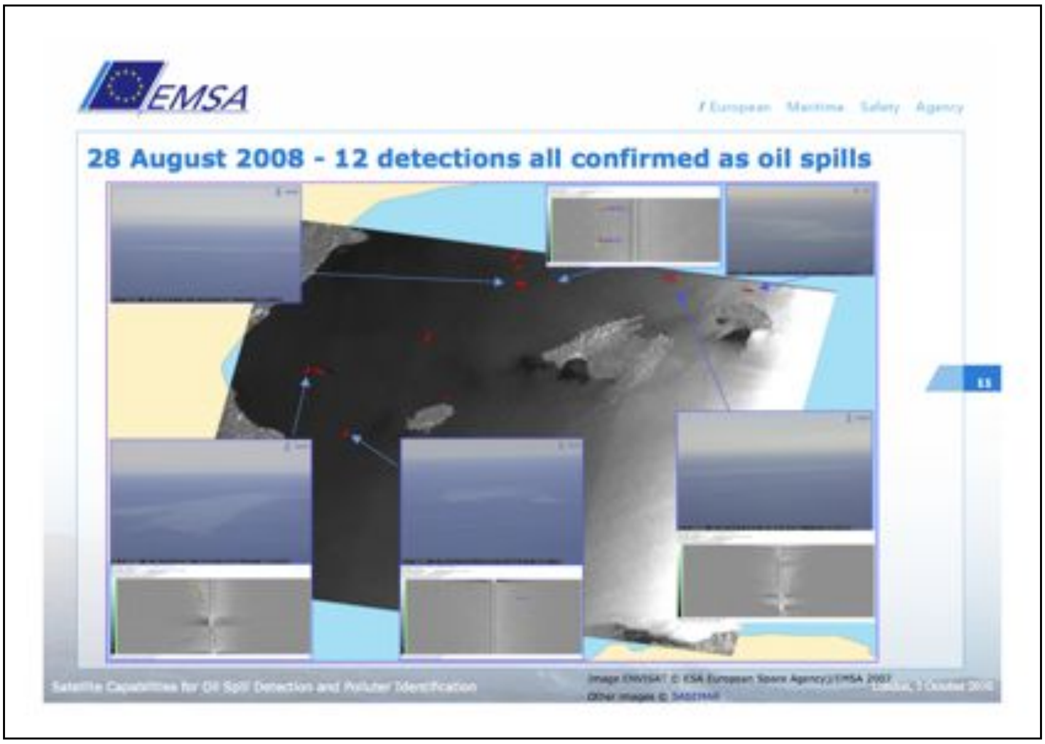
To meet near real time requirements, the satellite needs to be visible to the ground station while acquiring data and the oil spill analysis has to be done at the ground station. Then, the results are passed to EMSA and Member States. This requires a network of ground stations across Europe .

The current service, counts 3 service providers and 6 ground stations. CleanSeaNet 2nd generation will be progressively phased in as of December 2010. There will one additional service provider and one more ground station.

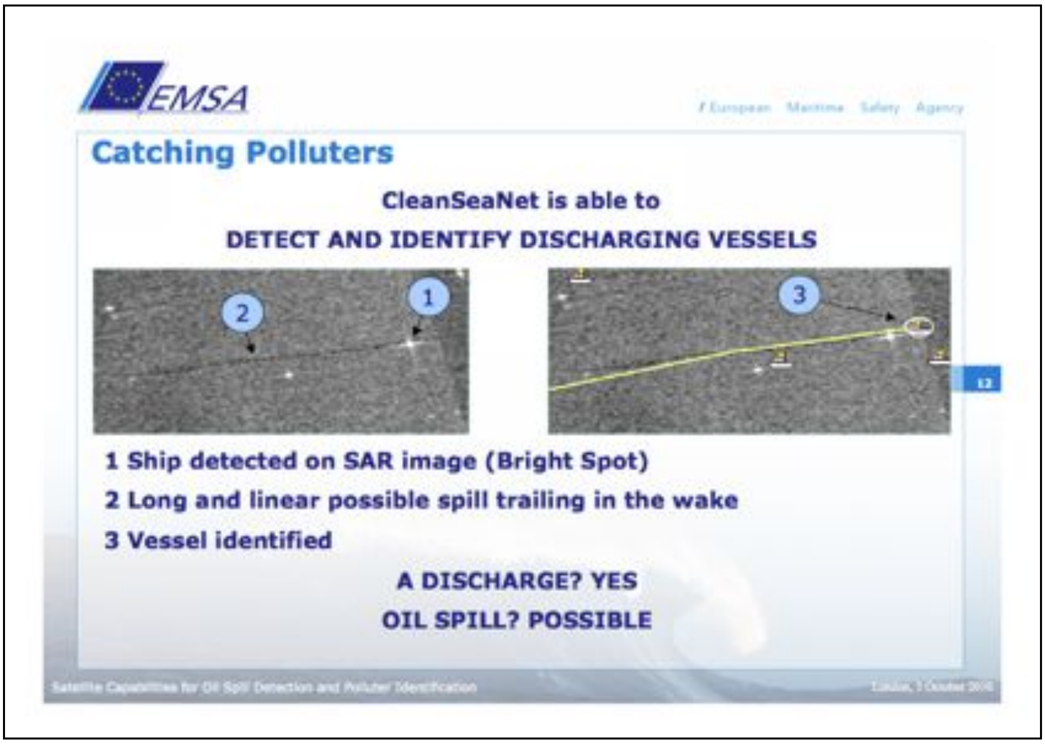
A SAR satellite does not detect oil spills – it detects possible oil spills. Any material that will produce the same effect as oil on the sea surface will have the same dark appearance. With experience it is possible to improve reliability and to be able to discriminate between oil spill and what we call 'look-alikes' that may be man-made, like fish or vegetable oil, chemical or natural phenomena.

Nevertheless, the system is very efficient at detecting oil spills. Oil spills are likely to be detected if there is satellite acquisition of the incident. Between the start of the service in April 2007, and December 2009, more than 7,000 spills were detected. Of almost 2,000 that were checked onsite, 542 were confirmed as mineral oil, a 27% rate of confirmation.

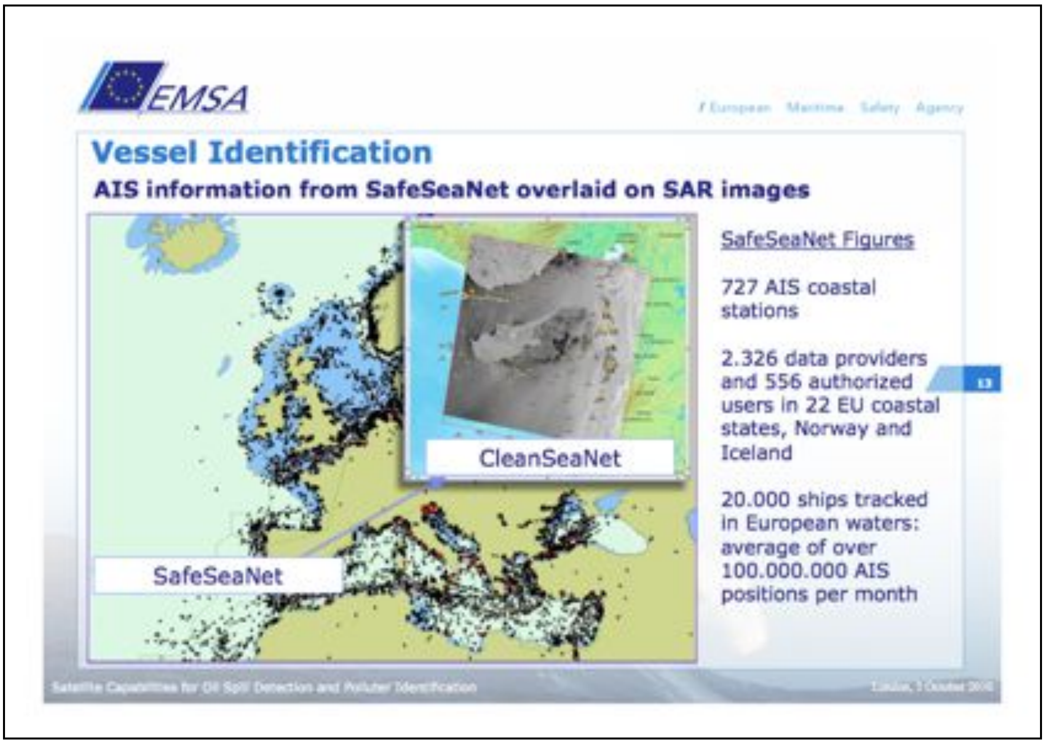
If the on-site verification is undertaken too late, there is a great chance that the spill will have weathered out and disappeared. By limiting the verification to aircraft and to a period of 3 hours after acquisition, the rate of confirmation increases a lot. In 2009 the confirmation rate was over 50% with an aircraft check less than 3 hours after satellite overpass. In the two past months, that rate was over 60%.



With this image 12 spills were detected and 12 were confirmed off Spain. The slide shows the SAR satellite image and for each spill the SLAR (Side Looking Airborne Radar) and optical images acquired on site by the aircraft.

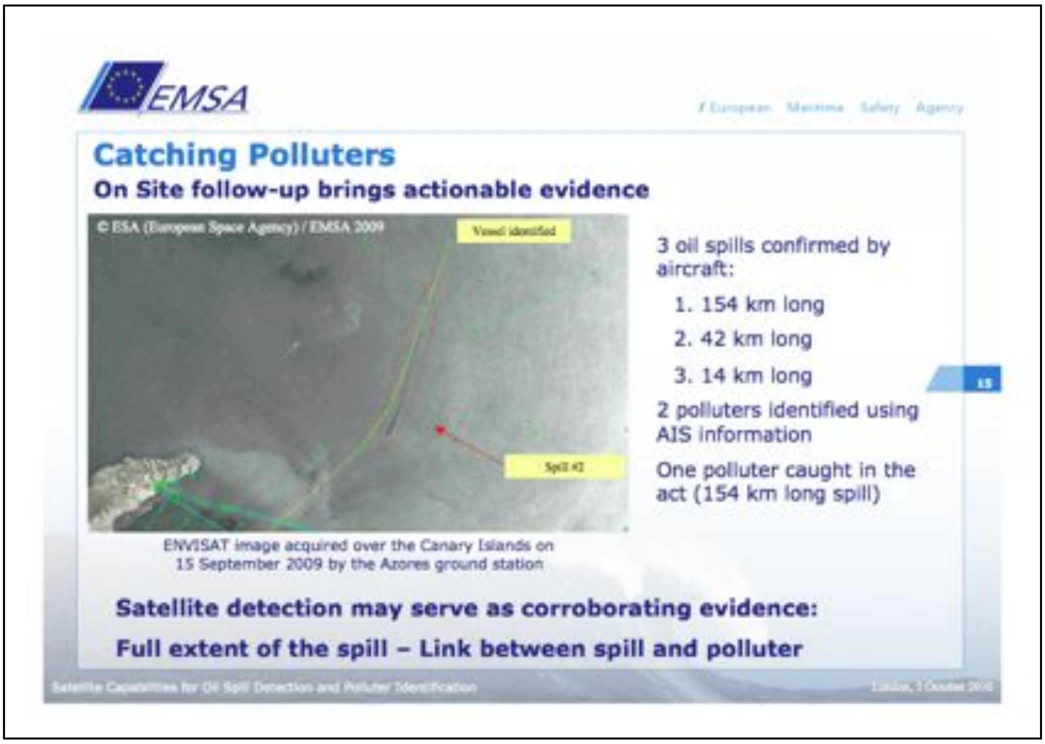


SAR is used to detect possible spills and discharging vessels. A ship appears as a bright spot on radar. A linear trail in the wake of the vessel shows a high probability a discharge is going on. Requires additional information to determine the product spilt (oil or other substance).



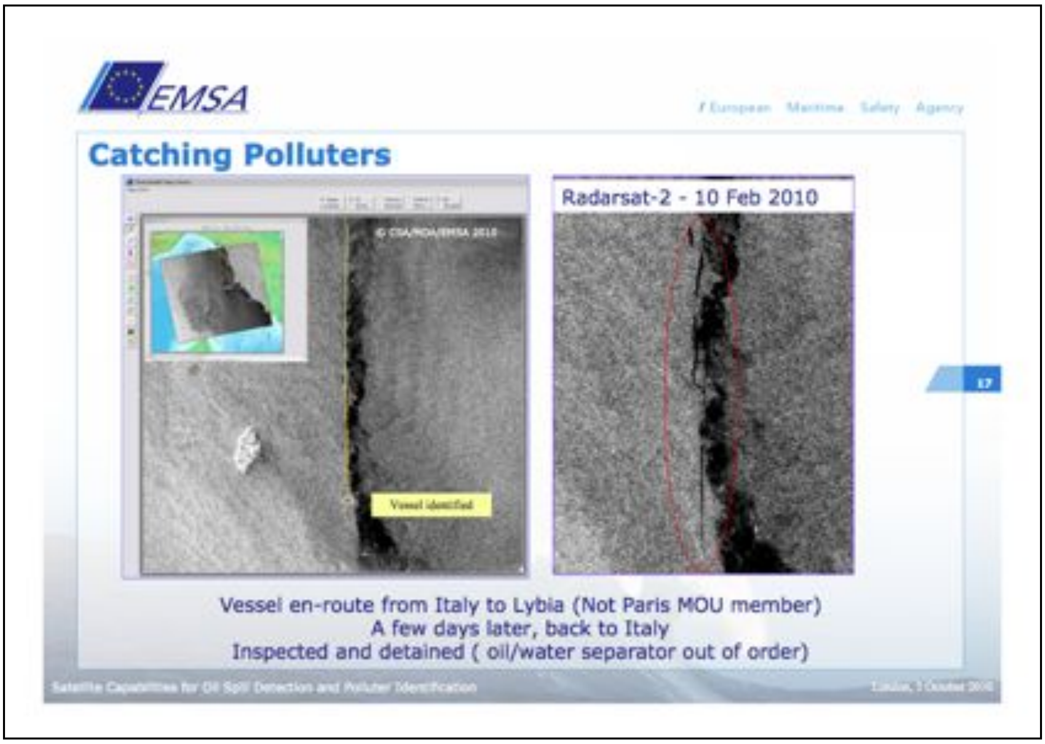
To identify the vessel, the satellite image is overlaid with vessel traffic monitoring information from SafeSeaNet. SafeSeaNet is a European service built on the traffic monitoring systems of the Member States, with more than 700 coastal stations. Onboard AIS information passes on the position of the vessel, based on GPS.

It is possible to detect a discharge, but not necessarily to say if it is a violation of the MARPOL marine pollution convention. For this, complementary evidence collected on-site or in port is required.



Following satellite detection, an aircraft was dispatched to the position of the satellite detection and the polluter was caught in the act.

In some Member States CleanSeaNet detection constitutes suspicion of illegal discharge. That may trigger an inspection in port on which proceedings are based.



Here the satellite information was used to trigger the inspection in port. Evidence collected in port, shows that the vessel has illegally discharged at some time, but it would be very difficult to prove that it was this specific discharge. Satellite data can also be used as corroborating evidence to demonstrate the full extent of the spill and the link between the spill and the polluter.

3.5 DISCUSSION

Comment: While there is great value in climate models, they are predictive. But, the legal community is many steps away from being able to use predictive model data in the courtroom. The predictive method treats observations as 'truth', against which the models are measured. The legal community has yet to take a standardised observation, and consider it 'truth' that can be considered as evidence in court.

Response: Even the so-called 'observations' have a model built into them, so one is really comparing model with model, which is not true in classical scientific terms. The scientific method involves reproduction of a result many times in the laboratory. There is only one Earth, and one realisation. The scientific method is used as closely as possible, but it is hard. On an oil slick, a model can be run many times to work out what the errors are. Whether they have been used or not is a different case.

Comment: When using something off a computer as the 'facts' of what was contained in the presentation, somebody actually put that in, the actual software is irrelevant, because those words are 'fact.' This is where the hearsay point is relevant. Where the software is controlling how the information is assessed and produced, then the original software and its affect on the information has to be considered. Otherwise it cannot be determined whether or not the assessment coming out of the software is correct. That is the crucial legal issue.

Response: That is a good illustration of how one designs the ground system. The requirements of this community will drive the requirements of the system.

***Comment*:** Some data, for example from GeoEye, is optical and its interpretation depends on the human eye. Others, like SAR data and subsidence of the land, are not. Similar Japanese radar data produce different results, depending on how they are analysed. There is no human involved in that, with the exception of the point about the software involving a human element. But it is produced from a data production chain. How does the law deal with different interpretations of the same data, either done by eye or done by computers?

***Response*:** Before the legal community can be expected to answer that question, technicians have to tell them what uncertainties are associated with the information that's being provided. One of the things expected out of this discussion is clarity in how the information is qualified.

***Comment*:** A typical problem, for example in oil spills, is not to prove that the vessel was there. It is to correlate the vessel with the SAR image. This evidence is not accepted right now in Italy, it is not understood. Legally a human being is needed to inspect the ship and make a validation in situ.

***Comment*:** In the international climate change negotiations, there is discussion of using remote sensing data to measure changes in land use and forestry, in particular deforestation. Is there any methodology in place to look into the uncertainties that are linked to the use of remote sensing data?

***Response*:** Yes. There is starting to be methods developed to model the whole system out and understand what all the different errors are, or how you combine the observations. There is a need to understand what the legal community needs in terms of what the errors are, and what information has to be included.

4. CASES USING EO INFORMATION – SPACE AND AERIAL INFORMATION

4.1 INTRODUCTION

This session deals with cases using earth observation information, focusing both on space and aerial information. In several areas satellite-derived EO information is already used. Applications examined were those of land subsidence, agricultural subsidy claims and audits of international aid provided by the Netherlands.

The technique known as Permanent Scatterer InSAR, developed by an Italian team, provides the means to measure land movement. It has been used in one decided case in Italy, relating to the subsidence damage caused to a historical monument in Rovigo. This was a penal proceeding, requiring a reasonably high standard of proof.

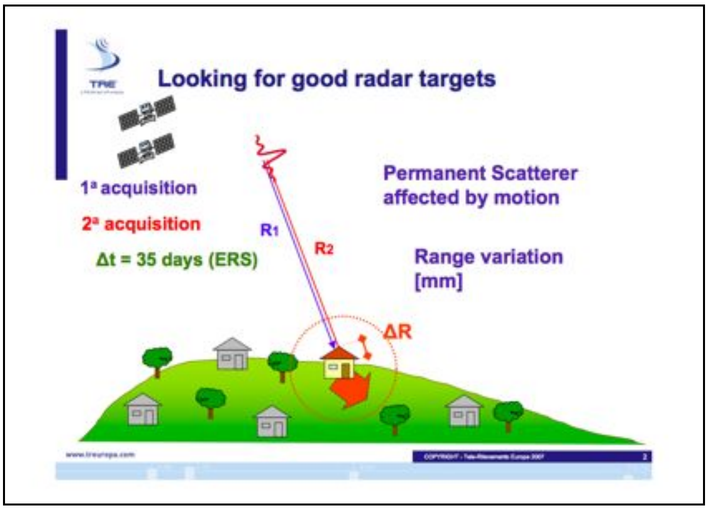
Satellite-derived EO is used to verify agricultural subsidy claims under the European Common Agricultural Policy from time to time. There are many grounds on which subsidy can be claimed. This provides a reasonably varied range of scenarios against which to assess evidential issues.

Another area of verification is presented by assessment of the flow and effectiveness of disaster aid from government funds. Satellite-derived information has been used for this purpose by the Netherlands. This presentation highlighted the importance of reliability and accuracy in audit applications.

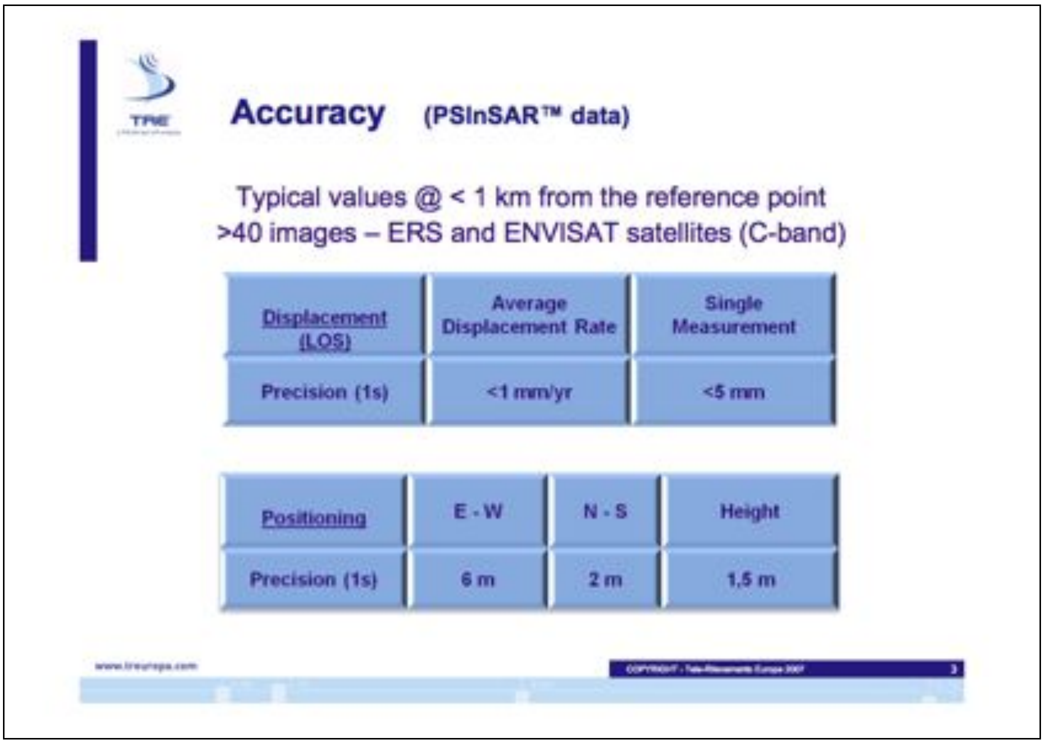
4.2 LAND SUBSIDENCE CASES, INCLUDING ROVIGO[9]

4.2.1 Presentation

Radar allows measurement of the distance between the radar sensor and the radar target. It is possible to compare acquisitions at two different times for the detection of possible surface deformation, in particular the displacement of individual buildings or structures.

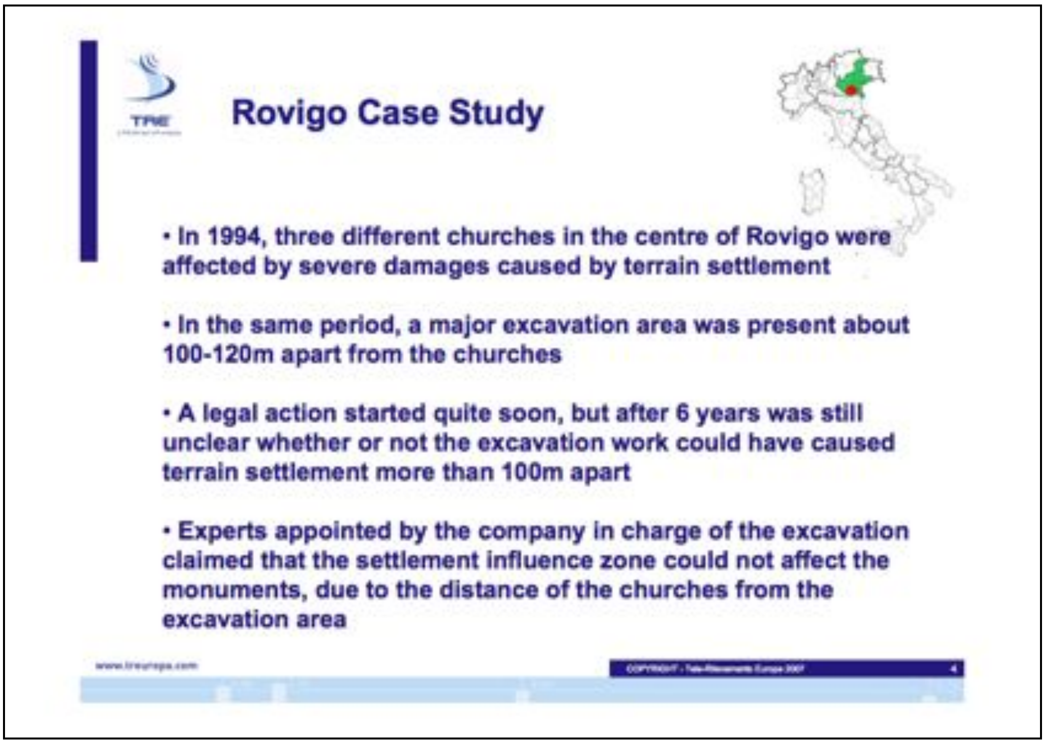


The radar data can be subjected to analysis by different techniques. PSInSAR (Permanent Scatterer Interferometric Synthetic Aperture Radar) is a technique developed by the Polytechnic University of Milan, particularly useful in measuring small land surface movement over time.



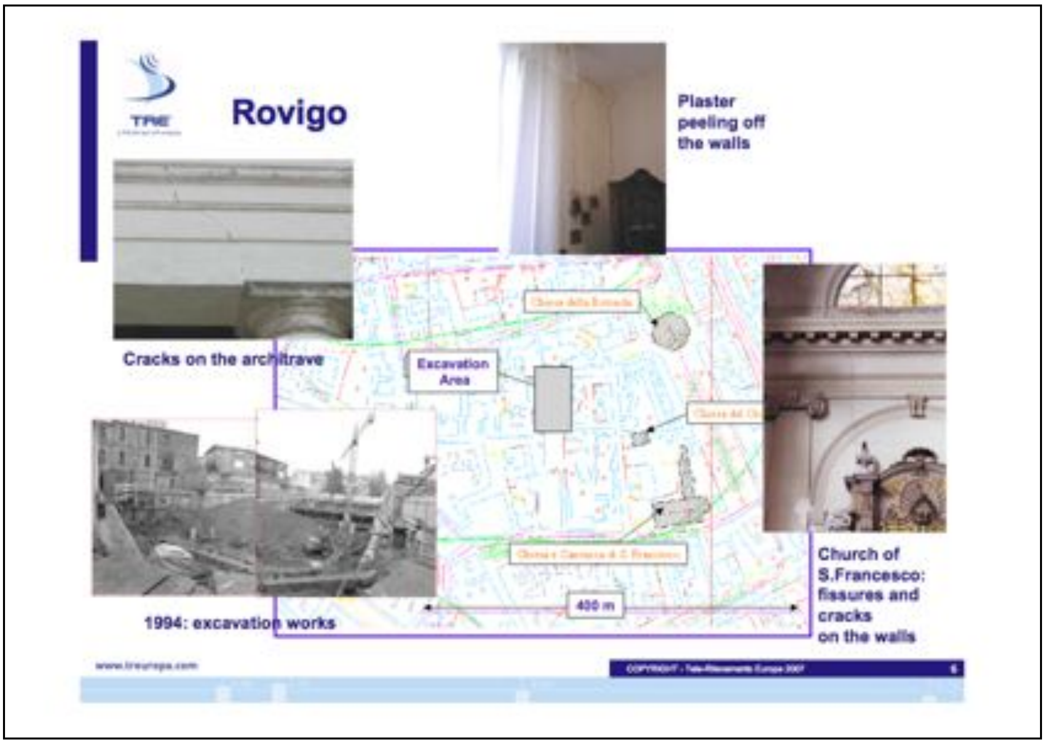
9 Presented by Alessandro Ferretti, TRE. The Land Subsidence Case Study is based largely on this technology.

The displacement rate can be as precise as 1mm per year. On a single measurement better than 5 mm is possible. These are differential measurements common to other geodetic networks.

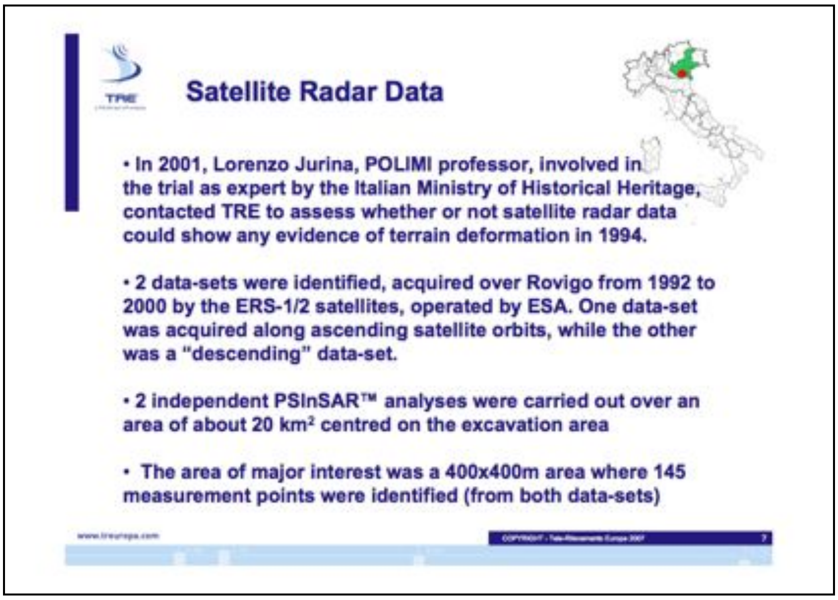


In 1994, three churches in the centre of Rovigo, all national monuments, were damaged by subsidence, at the same time that there was a major excavation about 100 metres away. In the legal action that followed, the excavating companies claimed that the damage pre-dated the excavation. Experts were appointed, and it was not at all easy to find a solution.

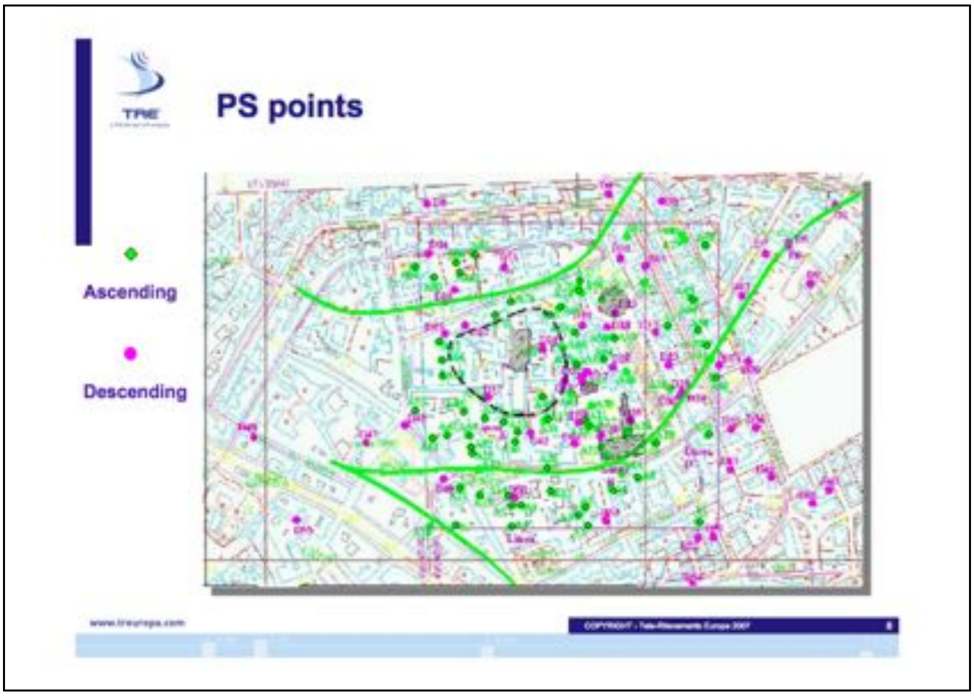
The damage was serious, and relates both to the size and the technique used for excavation.



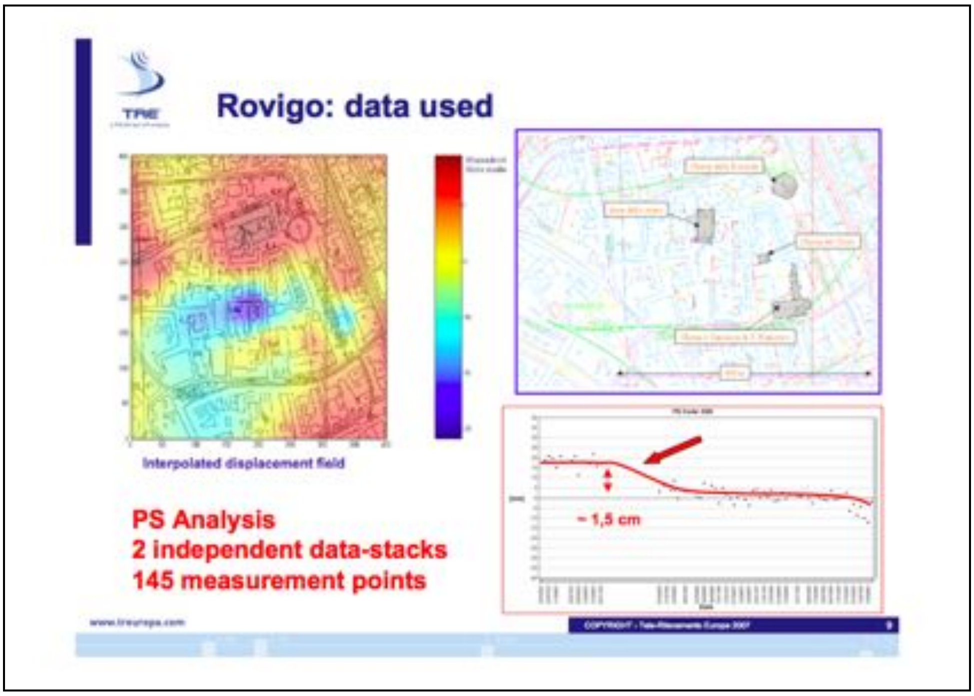
Fissures and cracks appeared in the walls of the Church of San Francesco. Plaster was peeling from the walls of the Chiesa del Christo. Cracks appeared on the architrave of the Chiesa della Rotonda. The map shows the excavation area at centre of the area where many buildings were affected. The difficulty was that there was some distance between the excavation area and the buildings.



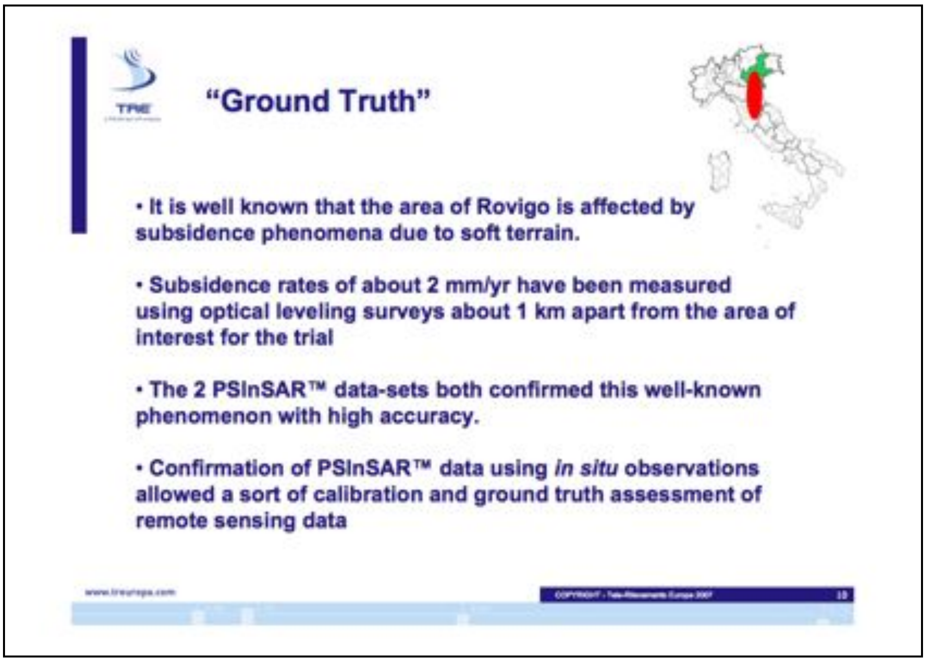
Many expert geophysicists, geologists, and structural engineers considered it unlikely that damage could have resulted 100 or 150 metres from an excavation. The city and the Ministry of Historical Heritage engaged Lorenzo Jurina, of the Polytechnic, who asked TRE to process the two available ESA data sets, to determine the date of subsidence. It was also possible to carry out PSInSAR analysis to identify more than 140 measurement points distributed over the area of interest.



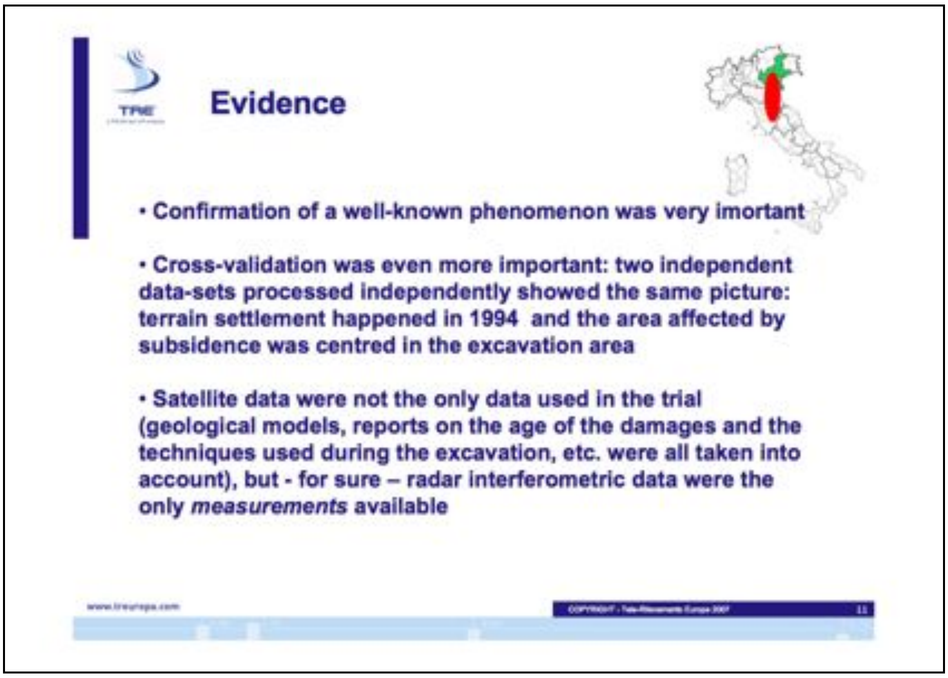
This is the area of interest containing the three churches and the excavation area. It illustrates the estimated maximum area that could be affected by the excavation works, based on geological data available. The coloured dots correspond to the permanent or persistent scatterer from targets on roofs of buildings, or balconies, which can be detected by the radar systems onboard the ERS satellite.



More than 70 measurement points were measured, 30 of one data set, and 40 of an independent data set, showing there was indeed a drop of more than 1.5 centimetres in 1994. The area affected by the deformation was much larger than expected.

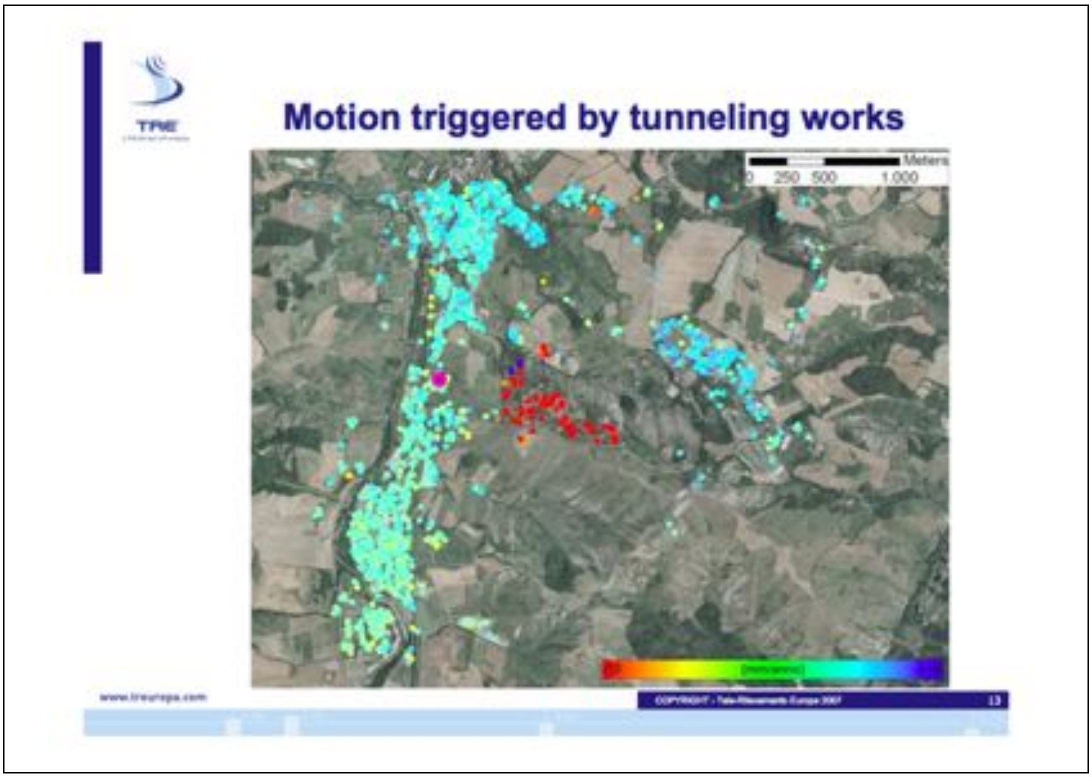


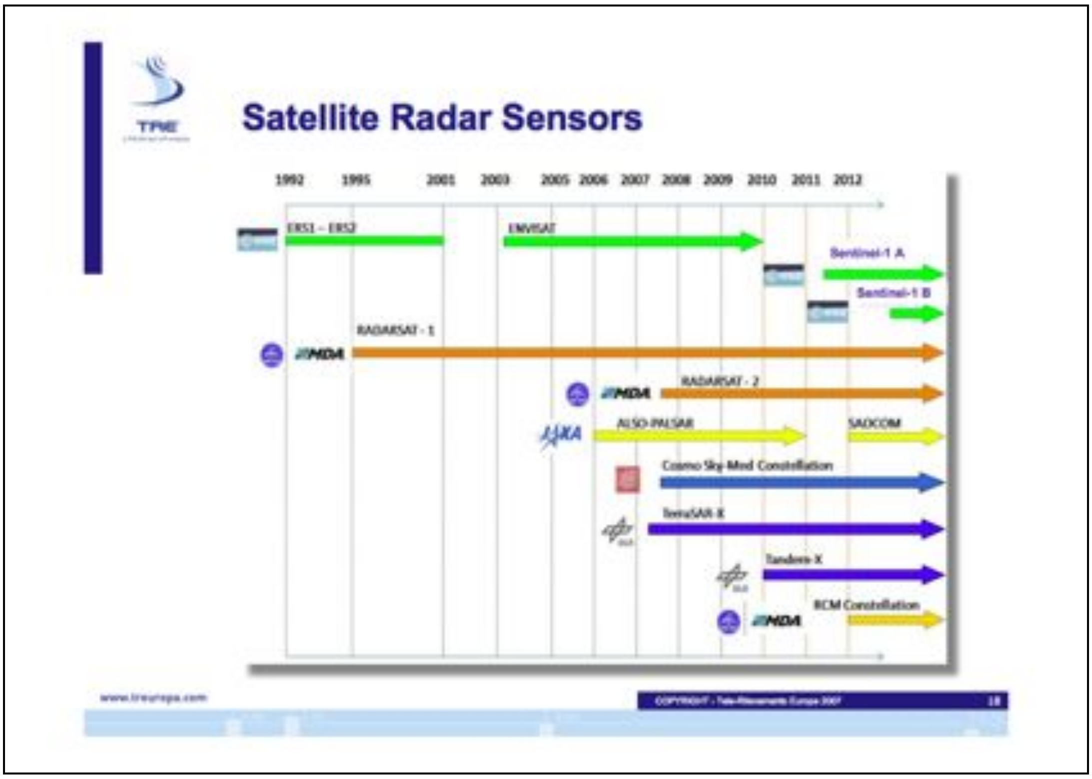
This is a new technique. It was important to calibrate the data with ground truth, as indeed was requested by the experts from the other side. It was possible to compare PSInSAR data with data from optical levelling surveys carried out over Rovigo, and in an area close to the excavation area. Exactly the same surface displacement rates were found in both independent SAR data sets, in agreement with the optical levelling surveys. The two PSInSAR data sets confirmed the phenomenon with high accuracy, better than 1 millimetre per year. The confirmation of PSInSAR data and situ information allowed a sort of calibration and ground-truthing.



For the first time it was possible to confirm the settlement, after years of experts saying it was not possible based on geological models. This kind of data will become more and more common in litigation.

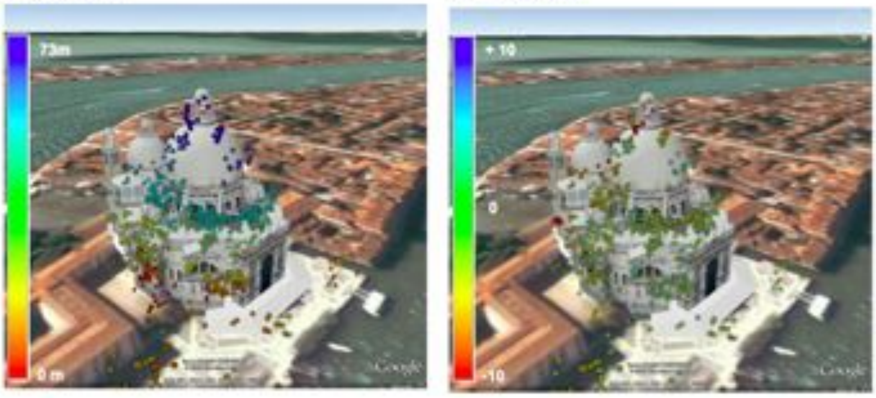
The following slides from the presentation were not shown at the Workshop, but may be of interest.





Venice – Santa Maria della Salute

PS HEIGHT [m] PS VEL [mm/year]



Example of PSInSAR™ analysis using HR TerraSAR-X data

Conclusions

- **SAR data** can be extremely useful to assess whether an area or an individual building was affected by terrain compaction or subsidence
- **Advantages**: high precision; quantitative and reliable data; fast data processing; regular updates; cost-effective.
- **Historical archives** of radar data are available since 1992
- **Limitations**: not all radar targets are good PS. Artificial reflectors should be installed to allow the monitoring of individual structures where no PS is present.
- In the **future** more and more satellite data will be available and SAR measurements will become a standard monitoring tool.

4.3 AGRICULTURAL SUBSIDY CLAIMS, VERIFICATION, FRAUD AND EXPERT EVIDENCE

4.3.1 Background: Experience in European CAP[10]

4.3.1.1 Abstract

Since 1992 when remote sensing controls were introduced in EU Common Agricultural Policy legislation (CAP), satellite images have proven each year to be an increasingly efficient tool for checking that agricultural subsidies are correctly paid. In 2009, 690,000 farm checks were performed throughout the EU (of the approximately 8m farms in the scheme); 61% were done using remotely sensed imagery, and around 70% is expected for 2010. Very High Resolution satellites or aerial orthophotos permit the check of the size fields, their cover type and in some case cover status, thus reducing the need of physical checks on farms and thereby contributing towards a more effective and efficient management of the CAP.

4.3.1.2 Introduction

EU Member States must ensure that direct payments to farmers – worth over €44B in 2010 – are implemented correctly, thereby preventing irregularities (over-claim, or double claims for the same fields), and potentially recover amounts that are unduly paid. Member States must also ensure that farmers meet certain standards – cross compliance with EU Directives – concerning public, animal and plant health, the environment and animal welfare, and keep their land in *good agricultural and environmental condition* (GAEC).

Member States must have a system to ensure a unique identification of farm businesses, as well as all holding's fields (the so-called Land Parcel Identification System – LPIS) and identify animals. Each year, CAP farms make an aid application using these systems. The check of the criteria to receive subsidies works on two levels: 100% administrative cross-checks on the information provided in these applications, and through checks carried out "on-the-spot" of at least 5% of total number of farmers claiming direct subsidies, in each Member State. Currently, more than 60% of on-the-spot checks are carried out with the help of satellite imagery.

The European Commission, through the Joint Research Centre (JRC), currently provides EU Member States with satellite images in 24 EU countries (i.e. all except Austria, Finland and Luxembourg) for a purchasing budget of around €6.5M/yr. In 2010, 255 zones – each of around 650 km^2 – were covered with High Resolution images (ground sampling distance of 5 to 10m), and 316 zones with Very High Resolution (VHR) images (ground sampling distance of < 1m), representing a European-wide VHR imagery area of nearly 200,000 km^2.

The JRC also provides a range of technical support services to European Commission's Directorate General for Agriculture and Rural Development and to Member State Administrations, by developing common specifications, standard measurement and data management tools. It validates methods to reinforce the consistency of land parcel identification and measurement across the Union and in Candidate Countries, and develops methodologies to accurately determine land cover types and status, in particular using remotely sensed data.

4.3.1.3 Methodology

The conditions under which aid is granted are verified on a sample of applications using current year remote sensing imagery. In practice this means that the claimed area, and to a

[10] This section is based on material provided by Dr Simon Kay and Csaba Wirnhardt, JRC.

certain extent the land cover or use, of each of the claimed parcels from the *Control with Remote Sensing* (CwRS) sample is checked. Some aspects of cross compliance – in particular GAEC – may also be checked using remote sensing imagery. Each agricultural parcel is categorized separately.

The photo-interpretation of agricultural parcels is normally carried out using at least one VHR image (aerial orthophoto or satellite ortho-image with a pixel size <1m) of the current year. The area of agricultural parcels, their land use or cover wherever necessary, and cross compliance issues are checked. In addition to the VHR image, multi-temporal high resolution (HR) images may be used.

In the case where the diagnosis may not be completed by image interpretation procedures alone, field visits are carried out to collect supplementary information on land use, area declared and/or other issues not able to be determined via the satellite image. These field visits may be carried out on all claimed parcels, for instance when only one VHR image is used, or limited to doubtful parcels, sensitive crop groups (such as crop groups receiving high payments) or specific commitments, such as payments linked to multi-annual contracts by farms.

4.3.1.4 CwRS Control Zones and Satellite Images Used

Remote sensing controls of area-based agricultural subsidies are carried out using a geographically clustered sample of farmers' applications. These clustered samples are called "control zones". The zones to be controlled are selected either randomly, or on the basis of risk analysis taking account of appropriate risk factors determined by the Member States.

For each zone to be covered by a VHR satellite image provided by the Commission, an "acquisition window" is defined by the Member State (usually a 6-8 week period). Over this window, acquisition attempts are allocated by the JRC to particular VHR multi-spectral sensors, which during this year's campaign have been Ikonos, Quickbird, GeoEye-1 and Worldview 2. In a few cases, VHR Panchromatic only sensors with a ground sampling distance lower than 1m (Worldview 1 and Eros B) have been used, in conjunction with lower resolution multi-spectral imagery on another platform.

Area (km^2) acquired under the CwRS programme per VHR sensor

VHR satellite sensor	**2008**	**2009**	**2010**
IKONOS	137.000	117.000	72.400
Quickbird	30.000	12.000	18.700
GeoEye-1	n/a	45.000	81.900
WorldView2/ WorldView1	n/a	n/a	25.600 / 400
Total	167.000	174.000	199.000

4.3.2 Presentation[11]

Farmers in the European Union receive subsidies under the Common Agricultural Policy, CAP, by filing claim under various farming provisions. To avoid excessive or unjustified claims, sample claims and those that appear wrong are verified. Earth observation plays an important role in this process.

[11] Presented by Simon Kay, JRC.

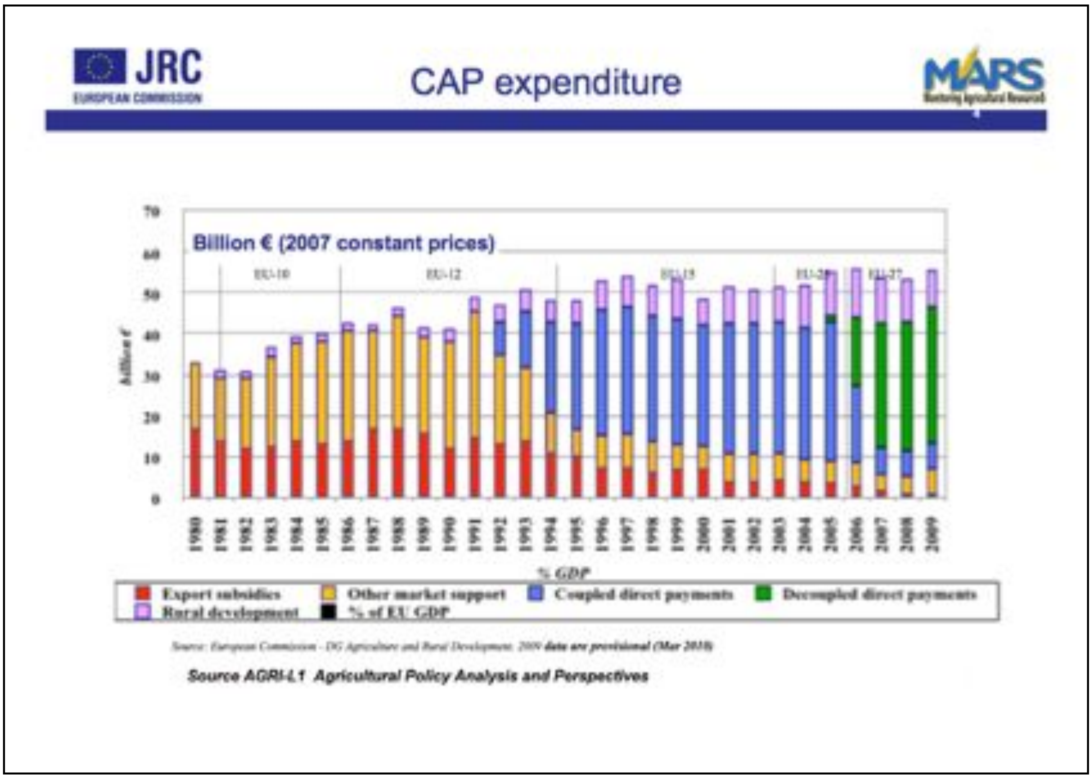
JRC
EUROPEAN COMMISSION

MARS

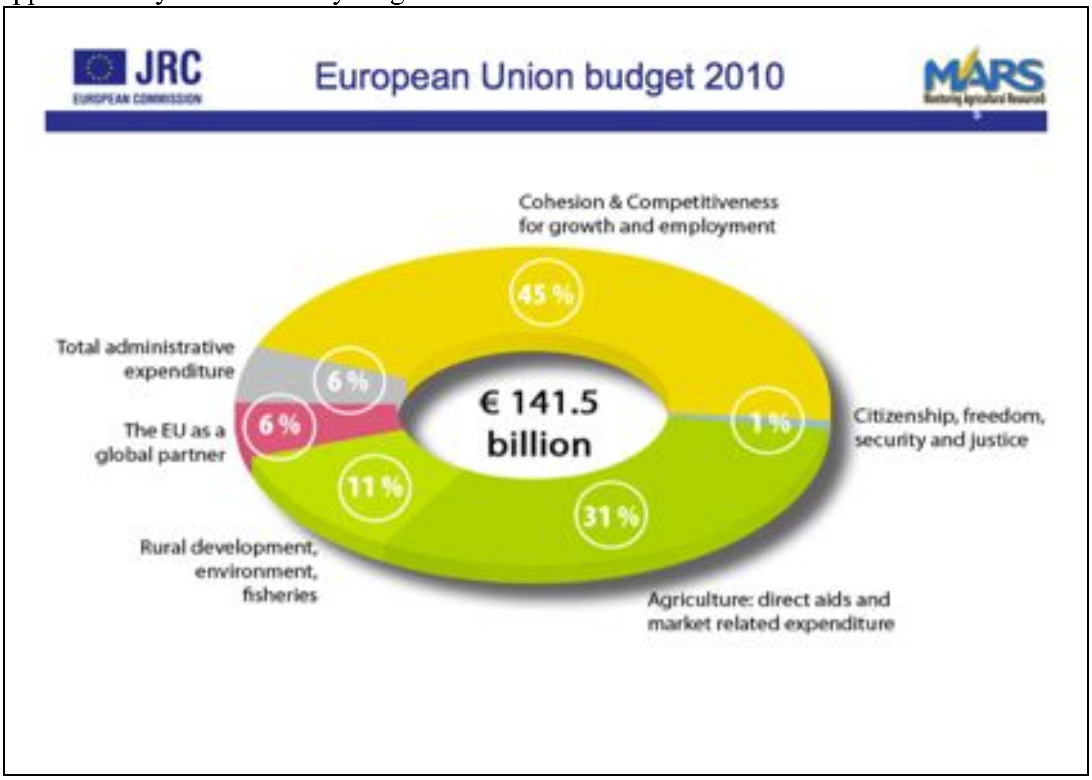
Joint Research Centre of the EC?

- JRC Mission:
  - **"The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies.**
  - As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union.
  - Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national."

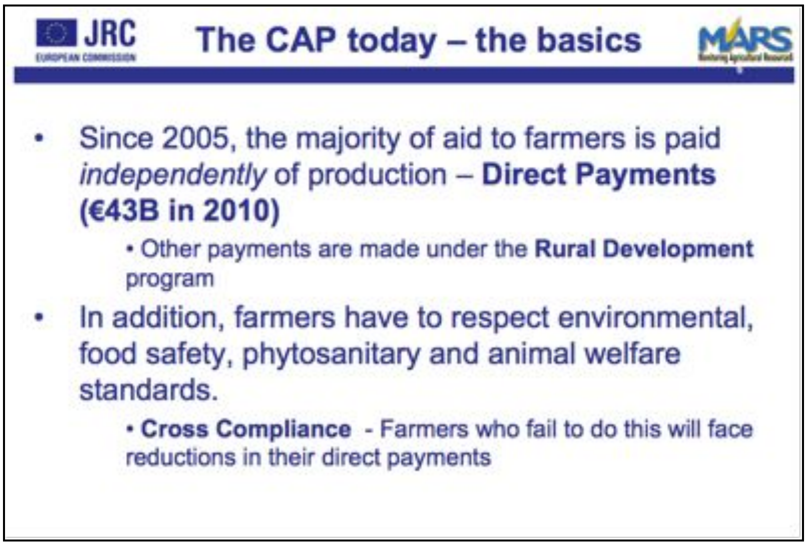
JRC is part of the European Commission, and provides technical support for Commission policy.



Approximately €56 billion a year goes to farmers.



This year direct payments are about €43 billion to manage land, and about €12-15 billion for various improvements on that land.



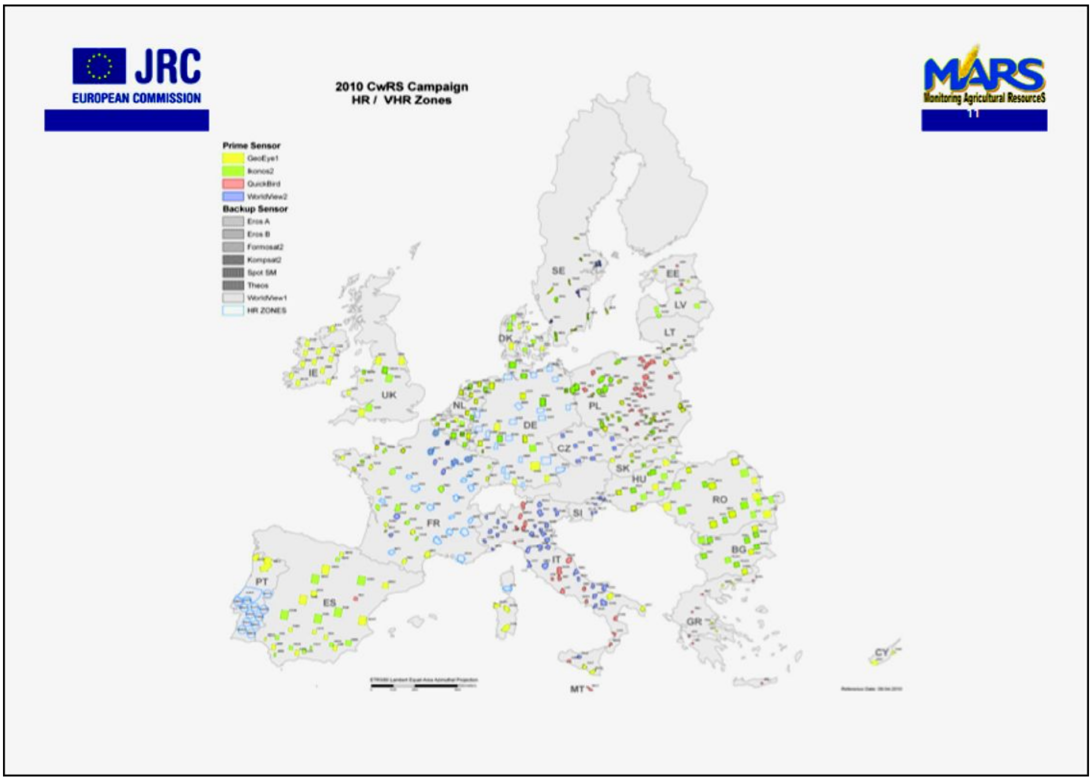
Farmers are not being paid for crops, but are effectively paid to take care of the land. They are required to do cross compliance, which relates to environmental and other Directives in European legislation that have been implemented in national law.

Behind this is an EO information framework, the Land Parcel Identification System.

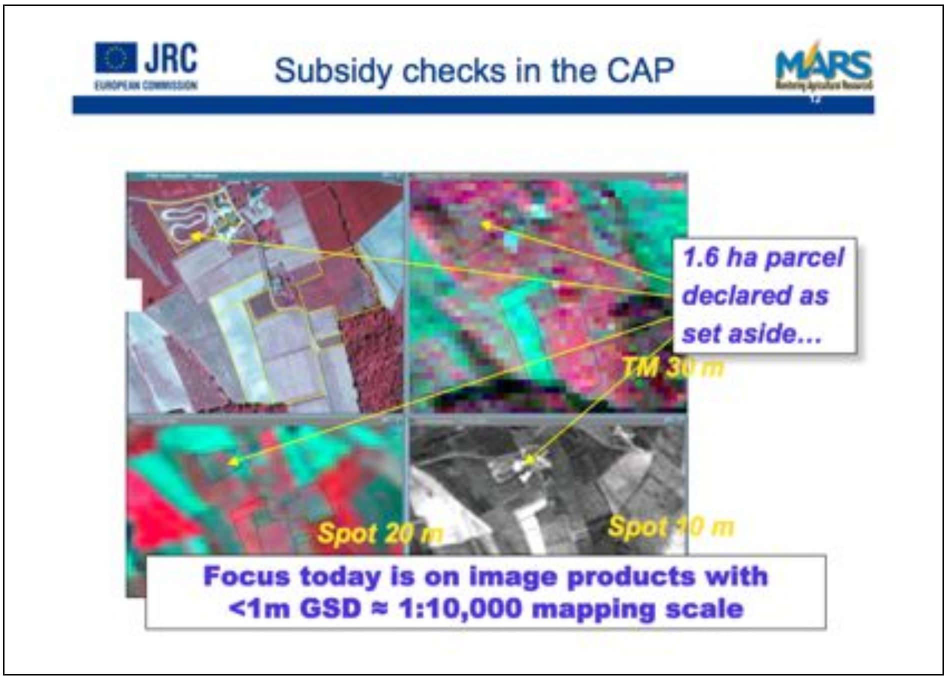
This example from Spain is based on aerial photographs taken about every 5 years (but several member states use satellite imagery). Each field managed by a farmer is actually located, like a cadastral system focused on the land that the farmer uses. There are 138 million European fields mapped. Farmers have to input into a database used to process their claims. The slide shows how precise these photographs can be, with detail including olive trees, on the left, which were the subject of subsidies at the time.

The basis for the system is legislation that has been in place for about 18 years. The latest version is Council Regulation 1122/2009, which includes the cross-compliance requirements. The slide details areas of monitoring, such as soil erosion, and landscape features like hedgerows.

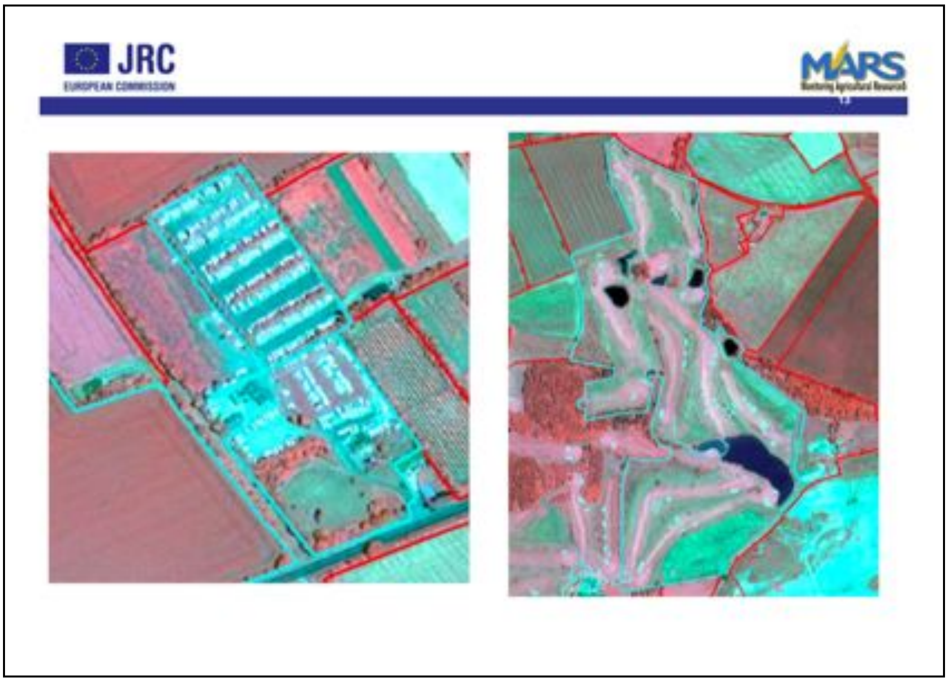
This example of an auditor in a field illustrates how expensive it would be to audit 138 million fields by sending a person to collect direct evidence. This is of course administrative management rather than specifically legal, but the collection of the evidence is fundamental.



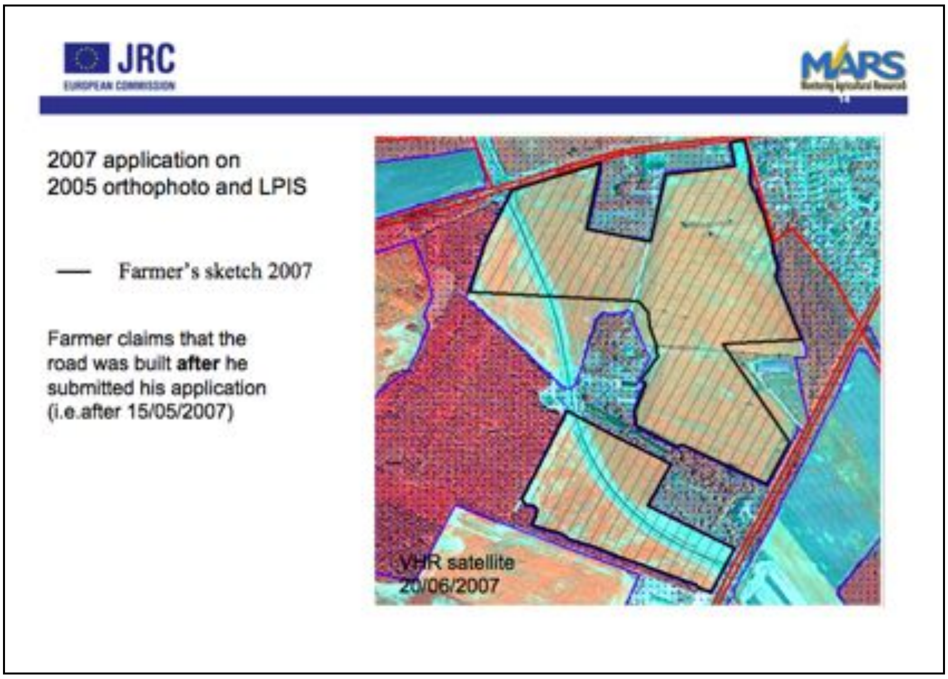
About 5-7% of farms are checked yearly, in the order of 5 to 10 million fields. This year's satellite acquisition campaign is shown, covering more than 200,000 square kilometres of earth observation imagery. The approach has evolved into this pattern, showing imagery with detail of about one half to one square metre.



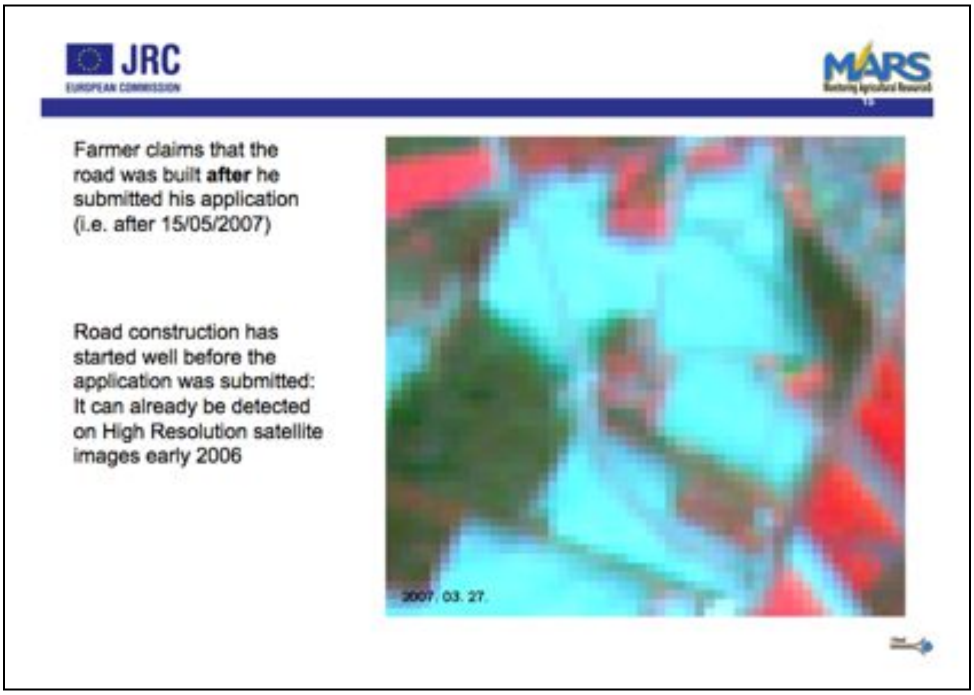
Imagery is complemented by multiple data. The system is widely used, with 24 Member States employing this approach in 2010. The European Commission pays for the imagery, this year €6.5 million, but the cost of processing and analysis of the information for use by the Member States is probably about €40 million a year.



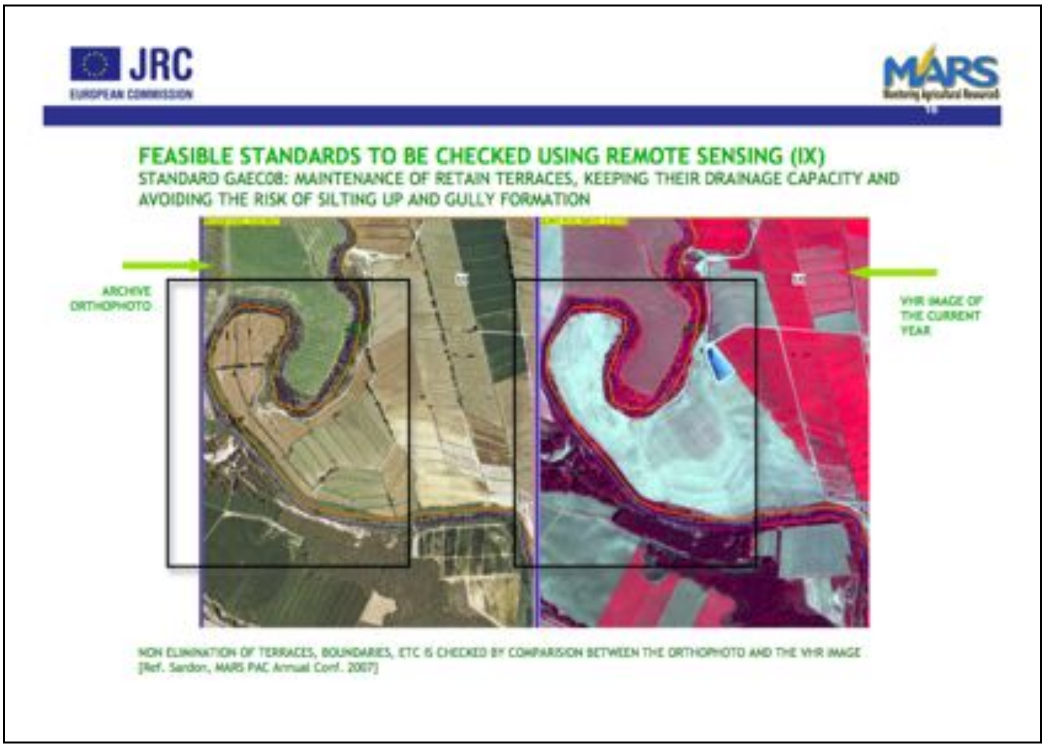
The outlined areas in this slide are fields in the land parcel information system, the left one showing use as a caravan park, and the right one as a golf course. Neither of these is eligible for payments. It is the exception, but irregularities need to be filtered out of the farmers' claims.



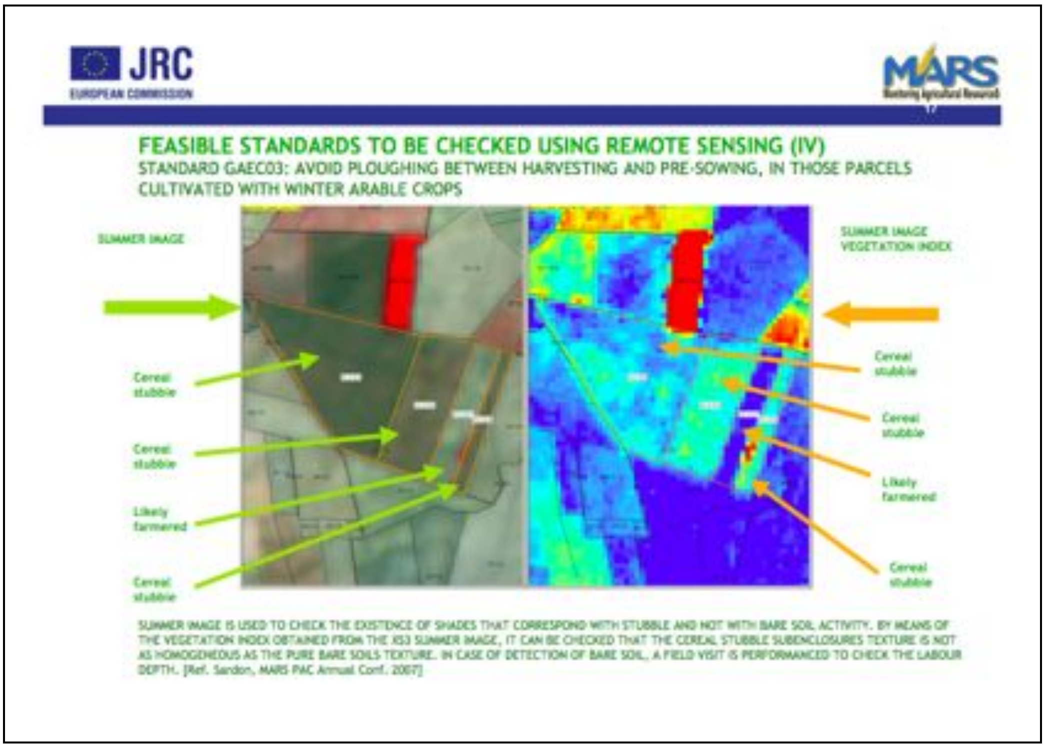
This slide illustrates another case where satellite imagery proved that a claim was false. The outlines drawn on the 2005 photograph show the fields that the farmer is declaring for subsidies, in his claim in April or early May 2007. It also shows a road that had been built through the field.



The farmer claimed that the road was built after his claim was submitted. However, the Member State was able to refer to earlier images, with coarser resolution but nevertheless confirming that the road was constructed earlier, probably between September 2005 and May 2006. The satellite data provided the only clear evidence that the claim made by the farmer was irregular.



The legislated standards include quite specific requirements. In this case a satellite-derived image reveals that the farmer removed terracing previously visible in the archived photograph, in breach of the standard.



This crop rotation case imagery illustrates a case requiring more expertise to interpret. Using non-visible data such as infrared channels might be specific to a particular season. Expertise is required both on the remote sensing instrument, and on the agronomic conditions of the land management in order to assess whether the land is being managed to standard.

Remote sensing has become a major tool for Member States, not only for prosecuting farmers, but also as a deterrent to false claims and an aid to farmers to make appropriate claims. The rate of irregularities in most Member States is down to around 1% or 1½% of payment value, much lower than before this technology was used.

4.4 USE EXPERIENCE IN AUDIT CASES:[12] AUDIT OF INDIAN OCEAN TSUNAMI AID IN ACEH WITH GEO-INFORMATION

4.4.1 Presentation[13]

4.4.1.1 Introduction

Supreme Audit Institutions (SAIs) have a role in safeguarding the spending of public funds by providing assurance with their audit activities: they provide assurance on the financial statements of government and public entities. Auditing also has another important function besides assurance; it is a learning tool for management that provides an assessment of weaknesses and strengths in performance.

SAIs have a role in assessing whether governments and public entities are well prepared for natural disasters (disaster preparedness and risk mitigation). They also have a role when disasters happen and government and public entities are planning, coordinating, funding and implementing disaster-relief efforts.

When the Indian Ocean Tsunami happened in 2004, the 189 members of the International Organisation of SAIs (INTOSAI) realised that this disaster would also have an effect on the SAIs from affected and donor countries. For SAIs of affected countries, such as Indonesia and Sri Lanka, it posed a huge challenge to audit the management of disaster-related aid. But also for SAIs from major donor countries the Tsunami-disaster posed a challenge: how could the SAIs provide assurance on public funds that are mixed with other public and private funds while those funds flow from one organisation to another and from one country to another? To be able to provide assurance, an audit trail is needed to provide insight and accountability into the movement of public funds from source to final destination.

In November 2005 the Governing Board of INTOSAI decided to create a Task Force on the Accountability for and Audit of Disaster-related Aid with the aim to reconstruct an audit trail for the Tsunami-related aid flows and to learn about how to improve transparency and accountability for these flows.

The flow of disaster-related aid is a geographical movement from source to destination. Furthermore, aid (e.g. funds for education) is intended to lead to a certain output (i.e. school building and training of teachers) and finally an outcome (i.e. the education) on a specific location. Geography, therefore, plays an important role in any audit trail, but is specifically important with regard to disasters. The INTOSAI Task Force was charged with exploring the possibilities of using geo-information in auditing disaster-related aid in order to minimize waste, competition, fraud and corruption of the aid funds. The Task Force's research question was broad: how and under what conditions can the use of geo-information in auditing help to ensure the regularity, efficiency and effectiveness of disaster-related aid?

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[12] This section is based on material provided by Wietske Bijker (Faculty of Geo-information Science and Earth Observation (ITC), University of Twente), Egbert Jongsma (Netherlands Court of Audit) and Richard A Kidd (Geospatial Consultant, Cairo, Egypt). These authors and ISPL would like to thank the Badan Pemeriksa Keuangan RI, the Indonesian Supreme Audit Institute, and the SIM-Centre, BRR for their support of the pilot study on auditing housing projects with geo-information. Furthermore, they would like to thank the KARI for providing the satellite imagery, the World Bank and the Netherlands Ministry for Development Cooperation for funding the pilot study.

[13] This report was presented by Egbert Jongsma, Netherlands Court of Audit.

This paper describes the methodology and results of the INTOSAI Task Force's study into the potential use of geo-information for auditing disaster-related aid.

4.4.1.2 Detection and Mapping of New Houses

To study the potential role of geo-information in audit of disaster-related aid, the Task Force focused on reconstruction of houses in the Indonesian province of Aceh, the most affected area of the Tsunami-hit countries, nowhere over 150,000 houses were damaged or destroyed. The interest was not only if new houses were constructed, but also where, so it could be determined if houses were constructed at the correct location.

Looking at disaster prevention and mitigation, it is also of interest whether newly constructed or reconstructed houses were built in areas that are not prone to disaster. For example, if houses were built too close to the coastline, then the risk for destruction at a next Tsunami would be high and so would the risk of aid funds being wasted. After the 2004 Tsunami, the Government of Indonesia regulated that houses should be built at least two kilometres from the coastline (in some areas the Tsunami reached two kilometres inland), therefore reducing potential risk of destruction.

Accurately mapping the location of the reconstructed houses in the province would provide a mechanism to assess compliance with this Governmental requirement. It would also provide the possibility to benchmark between implementing agencies: SAIs auditees are government agencies and private entities such as non-governmental organisations (NGOs). In this respect, situations such as the Indian Ocean Tsunami provided SAIs with the unique possibility of benchmarking government performance against that of private entities.

The proposed method [see Figure 2] uses two maps of the objects of interest: one at the start and one at the end of the audit period and to detect the changes by applying overlay-techniques (Bijker and Sanjaya 2008). Use of decision rules for change detection limits the result to provide only the changes of interest. These changes of interest can be sorted by administrative unit when combined with an administrative map and compared to the information supplied by the institution that is being audited.

Field sampling assesses the accuracy of the change detection and provides further detail on the nature and origin of the changes and the objects under study. Depending upon the required spatial resolution (i.e. sufficient to accurately locate and measure the object of interest) the maps would usually be derived from satellite images or ortho-rectified aerial photographs (orthophotos). This generic approach could be applied for all spatial objects under audit, such as forests, houses, agricultural fields, and for environmental impact assessment.

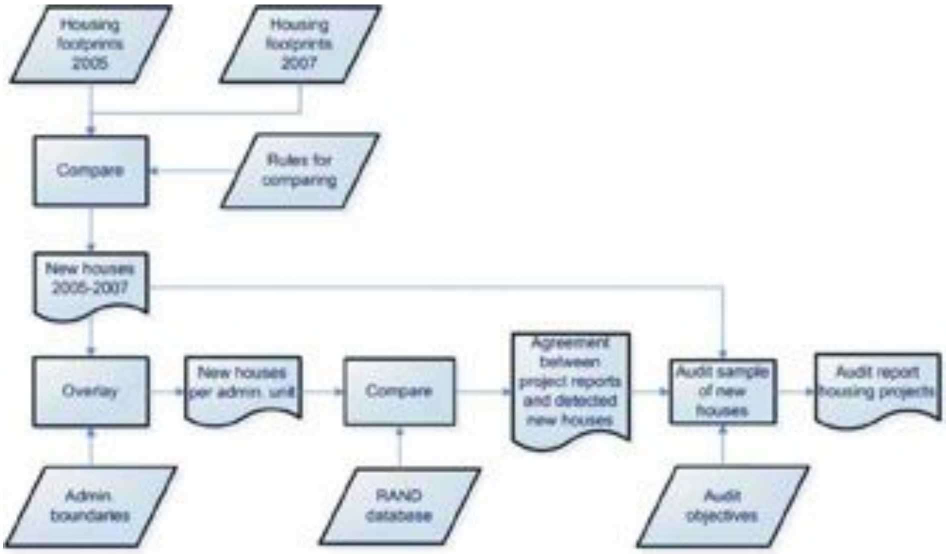

Figure 2: GIS based method for auditing housing projects

The method depends on data availability at the time of the audit. For the Aceh case study, high resolution (30 cm) orthophotos, acquired in June 2005, provided by the Indonesian National Coordinating Agency for Surveys and Mapping (Bakosurtanal) via BRR's Spatial Information and Mapping Centre (SIM Centre), along with the panchromatic 1m KOMPSAT-2 (Korea Multi-Purpose Satellite-2) images, donated by the Korean Aerospace Research Institute (KARI), acquired in May 2007 were available. Vector data (Topographic Line Map, at 1:10,000 scale) extracted from the 2005 high-resolution orthophotos was also available.

Combining the 2005 map of building footprints detailing the start of the rehabilitation phase, with that of 2007 showing the current state at the time of case study, provides all the buildings constructed between clearing the Tsunami debris and the end of the reconstruction period. Overlaying the map of new houses with the map of administrative boundaries provides the number and locations of new houses per administrative unit. These numbers can be compared with the information on housing projects available through the Agency for Rehabilitation and Reconstruction of NAD and Nias (BRR) Recovery Aceh Nias Database (RAND) database and other project information. Layout plans of housing projects existed only as paper sketches.

Based on location and degree of completion, as detected by comparing the building footprint maps, the Indonesian SAI, Badan Pemeriksa Keuangan RI (BPK) can take a stratified random or stratified systematic sample of these projects, for auditing according to its audit objective. Fraud is likely if there is a large discrepancy between the quantities of houses built according to the RAND database or project information, and the map of new houses. In such a case, the BPK field teams may want to take extra field samples to determine the reason for this discrepancy. Visualizing the spatial distribution of contractors and projects on maps shows the auditors whether there were likely to be any monopolies of building contractors in certain areas, and focus their audits accordingly. Using the map of new houses, the audit data of the houses in the sample can be extrapolated for the whole study area.

In the case of the housing audit conducted by the BPK, the results of the analysis of the KOMPSAT-2 imagery providing the housing footprints for 2007, were not ready before the field teams started their survey, so the method shown in Figure 2 was adapted [Bijker and Sanjaya 2008]. While the field teams of the BPK were conducting their survey, suitable remote sensing methods were developed to detect houses on the KOMPSAT-2 imagery and used to create the map of new houses for selected sites (Du 2008).

The field teams took copies of the 2005 orthophotos to the field and delineated the sites of the housing projects on these images. The project delineations of the field teams were digitized and combined with the map of new houses. In this way, thematic (audit) data of the housing projects could be related to the new houses mapped from the imagery.

4.4.1.3 Check for Compliance with Risk Regulation

When the available Topographic Land Map and the housing data from the RAND were combined, it was possible to map all settlements within two kilometres of the coastline. A limited number of inspection sites were selected, where it was possible to collect field data including the use of a handheld Global Positioning System (GPS) to ensure positional accuracy. To be able to provide a benchmark, inspection sites were selected from various implementing agencies. To ascertain if newly constructed houses complied with government regulations, it is a straightforward process to simply map the distance from the coast. Some of the houses were constructed within 300 metres of the coastline. Houses built by NGOs are located even closer to the coastline.

4.4.1.4 Lessons Learned

From the housing audit in Aceh Indonesia, it is clear that many limitations exist concerning the availability of data. Data required for the audit do not exist or are not provided by the auditee. The combined use of GIS and remote sensing could help in resolving this problem. Data accuracy and methods to assess the accuracy of spatial (audit) data still require more attention. As with all data used by an audit institute, reliability of the data used in the audit is important for its credibility and the confidence of the general public.

GIS is a useful and cost-effective technology for the preparation and planning of an audit, and can be used to visualize where risk of fraud is highest and to limit the amount of data that has to be collected in the field, (INTOSAI Tsunami Task Force, 2008). Remote sensing can be used to acquire spatial data, which is not yet available as maps, also allowing independent verification of certain objects and processes. In the field, having the data at hand in a mobile GIS and storing the data immediately in a digital form speeds up the survey and reduces the risk of errors, and also possibly the number of samples needed. For presentation of the results of the audit, maps are very effective for summarizing information and for showing spatial relations.

The housing audit in Aceh has made INTOSAI more aware of the crucial role geography plays in compliance and performance of the public entities it audits. Using geo-information helps SAIs to understand and tackle the complexity of policy implementation in situations such as disaster areas. It also leads to more efficient and effective audits, thus enhancing the contribution of SAIs to good governance. The Netherlands Court of Audit launched a knowledge centre on GIS and Audit to further develop GIS as an audit tool.[14]

4.5 Discussion

This session was devoted to practical experience in the use of satellite earth observation information. These related to evidence of land subsidence causing damage to a historic monument in Italy, monitoring and verifying CAP subsidy claims by European farmers, and audit of foreign aid and disaster aid grants by the government of the Netherlands.

***Comment*:** It was stated that satellite remote sensing monitoring for CAP verification this year covered about 5%–7% of the total area. It implies that farms in a large area can get

[14] www.courtofaudit.nl/english/gisandaudit.

away with inflated subsidy claims this year. A second related question is how to determine which areas are monitored. In Britain and the Netherlands there is a risk-based approach, focusing on where there are likely to be breaches. Is that going on with CAP monitoring, concentrating on likely problem areas?

Response: Legislation requires a minimum of 5% controls, bearing in mind that of the information collected from the farmers, 100% is already given an administrative check through the system. This creates a scatter-shot of places across Europe. There is a requirement that ¾ of the checks be made on the basis of some kind of risk analysis, using the database of farmers and the types of declarations they have made. Member States decide on higher probability of risk in terms of where they locate their checks. Freedom of information obligations requires release of sensor location, but maps are too small-scale for individuals to assume they would not be monitored by earth observation. The locations are released after the fact, i.e. not made available before the monitoring process starts. Areas surveyed are published at the end of the year.

Comment: How do you make sure that the regulation meets the desired aims and is not adapted to what is measured? In other words, to do it by biodiversity or water quality or things of that sort, that is efficacious in some way.

Response: The actual checking part is not necessarily directly linked to what the policy is trying to get, but the checking has to go in step with policy. Policy is not driven by what is checked, it is driven by political goals. Technological solutions are sought at the same time to enable that to actually be deployed directly. Both the regulations and technology have been changing.

Comment: The Rovigo case was very clear, but in many respects it was too clear to be interesting. What happens when the actual signal gets so low that it can be challenged in court? Also, the other issue with PSInSAR technique is that a long time series is needed. What happens when people try to force you into a statement about whether something is happening now rather than having happened many years before?

Response: In such a case no data can be given. A very noisy time series may contain a measurement point that is perfect for the client. If the false alarm rate is really high, it cannot be used before a tribunal. Typically, it is not so easy even to find the number. The false alarm rate is 10^{-5}, 10^{-6}. It is sometimes possible to use the Monte Carlo simulation, but not always. Sometimes a measurement point may be not on the roof of the building, but just at the basement level, and can be interpreted to say almost anything about the tilt of the structure. So, it's still a matter of the expertise of the people in charge of the processing, who should be able to say "Yes, I can tell you." It's really almost impossible that this kind of time series is generated completely randomly. Of course, the more data we have, the better.

Comment: In all three cases it seems that satellite data is not easy to use in a self-standing manner without supporting information, but it is used effectively. Also, you always need interpretation.

5. JURISDICTIONAL TREATMENT [15]

– CASE REPORTS AND REGULATORY EXPERIENCE
– COMPARATIVE PERSPECTIVES

5.1 INTRODUCTION

A number of factors govern the admission and use of evidence. These vary by jurisdiction, the nature of the judicial or administrative process as well as the applicable substantive and procedural laws and rules. No general rule is possible given the possible permutations. In order to provide a broad survey of the issues, this session examined a number of jurisdictions for points of similarity and difference. The underlying proposition is that if any rules or guidelines conform to the strictest requirements, the evidence will be admissible in all jurisdictions.

This session was therefore a comparative look at some cases and law in the UK, US, Belgium, Netherlands, France, Germany, and international law. It covered admissibility of evidence, restrictions on admission of evidence and standards of proof. A distinction to be made is between common law and civil law systems. Broadly speaking, civil law jurisdictions use an inquisitorial system, where the judge has wide discretion to admit or reject evidence. Common law jurisdictions generally rely on an adversarial system to present and challenge evidence, under strictly defined rules of admissibility.

The discussion following the presentations is reported in Section 5.4.

5.2 BACKGROUND MATERIAL FOR WORKSHOP[16]

5.2.1 Admissibility

5.2.1.1 Australia

There are a number of legislative provisions that specifically permit the admission of satellite-derived information in certain circumstances. There have also been several cases in which such information has been admitted, although there is no line of decisions that thoroughly address the conditions for admission of satellite-derived information.

In *John Nominees Pty Ltd v Dixon* (2003), the Court upheld the admission of satellite images, likening them to photographs. The Court referred to the processing of digital data according to a defined methodology, calibrated to a standard, so that they can be compared over time. The Court also referred to the need for verification or authentication of sources of satellite evidence.

5.2.1.2 Belgium

The Code of Criminal Procedure summarises types of evidence in Belgium. This list is illustrative and the judge is free to accept other evidence. There is no national legislation in Belgium that prohibits the use of satellite-derived evidence in legal proceedings. Any evidence can be used to prove an illegal act. However, there are no cases in Belgium where satellite data were used as evidence for illegal oil discharge by vessels at sea.

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[15] Jurisdictional issues were addressed by a panel comprising Professor Kevin Madders, Professor Sa'id Mosteshar, Professor Lucien Rapp and Professor Maureen Williams.

[16] This digest is based on reports by Yeliz Korkmaz, Professor Kevin Madders, Professor Frank Maes, Penny Martin, Tanja Masson-Zwaan, Sarah Moens, Professor Sa'id Mosteshar, Professor Lucien Rapp and Johanna Symmons.

Corroborative “ground truth” or contextual evidence may be required to support satellite evidence. For example, Synthetic Aperture Radar (SAR) can provide information on the presence of oil at sea, but may be confused by algal growths, wind front areas and internal waves. They need to be corroborated by vessels in the neighbourhood or by surveillance airplanes. SAR imagery combined with Automatic Identification System (AIS) position data could identify a polluter.

5.2.1.3 France

To be offered as evidence, information must be contestable by each party; satisfy rules of admissibility reliable and must not breach privacy

To be admitted, evidence usually has to be written. Electronic records have the same probative force as traditional written forms, and must be authenticated. Requirements include:

1. Duly identified person: secure digital signature, certification by a third party;

2. Guarantee of the integrity of the record (creation and conservation).

5.2.1.4 Germany

There are no specific provisions on the admissibility of satellite imagery in German law. Therefore general admissibility rules apply.

If scientific evidence carries a high margin of error, courts will often require additional supporting evidence. This requirement could apply to certain applications of satellite earth observation such as oil spill identification, where a large number of false positives are reported.

A court may also require proof of correct functioning and state of the art processing from expert witnesses. Case law related to speed camera evidence shows that standardised devices and methods could relieve the court from having to rely on expert opinion on a regular basis. Expert opinion is still needed where a case shows specific difficulty or where inaccuracy is likely.

As electronically stored digital data might be altered without leaving any evidential trace, a court may require further evidence to authenticate the satellite-derived information, proving it comes from the original data and has not been altered.

Few reported cases mention the use of satellite data as evidence. Most are administrative law cases. Of these, the majority used the satellite-derived data to prove the location of an object or land boundaries. A second use of satellite images is assessment of character or vegetation of an area in the context of agricultural subsidies and planning law. In most cases the data was supported by additional evidence.

Satellite-derived evidence may form part of *expert opinion* or *witness testimony*, when their use is not separately recorded in the case report.

5.2.1.4.1 German Civil Law

In civil claims, most satellite-derived information is likely to be submitted as evidence for *judicial inspection*. The court can order that one or more experts be consulted, generally appointed by the court.

Satellite images cannot be deemed *documents*, which must embody human thoughts. They therefore lack probative value of documents and are subject to the general principle of free evaluation of evidence.

5.2.1.4.2 German Administrative Law

Under the inquisitorial system operated in Germany, it is the responsibility of the court to investigate the facts. To do so the court uses all appropriate forms of evidence. However, the principle of proportionality, which is fundamental to German public law, could prevent administrative authorities from using satellite images as evidence if the cost of providing satellite imagery is significantly higher than other means of evidence supporting the same facts.

5.2.1.4.3 German Criminal Law

The Court has discretion in assessing the probative value of evidence. Given the serious effects of its decisions, the court investigates the facts of a criminal case more thoroughly than in administrative cases, setting a higher standard of admissibility.

5.2.1.5 Netherlands

In the Netherlands, satellite-derived EO information, or similar material such as aerial optical pictures, are generally used and admissible in administrative and criminal proceedings, if probative.

There is however no abundance of cases, and in some instances the matter of the admissibility as such was not at stake. There is no clear precedent on the admissibility of satellite-derived information.

5.2.1.5.1 The Position of the Expert Witness

As in other jurisdictions, the Court relies on expert testimony and interpretation to determine the correct meaning of the evidence provided. In administrative cases it decides whether the administrative authority observed its own rules, but does not judge the quality of the expert's working methods.

5.2.1.5.2 Administrative Cases in the Netherlands

5.2.1.5.2.1 Farm Subsidy

In farm subsidy cases the Court has stated that remote sensing is commonly accepted practice in the European Union. Satellite imagery has been admitted in each case. The Court has held that satellite-derived images are similar to x-rays, aerial or ultrasound pictures or DNA information.

5.2.1.5.2.2 Water Management

Satellite-derived information is frequently used in the preparation of 'environmental impact reports' to obtain permits for new water projects. An example is the planned expansion of the Tweede Maasvlakte in the Port of Rotterdam, where the Rotterdam Port Authority requires a permit from the Directorate General for Public Works and Water Management.

In preparing the Environmental Impact Report, satellite-derived EO images were extensively used by the Port Authority to verify compliance with the legal framework.

5.2.1.5.3 Criminal Cases

Satellite-derived Earth observation information has not been used in criminal proceedings, although aerial optical pictures have been used.

5.2.1.6 International Law

International law primarily covers disputes between countries. Jurisdiction rests with the International Court of Justice (ICJ) and the International Court of Human Rights (ICHR), along with arbitration tribunals.

Satellite-derived information, more particularly satellite images, has been used in a number of cases before the ICJ. These include nation-to-nation boundary and maritime delimitation disputes. However, the ICJ tends to admit any evidence that the Court considers may be helpful.

5.2.1.7 US and UK

The US and the UK are common law systems, and both of them comprise more than one jurisdiction. In this report we refer to English Law (the laws of England and Wales), not to all countries within the UK. In relation to the US, we refer mainly to US Federal law, rather than to the individual states within the US.

Both jurisdictions have shown willingness to embrace new technologies, and both have a reasonably permissive approach to evidence. There have been a number of cases in both jurisdictions where satellite-derived information has been admitted as evidence. However, it will be necessary to prove reliability and accuracy of the information before there is routine use of such information as evidence in judicial and administrative proceedings.

The Federal and State courts in the United States frequently admit and rely on satellite-derived information. However, there is no major authority directly dealing with admissibility of such evidence. One area of concern is often the determination of time and date on which the information was gathered.

US standards for admissibility of scientific evidence were set in the *Daubert v Merrell Dow Pharmaceuticals* ruling of the Supreme Court in 1993. It established tests that include falsifiability, known error rates and peer review. Most States use the *Daubert* ruling, which provides the following guidelines for admissibility:

a. Whether the methodology has been peer reviewed;
b. Whether the methodology can be, and has been, tested;
c. What are the error metrics associated with the methodology; and
d. Whether the reasoning or methodology underlying the testimony is scientifically valid, and whether it can properly be applied to the facts in issue.

In English law, very similar tests are applied. Admissibility depends on the reliability of the evidence adduced and its probative value. It is therefore necessary to show that the evidence relates to the fact being proved, and that is has been in safe and traceable custody without interference or inappropriate manipulation. Computer-generated evidence is now admitted and used in criminal and civil proceedings.

In addition, the potential use of satellite-derived information is recognised in UK legislation implementing European Commission Regulations.

5.2.2 Restrictions on Admission of Evidence

5.2.2.1 Hearsay in the US and UK

In the UK, the rule against hearsay in civil proceedings was largely abolished in 1995, and in criminal proceedings in 2003. There were exceptions to the rule for business records and official documents, and to the extent that the common law rules still apply, some remain.

The US hearsay rule is not very different from that in English law, tending to permit rather than exclude hearsay evidence that is reliable and probative. Under Federal Rules of Evidence, the rule against hearsay remains, with exceptions that extend to some machine-generated information. Satellite-derived earth observation information may be admissible under the exception applicable to business records or to public records. Such records need to be authenticated by complying with collection and custody rules, or to meet the requirements for self-certification.

5.2.2.2 Constitutional and Other Legal Barriers

5.2.2.2.1 Australia

Evidence may be excluded on grounds of privacy, intellectual property rights, trade secrets, monitoring rules and national security.

5.2.2.2.2 Belgium

In Belgium the 1992 Privacy Act protects privacy of personal data. The independent Belgian Privacy Commission is the authority ensuring the protection of privacy during the processing of personal data.

The Privacy Commission, considering whether satellite images could be used to prosecute building offences, confirmed that satellite images are regulated by the 1992 Act. It ruled that satellite images can be seen as information, and the properties on the pictures can be identified. Data subject to the Act can only be used for the specified stated purpose. It is also prohibited to save the data longer then is necessary.

There are enough similarities between satellite images of building offences and those of illegal oil discharges at sea that it is likely that the Commission will give the same advice on satellite images of illegal oil discharges. This means that the gathering of satellite images of illegal oil discharges must follow the requirements of the Act.

Proactive investigation, particularly of offences not yet committed, is only allowed for serious crimes and when there is prior written permission by the public prosecutor, which can only be given when an investigation takes place. This is not always possible with an illegal oil discharge at sea.

5.2.2.2.3 France

There are similar Technical and Legal Difficulties relating to Satellite Images, as apply in other jurisdictions, including possibility of mistake, reliability and accuracy of the equipment, pre-processing and processing manipulation and the need for expert interpretation. Evidence may also be excluded in the future on grounds of the right to privacy and personal data protection.

5.2.2.2.4 Germany

Satellite evidence could violate the right to informational self-determination contained in the German Basic Law. There are Constitutional Court decisions concerning the publication of satellite imagery and the use of automated speed camera evidence.

However, this right is not unlimited. Data is only protected if it is related to a person. The 2007 Satellite Data Security Act places restrictions on the generation and dissemination of "high-grade" satellite data. Other data protection laws regulate the dissemination of private data and access to geographical information. In addition, if there is a prevalent public interest, the right may be limited.

5.2.2.2.5 UK and US

In a number of cases remotely sensed information, aerial or satellite-derived, have been challenged on the basis of the Fourth Amendment to the US Constitution prohibiting search without warrant. Other issues have been *privacy* and *trade secrets*. The decisions have gone both ways, depending on the facts of each case. One relevant factor often is whether there is a *reasonable* expectation of privacy.

English law also puts limits on the introduction of evidence on similar grounds. National security is also a limiting factor in both jurisdictions.

5.2.3 Standard of Proof

Once evidence is admitted and its reliability established, it remains for the court to determine whether it proves the fact in issue with the appropriate degree of certainty. In general, in private disputes and other civil matters, a fact need be proved on a *balance of probability*. In criminal and other penal proceeding, the general standard of proof is *beyond a reasonable doubt*. The standard of proof is related to, but not the same as, reliability.

5.2.3.1 Belgium

There are no cases in Belgium where satellite data were used as evidence of illegal oil discharge by vessels at sea. Other cases were not investigated.

5.2.3.2 France

Electronic records can be considered more reliable than traditional written forms. Therefore, they may be regarded as of greater weight than alternative evidence.

5.2.3.3 International Law

The ICJ and has not articulated a standard of proof to which the evidence must conform, and approaches each case on its merits.

In the 1986 frontier dispute between Burkina Faso and Mali, the ICJ considered that maps alone could not constitute binding documents or territorial title by themselves, however accurate and technically valuable, without the parties' acceptance.

5.2.2.4 UK and US

There are a number of English cases in which satellite-derived information has been offered and accepted in evidence. However, this evidence is corroborative rather than primary evidence on which the decisions are based.

5.3 PRESENTATIONS

5.3.1 Belgium and the Netherlands

This presentation focuses on Belgian criminal law. The Criminal Code is a permissive regime in principle, with no specific barrier to the use of space earth observation data under Belgian law generally. There are issues of admissibility in relation to civil law, particularly where violation of private life is concerned.

- No barrier in principle to use of space EO data
- Focus on criminal law especially oil spills); no satellite EO cases yet
- Interviews with coastal authorities
- Law of 06.04.1995 on prevention of oil pollution from ships: all means of proof open, thus eyewitness, pictures, videos (Art. 5bis); satellite not specified
- Aircraft photos and videos accepted 2003 case (Court Appeal, Ghent)
- Advantage of aircraft over satellite images: agents of observing state institute (MUMM) act to corroborate to counter problem of look-likes
- Privacy Commission advice 26/2006 qualified satellite imagery as subject to Data Protection Act 1992 requirements. As such, processing of PII can only be performed by an authorized person where any form of litigation is involved.
- Proactive investigation prohibited unless for serious crimes with authorization of public prosecutor

Interviews with coastal authorities, particularly in relation to MARPOL in its implementing legislation, resulted in the view that all means of proof are open, including eyewitnesses, pictures, and video. Satellite is not specifically mentioned. Related case law concerned aerial photographs and videos. The authorities prefer aircraft data to satellite data, because the agents are able to observe, and therefore to exclude look-alikes.

Two points may be fruitful areas for further investigation. First, advice given by the Belgian Privacy Commission in 2006 specifically on satellite imagery was that it is unequivocally subject to the Data Protection Act of 1992 concerning personally identifiable information ('PII'). The implication was that only an authorized person could process PII where any form of litigation is involved.

Second, proactive investigation is prohibited in Belgium unless for serious crimes, and then only with the authorization of the public prosecutor.

- No barrier in principle to use of space EO data
- Focus on use of EO information products in agriculture, water management
- Interviews with agencies, companies, judges, counsel
- Administrative proceedings: analysis of doctrine and evidential requirements
- 2002 agricultural subsidy case. Satellite images accepted as "common and accepted" system in EU for evidence (that crop different than subsidy claimed for), but with expert witness
- Satellite EO images treated on par with x-rays, etc.
- Court did *not* investigate quality of expert (Georas) evidence – only if minister correctly exercising powers
- Quality of local EO processor nevertheless checked by JRC
- Issues of procedural equality regarding access to expertise; need for independent source of expert advice?
- Privacy – Special Powers of Investigation Act: constraints on gathering data but court held thermal camera no violation
- Proactive investigation prohibited unless for serious crimes with authorization of public prosecutor

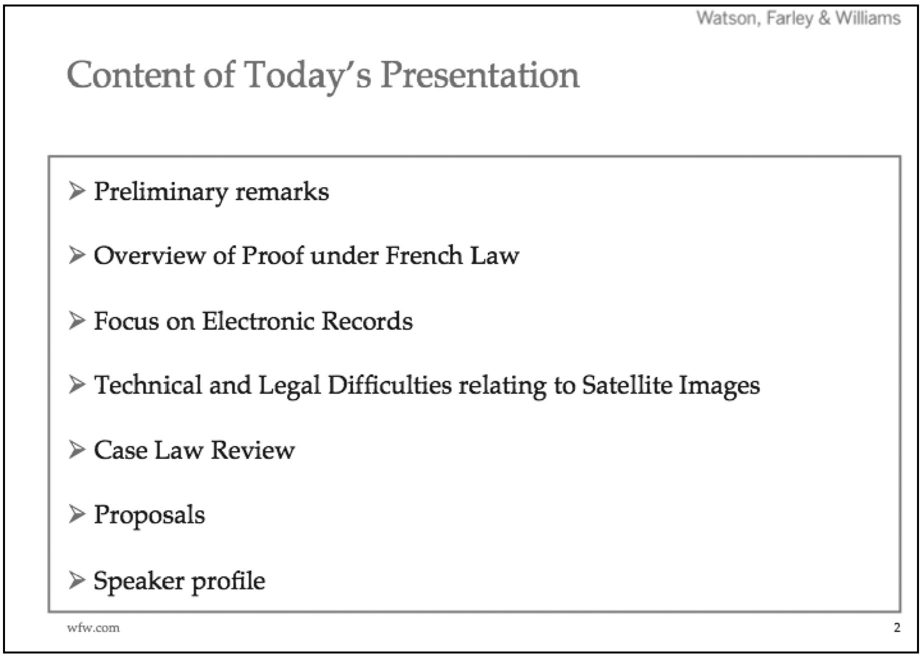
In The Netherlands, there is no barrier in principle to use of space observation data, exactly as in Belgium. The report looks at agriculture, water management and cannabis production. There were interviews with administrative agencies, companies, judges, counsel and legal academics interested in evidence and civil procedure, related to administrative proceedings. There was analysis of the doctrine and evidential requirements, including the standard of proof of about 60% as compared to a standard of about 90% for criminal prosecution.

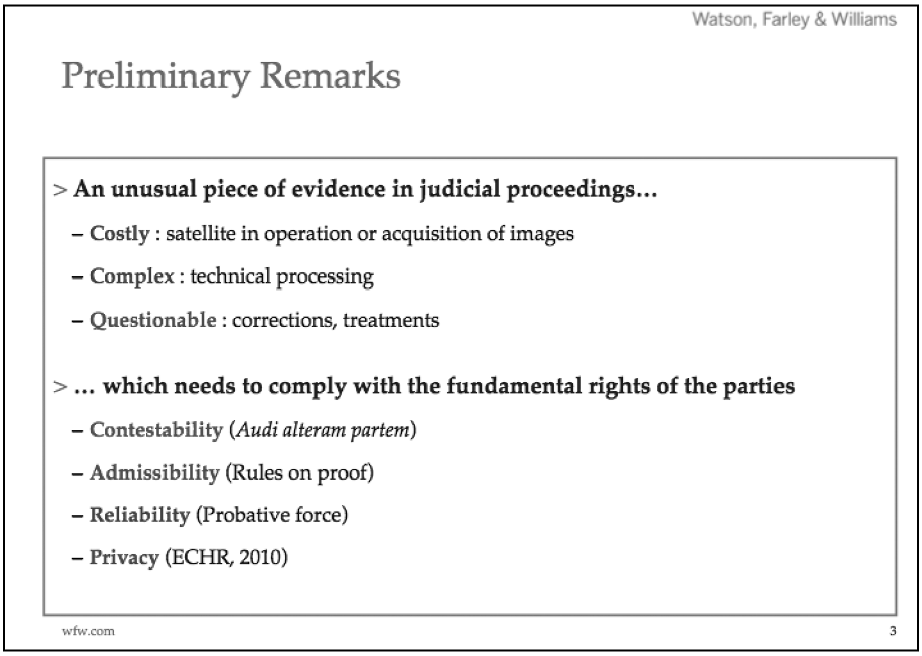
In relation to case law, there was a 2002 agricultural subsidy case in which satellite images were accepted, on the basis that they are a common and accepted form of evidence within the European Union. The expert witness was from the company holding the current contract from the Ministry. The case had two notable features. First, satellite earth observation images were treated as on a par with x-rays. Second, the court did not investigate the quality of the expert, only if the minister was correctly exercising his or her powers. This is significant in The Netherlands, where technical experts are appointed by tender by the Ministry, and therefore are not independent of government. This is obviously noteworthy when it is not the practice for both sides to present independent experts.

The authorities would like to be able to use the potential of this type of technology.

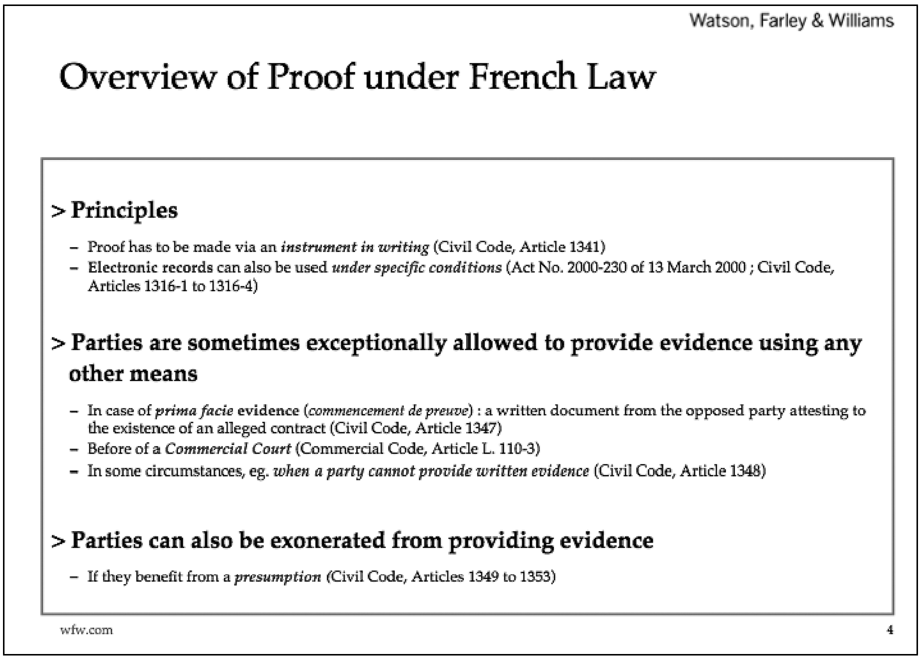
5.3.2 France

Difficult questions arise in relation to the use of space imagery. It is an unusual type of evidence because it is costly, complex, and questionable. It needs corrections and human intervention, which could lead to challenges to the evidence.



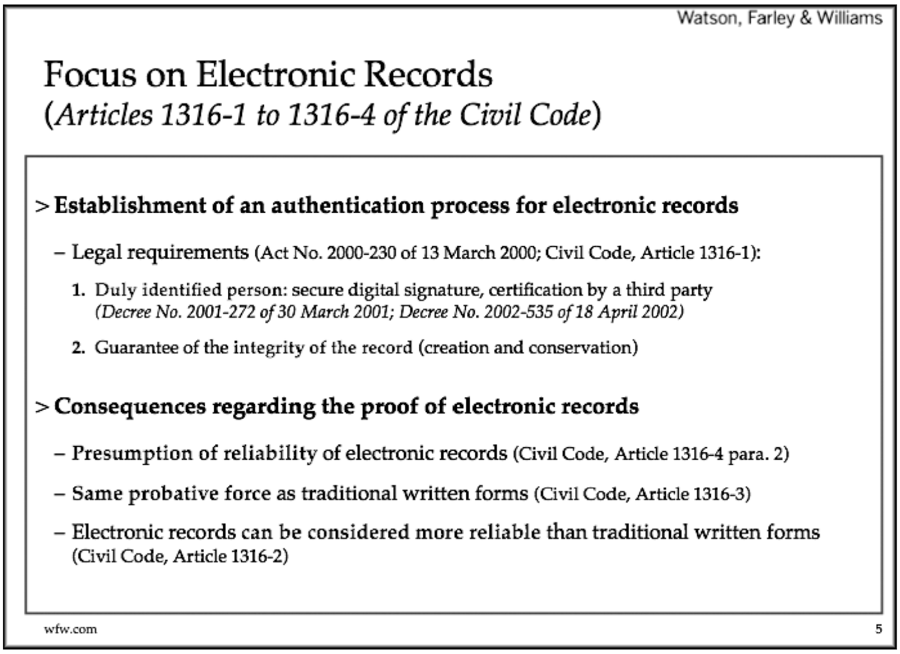


In France, as well as many other countries, there are fundamental human rights to consider. Evidence must be contestable, so that the other party could challenge it. It must be admissible and reliable. This relates to burden of proof and the probative force of the evidence. Evidence must also comply with protection of human rights, especially with privacy, since September 2010.



Under French law, there are principles, and exceptions to these principles. First, any piece of evidence has to be provided by a written instrument. The March 2000 Act authorized the use in France, as in some other countries in the world, of electronic records as evidence.

Exceptionally, other parties may provide other evidence. Prima facie evidence might be presented. In a commercial court, there are other means of proof. The Civil Code, allows other means of proof if there is no written evidence, for instance, if documents have been destroyed in a fire. In some cases, parties can also be exonerated from providing evidence, where there is a presumption.



The Act authorizes the use of electronic records, providing that there is a duly identified person, and integrity of the record can be shown. There is a presumption of reliability of electronic records, which have the same probative value as written evidence.

Watson, Farley & Williams

Technical and Legal Difficulties relating to Satellite Images

> **Admissibility of satellite images** when parties can prove be any means of evidence

> **Authenticity and accuracy would raise some issues**

– **Step 1: Image acquisition:** possibility of mistakes related to the **accuracy and reliability of the equipment**

– **Step 2: Pre-processing and processing**

– Removal of errors introduced during image acquisition, colour adjustment, removal of certain objects from the image

– **Very dependent upon the processing operator**

– **Step 3: Image interpretation:** a judge could find it difficult to interpret satellite images **depending on their precision**

> **Issues might also arise in the future regarding of the right to privacy and personal data protection**

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Watson, Farley & Williams

Precedents

> **Aerial photography**

– **Admissibility of the evidence of a breach of the law on maritime navigation and fishing provided by an aerial photography** (CA Bastia, 15 April 1992; CA Poitiers, 2 April 1993)

> **Space data case law**

– **GPS surveillance of a crime suspect, although interfering with the individual's right to privacy, can be justified if implemented in accordance with the law** (ECHR, 2 September 2010, *Uzun v. Germany*)

– **GPS surveillance of employees interferes with the individual's right to privacy if not implemented with respect to data protection regulation** (CNIL, Decision of 16 March 2006; Cass. soc., 26 November 2002, *Ms X v. Société Wieth-Lederlé*)

> **DNA evidence legislation** (Act No. 94-653 of 29 July 1994; Civil Code, Articles 16-10 to 16-13)

– Requirements for the admission of DNA evidence:

– **Filiation litigation**

– **Consent of the person**

– **Carried out by an authorised expert**

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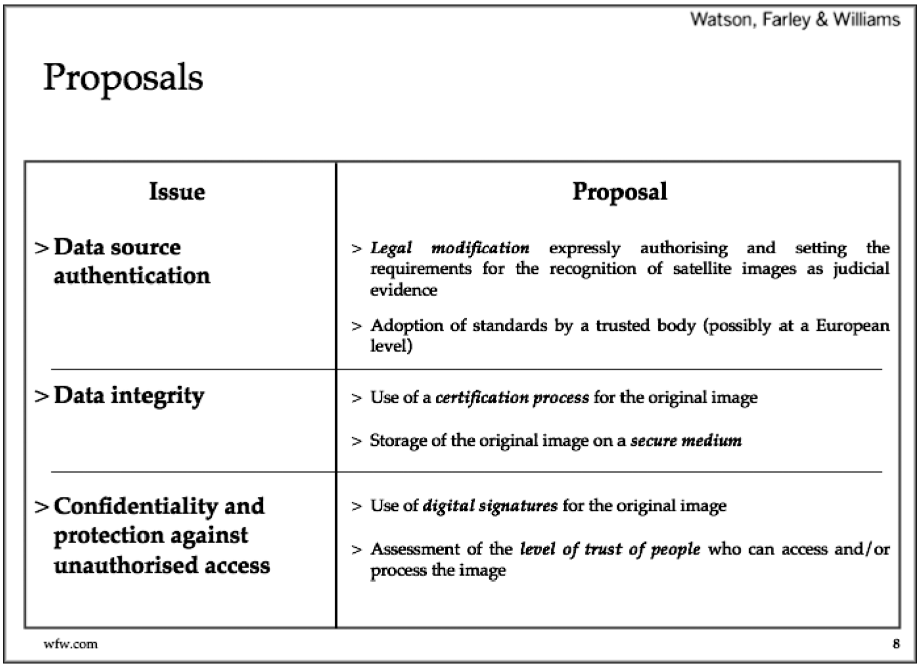
Several cases might be of interest. First, there are precedents from aerial photography although there are differences between aerial photography and satellite-derived imagery. Aerial photographic evidence has been admitted as proof of breach of law. Two particular cases are cited.

There is no case law regarding space data, but there is on GPS. The case concerns remotely gathered personal information and privacy protection. The European Court of Human Rights ruled that the use of GPS surveillance could be admissible in some circumstances.

DNA evidence, which is only used to prove any affiliation, or any element relating to the family, requires the consent of the person, and must be carried out by an authorized expert.


Watson, Farley & Williams

Proposals

Issue	Proposal
> **Data source authentication**	> ***Legal modification*** expressly authorising and setting the requirements for the recognition of satellite images as judicial evidence > Adoption of standards by a trusted body (possibly at a European level)
> **Data integrity**	> Use of a ***certification process*** for the original image > Storage of the original image on a ***secure medium***
> **Confidentiality and protection against unauthorised access**	> Use of ***digital signatures*** for the original image > Assessment of the ***level of trust of people*** who can access and/or process the image

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In conclusion, several steps should be taken if space imagery as evidence is to be used more extensively, at least in France. First, legal modification is needed, which might take the form of a new Act recognizing satellite imagery as evidence. Second, there should be standards issued by a trusted body, if possible at the European level, and a certification process. Third, a secure medium is required for storage of satellite-derived information. Fourth, in relation to confidentiality and protection against unauthorized access, digital signatures may be useful. Finally, there should be assessment of the qualifications of the people who have access to, or process, the data.

5.3.3 Germany

Germany is a civil law jurisdiction, so is somewhat different from other jurisdictions discussed. There are some very precise legal provisions in the codes, but there are no specific provisions on the admissibility of satellite imagery.

The German evidential code defines several categories of evidence. These include judicial inspection, witness evidence, expert opinion, documents, and interrogation of parties. Most satellite images are likely to be submitted as evidence for judicial inspection. The court can order that one or more experts be consulted at the time of judicial inspection. The court will rely on, and either accept or reject, expert witnesses, and the satellite information they use as visual aids becomes incorporated into the expert's opinion.

Courts enquire into the technical quality of the evidence that is produced, and will require supporting additional corroborative evidence if the margin of error in the system is unacceptably large. However, with some evidence, such as speed cameras, there is reliance on standard devices and methods of generating the end product, and decisions may be made without hearing any expert evidence.

In terms of limitations and restrictions on using evidence in Germany, there is a constitutional right to informational self-determination. The 2007 Satellite Data Security Act imposes restrictions on the use of, and particularly the dissemination of, high-grade satellite data if it impinges on personal privacy.

There are very few reported cases in Germany. Most are administrative, and the majority deal with the location of an object, or land boundary disputes. Frequently, issues of admissibility of the evidence generated from the satellite information are not articulated in the decisions. This has been a recurring theme in the Project to date.

5.3.4 International Law

This presentation summarizes the major issues involved in the production of satellite imagery as evidence in court, focusing on the International Court of Justice, international arbitrations and other related examples. There is also reference to the views of lawyers, judges and scientists about satellite data in international litigation. Its use is growing. Satellite data is nowadays used as evidence in various fields of science, such as biology. Awareness of its use is spreading in Latin America..

A number of these questions and ensuing difficulties were clearly outlined in the Report prepared by the BIICL, concluded in 2001 recommending, inter alia, the need to create awareness and the importance of capacity building in this field. It observed, in rather worrying terms, that it was not the satellite data that that judges were using in court but, rather, the opinion of the expert interpreting the image. This situation left judges and arbitrators particularly uneasy.

The problem is, in fact, that even though satellite images, as evidence in court, allow little margin for human error in the production of the image, there is scope for manipulation during the interpretation stage by the expert. Glaring examples in the nineties were the boundary disputes between Nigeria and Cameroon, Qatar-Bahrain and Botswana-Namibia, within the ICJ, and Yemen-Eritrea in the field of international arbitration.

Briefly, Nigeria had used a recent satellite image to show the location of a certain area. The image was interpreted differently by the parties and, instead of helping, caused even more confusion. The net result was that, whereas Nigeria considered the satellite data as a very clear way to clarify a point to the Court, once interpreted, it had the opposite effect.

More recently, the award from the Eritrea-Ethiopia Claims Commission (2009) is illustrative. This Commission was called to decide, by means of binding arbitration, all claims for loss, damage or injury related to the violation of International Humanitarian Law. In other countries, the Terrero case decided by the Supreme Court of Argentina in 2002 marked the first stages of the use of satellite data as evidence in court in that country.

From the very outset it was perceived that the issue of evidence from space was particularly sensitive in cases of boundary disputes on the international front where questions of sovereignty over land and water were disputed. The essential issue, doubtless, is the legal value of EOS data; a result of a long chain of interpretations from the moment satellite collects raw data until it is submitted to court.

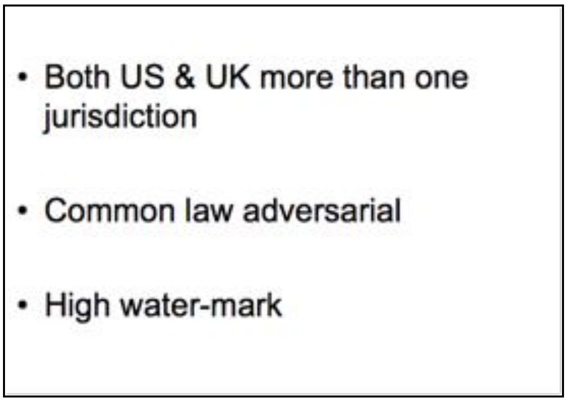
One of the first landmarks, noteworthy for its implications, was the Frontier Dispute case in 1986, between Burkina Faso and Mali, where the ICJ considered that maps could not constitute a binding document or territorial title by themselves, whatever their accuracy and their technical value, unless the parties concerned had expressed their acceptance.

Twenty-four years on, however, the advances of science and technology have led to a completely different international context that indicates the need for further studies on the topic. This would provide useful pillars for drawing up international standards and give a more precise legal framework for the use of satellite data in court. The prevailing opinion is that higher precision is not the only difference between satellite data as evidence in court and that supplied by more traditional means (aerial or terrestrial). The difficulties, rather, concern the very nature of satellite imagery that mainly consists of data and not photographs proper. This point is essential where evidence is concerned. The falsification of a conventional photograph could be detected at a later stage. This is not the case when dealing with numbered images which are merely a list of data that can be modified without possibility of detection and the modification of which are invisible to the human eye.

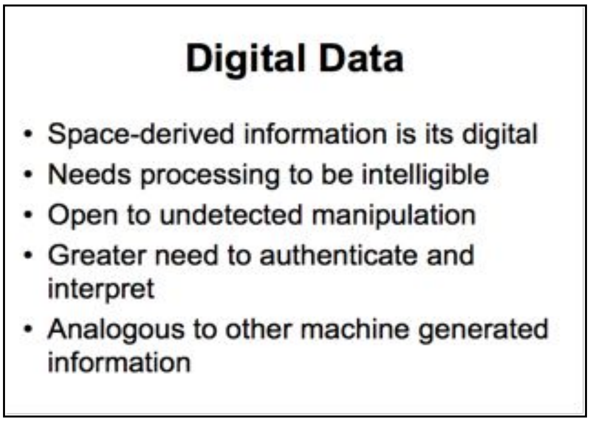
In short, satellite data should be viewed in more positive light. This is the general opinion. International standards should be agreed on the authentication of data, and reliable mechanisms for the production of satellite imagery in court should be enforced controlling the whole process of data collection.

5.3.5 UK and US

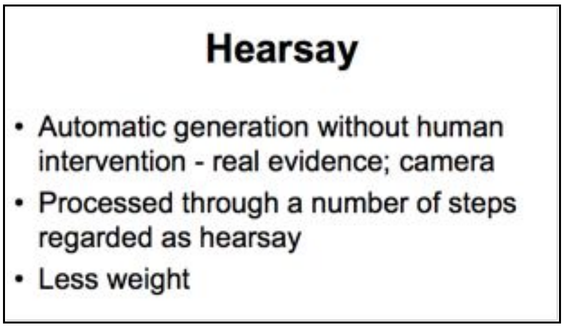
This presentation describes and compares the UK and US evidential rules.



Both the US and UK are multi-jurisdictional. The United Kingdom comprises 3 jurisdictions and the United States 51, the States and the Federal system. Both are adversarial common law systems, where evidence is not extracted and weighed by the court itself, but the opponents who will try to keep each other in line and to the point.



Space-derived information is digital, and must be processed. It can be manipulated, so there is a need for authentication and interpretation. It is analogous to other machine-generated evidence and information.

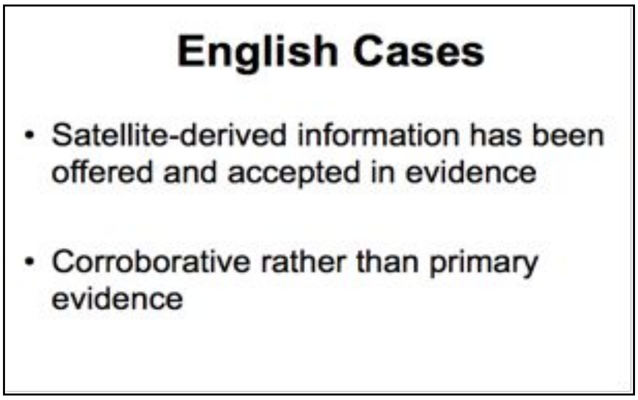


Automatically generated intelligible information, such as that from speed cameras, is real evidence, a record of what actually happened. The issue of hearsay doesn't arise, because there is no intervention aside from writing the software and processing through a number of steps. That obviously affects the weight that is given to any particular evidence.

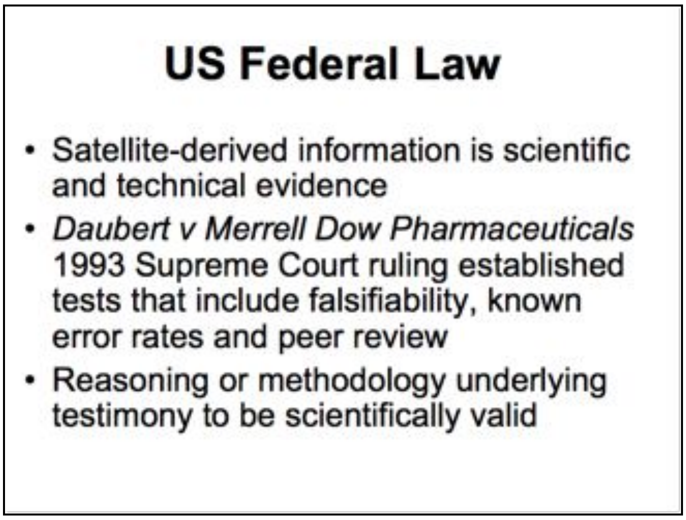
Evidence in the English system is admissible if it goes to establish the fact, or is capable of establishing the fact, and is reliable. In the case of satellite data, one of the important issues is the audit trail, whether it has been in safe custody through the various stages.

Hearsay was a major preoccupation in the past, but in England the 1995 Civil Evidence Act, and the 2003 Criminal Justice Act, have largely done away with the issue. The court rules on the reliability of evidence, and its usefulness as proof.

In terms of satellite information, there are regulations and Directives of the European Union that have been given statutory and regulatory recognition in England. These are mainly environmental and agricultural, frequently concerned with monitoring illegal fishing, fisheries, and verification of compliance with agricultural requirements.

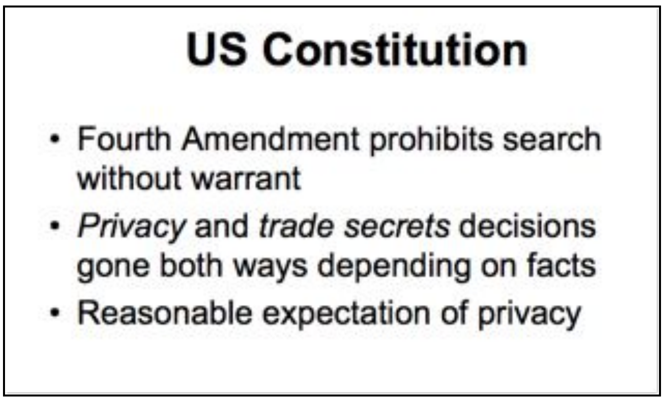


There are many cases in which satellite-derived information has been offered and accepted in evidence. There are no direct decisions on the issue of admissibility, or the reasons why it was admitted or rejected. It is mainly used as corroborative evidence rather than primary evidence.



Turning to the US system, many of the State jurisdictions have very similar rules. Satellite-derived information is treated in the same class as scientific and technical evidence, and there are tests for whether or not it would be admissible.

Formerly, it had to be generally accepted by the relevant scientific community. The Supreme Court in 1993 decided that instead it was necessary to inspect whether evidence can be falsified, error rates, peer review of the methods used, and whether evidence was regarded as acceptable by the relevant community, or a good sector of it.



As a constitutional system, the US is better at keeping things out of court than the English system. In search and seizure and in trade secrets, decisions have varied depending on the facts of the case. The search and seizure provisions of the Fourth Amendment come into play in a number of relevant cases, particularly in detecting cannabis growth in buildings, with thermal imaging used where illegal activity is suspected.

In the area of trade secrets, the test is generally whether there is a reasonable expectation of privacy. It may be that there is a slightly exaggerated sense of the intrusion into privacy by satellite detection.

In conclusion, in the UK and the US courts frequently admit and rely on satellite-derived information. There is no direct authority dealing with admissibility itself. Judges, particularly in the US, seem to be concerned about the reliability of dating the information.

5.4 DISCUSSION

***Comment*:** It seems that for each topic, each use of satellite evidence, a methodology needs to be defined and the situation analysed in detail. It would be very beneficial for everybody if as an outcome of the Study a more or less agreed analysis is produced of what is needed to be studied to deal with a specific problem.

***Response*:** A primary object of the Study is to identify areas that need further investigation. We certainly do not imagine we can come up with all the answers in this Project.

***Comment*:** On the central issue of authentication, what is lacking is awareness of multi-national satellites. First, there are many countries, with equally capable orbiting satellites, from which information could be drawn. There appears to be focus on just a narrow band of European satellites. Use of information from those others may help overcome the authentication problem. A uniform international processing system can overcome some of these difficulties. Secondly, other kinds of applications of remote sensing should also be considered. For example, as far as international law is concerned, satellites are routinely used to ensure compliance with international arms control treaties.

***Response*:** Using alternative systems is a great way to achieve authentication and verification, or at least to get an indication of the range of requirements for authentication, and to assess where error margins may be. The International Standards Organisation is developing some standards looking at satellite-derived information. This is largely focussed on storage and handling, as opposed to authenticating or validating the processing, which is the other element that is needed for reliable evidence. International treaties invoke international relations and the diplomatic arena that is somewhat different from the legal and administrative I of concern here. Not the same degree of certainty is needed.

***Response*:** Regional standards may be accepted, in Europe, in other regions, South Pacific, but not internationally. Developing international norms in this area is a very high priority.

***Comment*:** Introduction of digital signatures, created for the banking environment, into the earth observation chain was discussed and demonstrated under an ES study of a year ago. There is no need for something completely new. Digital signatures, under the Digital Signature Act signed by the European Commission, can be used to sign the data, follow up the complete processing chain, to authenticate all the data and all the information that is coming from satellites.

6. UCL ESRC PROJECT – USE OF SATELLITE INFORMATION IN AUSTRALIA AND LESSONS LEARNED[17]

6.1 INTRODUCTION

Environmental regulators across the world face a number of common challenges, which hamper their quest for effective and efficient enforcement. One of the most obvious challenges is having good information reporting systems that can both report on environmental conditions and compliance with legislation.

There have, in the last decade, been a number of publications and significant evaluations in the EU, which have looked at the potential role of satellite monitoring to the legal and regulatory sectors. These include:

1. European Commission, 'APERTURE Final Report' (European Commission, Report ENV4-CT97-437, 2000).

2. NPA Group, 'Applications of Earth Observation to the Legal Sector' (British National Space Centre Sector Studies Programme Report, 2001).

3. 'Satellite Monitoring as a Legal Compliance Tool in the Environmental Sector' (AHRC Study, University College London, 2008).

Some will be familiar with these earlier studies, but for those that are not, they mainly concentrated on issues of evidence from imagery in courts, as well as identifying potential future environmental applications for the use of satellite monitoring. Understanding in Europe, as to the wider regulatory implications of using satellites to monitor regulatory regimes has never really been analysed. There will be reluctance by regulators to move from one form of obtaining evidence, to accepting a new form of technological evidence unless more substantiation is given as to whether satellite monitoring works at an operational level.

The lack of any empirical evidence on experiences, operational effectiveness and cost has meant that there has been little regulatory uptake and a poor level of the use of satellite technologies in regulatory strategies, relative to its full potential, in part, because its effectiveness has not been adequately demonstrated to regulatory bodies.

6.2 BACKGROUND MATERIAL FOR WORKSHOP

6.2.1 Introduction: UCL ESRC Study on Satellite Monitoring in Australia

This presentation will discuss the results of a recent UCL study, 'Smart Enforcement in Environmental Legal Systems: A Socio-Legal Analysis of Regulatory Satellite Monitoring in Australia,' which was funded by the Economic and Social Research Council in 2009/2010.

This UCL study examined whether modern satellite technologies could provide a rigorous, legally reliable, and cost effective tool in inspection and compliance regimes in environmental regulatory systems. It considers these issues in the context of relevant experience and expertise in Australia, where State Government's have been using satellite monitoring for a decade to monitor compliance with vegetation clearing/forestry legislation. This is the only sustained comparative example internationally where satellites have already been used to monitor an environmental law this way.

[17] Ray Purdy, UCL.

As part of this study, I spent 4 months in Australia examining the overall design, implementation and operational effectiveness of satellite monitoring programmes in 3 Australian States: South Australia, Queensland, and New South Wales. A survey of regulated farming communities in these States was also undertaken. This was to investigate the awareness and attitudes of those in Australia regulated this way, as well as to consider the impact of satellite monitoring on actual compliance with vegetation clearing legislation.

6.2.2 Scope of this Presentation

This presentation will provide some background information about how the satellite imagery is used by State regulators and some context as to why it is perhaps being used in Australia before other countries. It will also consider the legislation itself and whether provision for satellite monitoring was expressly included and why.

A key factor for the future use of satellite technologies is whether they can be more cost effective than what we have under current monitoring and enforcement approaches. This talk considers what imagery is being used and why, how much the imagery costs, as well as the other associated costs, which could come with operating a regulatory satellite monitoring programme.

Governments wishing to adopt a monitoring programme, which uses satellite technologies, may be required to have a far more strategic regulatory approach than other conventional land-based approaches. This presentation will discuss regulatory structures when using imagery based products and the challenges of interdisciplinary working when using satellites in a regulatory setting.

To date satellite images have been admitted as evidence in court in relatively few cases around the world. There have been many court cases in Australia where satellite imagery has been used and as a country it has an unrivalled wealth of understanding in knowing the usefulness and limitations of using it as evidence. This presentation will discuss satellite imagery in the context of admissibility as evidence, including a discussion on programmes on standardisation and best practice, which could influence its probity. I will mention the outcome of some these cases, how the judiciary in Australia have reacted to its use in the courts, and what they believe is necessary to make it more effective as an evidential tool.

There has also been little research, thus far, as to whether mere knowledge of being monitored by satellite could ‘press the right buttons’ in terms of having higher deterrence effect and influencing compliance behaviour. This presentation discusses whether this method of monitoring appears to have had a strong influence on the compliance behaviour of those being monitored this way. It uses the data from the surveys to give an opinion of the extent that regulated communities think they are being monitored and whether satellite monitoring might have ‘nudged’ some of them into compliance.

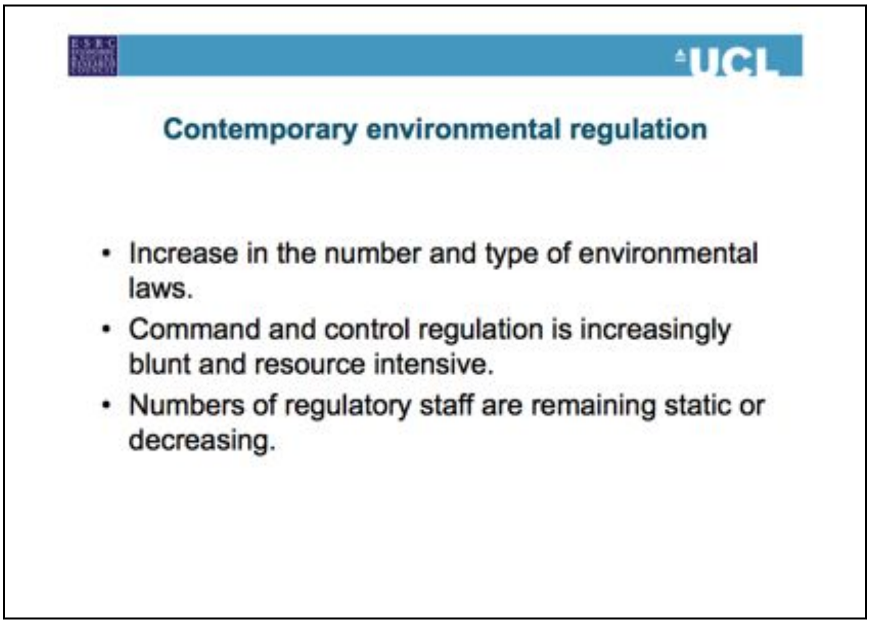
It will also consider the acceptance of satellite monitoring by regulated communities in Australia. Use of satellite technologies in a monitoring and enforcement context has the potential to polarise opinions. Although we are in an era of more pervasive technology, some regulated entities might dislike it on account of its ‘Big Brother’ characteristics, even though comparable data is publicly accessible on GoogleEarth. Conversely, others might embrace it and prefer it to ground-based checks, especially if it increased the opportunity for even-handedness and equal treatment in monitoring and enforcement. There has been little research to date about the attitudes of those that are monitored this way. This presentation will examine the opinions of farmers in Australia from the surveys and consider ways forward that might lead to improved co-operation and making this form of monitoring more acceptable to those being regulated using such technologies.

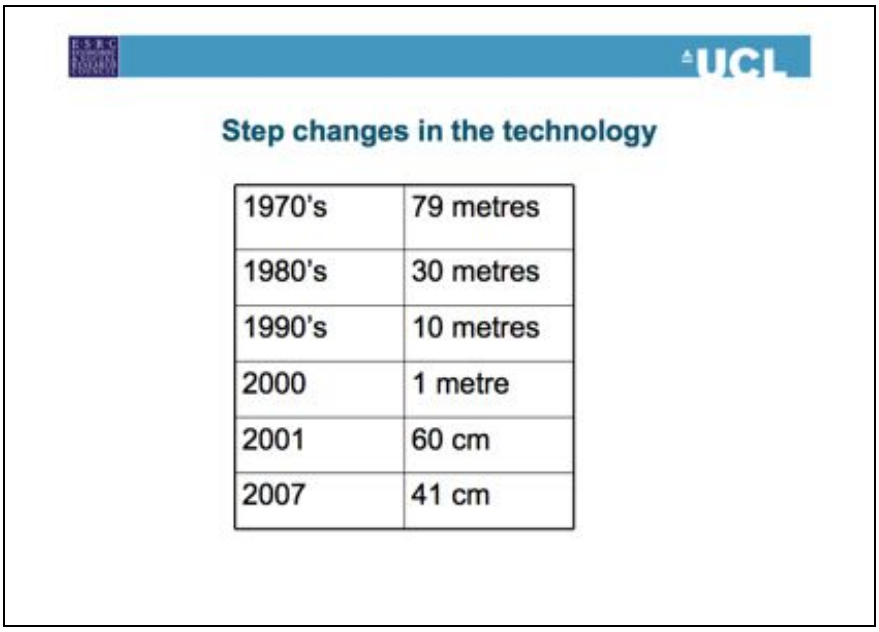
Finally the presentation will consider the overall impact that satellite monitoring has had in practice, in terms of compliance with the native vegetation legislation. Evidence of effectiveness and any measurable differences will be extremely important to those regulatory bodies considering using such technologies. On a basic level I will discuss whether it has worked and improved things and to what extent?

6.3 PRESENTATION

Because of its large land mass and low population density, Australia is ideal for satellite-based monitoring and has one of the largest bodies of legislation and decided cases in which satellite-derived EO information has been used in evidence.

Please note: The contents of the following PowerPoint presentation are from a UCL ESRC sponsored project: ‘Smart Enforcement in Environmental Legal Systems: A Socio-Legal Analysis of Regulatory Satellite Monitoring in Australia.’ Nothing in this PowerPoint can be used or reproduced without the author’s permission.





Potential drivers for satellite monitoring

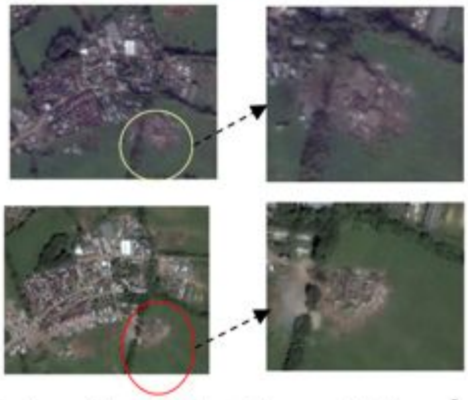
- If they have advantages over existing monitoring approaches (e.g. quicker, more accurate).
- If they can monitor something which could not be monitored by conventional means before, or where this was problematic to monitor.
- If its use can save money whilst protecting the quality of front-line services.

Legal research on satellite monitoring

- European Commission, 'APERTURE Final Report' (European Commission, 2000).
- NPA Group, 'Applications of Earth Observation to the Legal Sector' (British National Space Centre Sector Studies Programme Report, 2001).
- 'Satellite Monitoring as a Legal Compliance Tool in the Environmental Sector' (AHRC Study, University College London, 2008).

Using archived imagery to identify offences

- October 2005
- June 2004



- Offence was between May 2005 and January 2006.

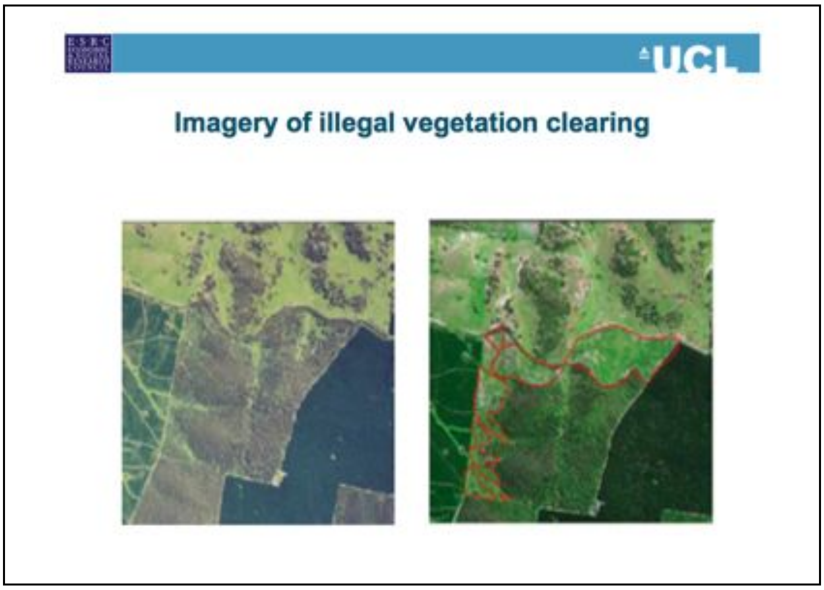
6

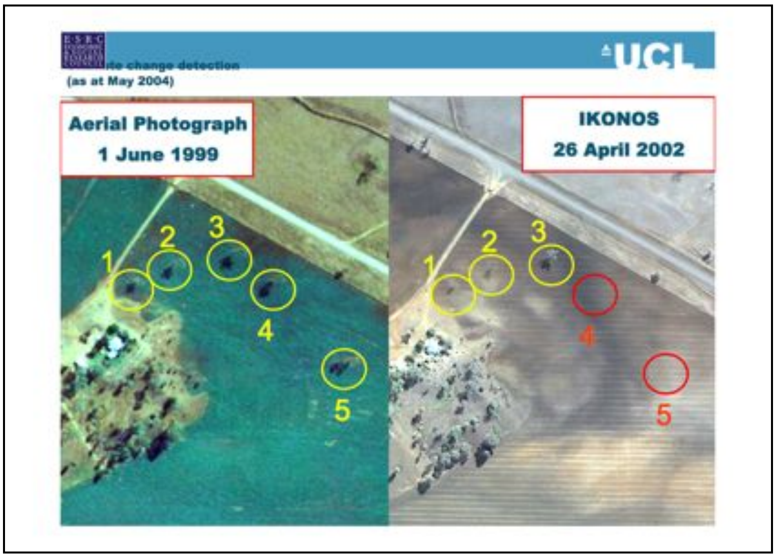
An Examination of Australia.

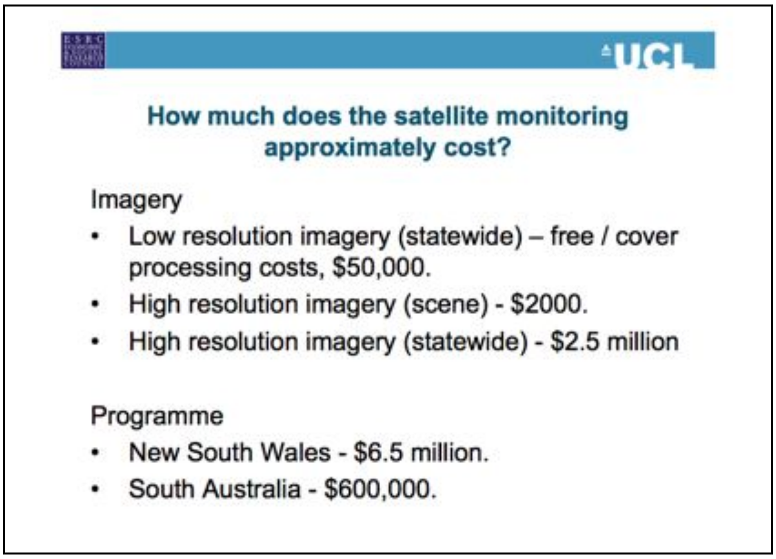
- first international example where satellites have been systematically used to monitor compliance with a specific environmental law.
- it has a wealth of understanding in knowing how to make satellite imagery 'game-fit' for court.
- there have been many lessons learnt, over a sustained period, that could be useful for regulatory agencies in other countries.

Remit of the ESRC study

- to consider the operational effectiveness and cost of existing Australian State satellite monitoring programmes and any constraints affecting their use.
- to investigate the awareness and attitudes of those regulated this way and to see if this has had an impact on their compliance behaviour.
- to analyse whether those regulated see it as a more/less desirable method of regulation than conventional forms of regulatory monitoring.


UCL
Imagery of illegal vegetation clearing


UCL
(as at May 2004)
Aerial Photograph
1 June 1999
IKONOS
26 April 2002
1
2
3
4
5


UCL
How much does the satellite monitoring approximately cost?
Imagery
• Low resolution imagery (statewide) – free / cover processing costs, $50,000.
• High resolution imagery (scene) - $2000.
• High resolution imagery (statewide) - $2.5 million
Programme
• New South Wales - $6.5 million.
• South Australia - $600,000.

Why is Australia spending money on this?

- There was practically no monitoring before this programme. It was impossible to adequately monitor vegetation clearance before satellites.
- In the time it takes inspectors to survey 20 hectares on the ground in Queensland, the remote sensing team can look at 2.5 million hectares using satellite imagery in the same period.

Queensland – reversal of burden of proof

- The equipment used is deemed to be accurate and precise and to have been used by an an appropriately qualified person.
- A statement of any of the following matters in a certificate or report is evidence of the matters stated in the absence of evidence to the contrary: (a) the person's qualifications; (b) that it is a remotely sensed image of a stated area; (c) the date on which it was produced; (d) the person's stated conclusions drawn from a stated remotely sensed image; (e) the location of the stated area; (f) whether vegetation in a stated area has been cleared;
- If a party wishes to challenge any of the above they have to give the other side 20 days of this and state the detailed grounds on which they rely.

Regulatory changes?

- Could potentially have more offences to investigation! Can't investigate all of these so have to prioritise how they are dealt with.
- Have to adopt more strategic approaches with interdisciplinary teams.
- Need for training and communication.

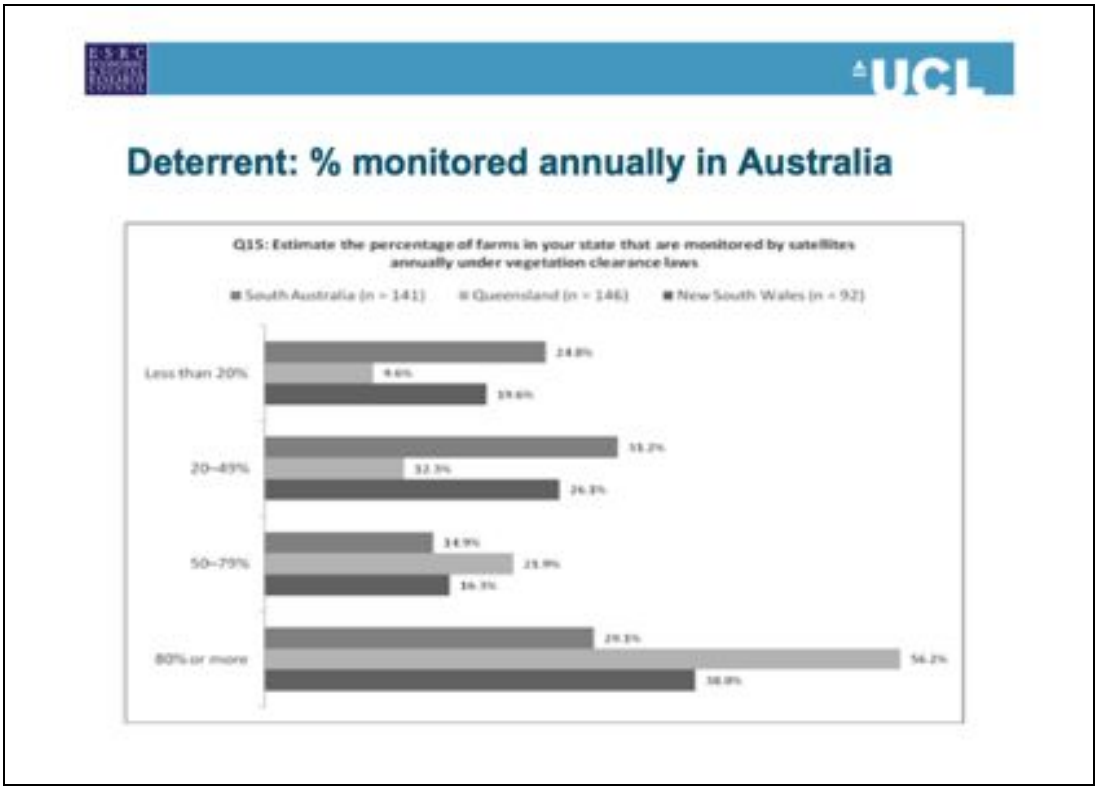
What is under attack in court?

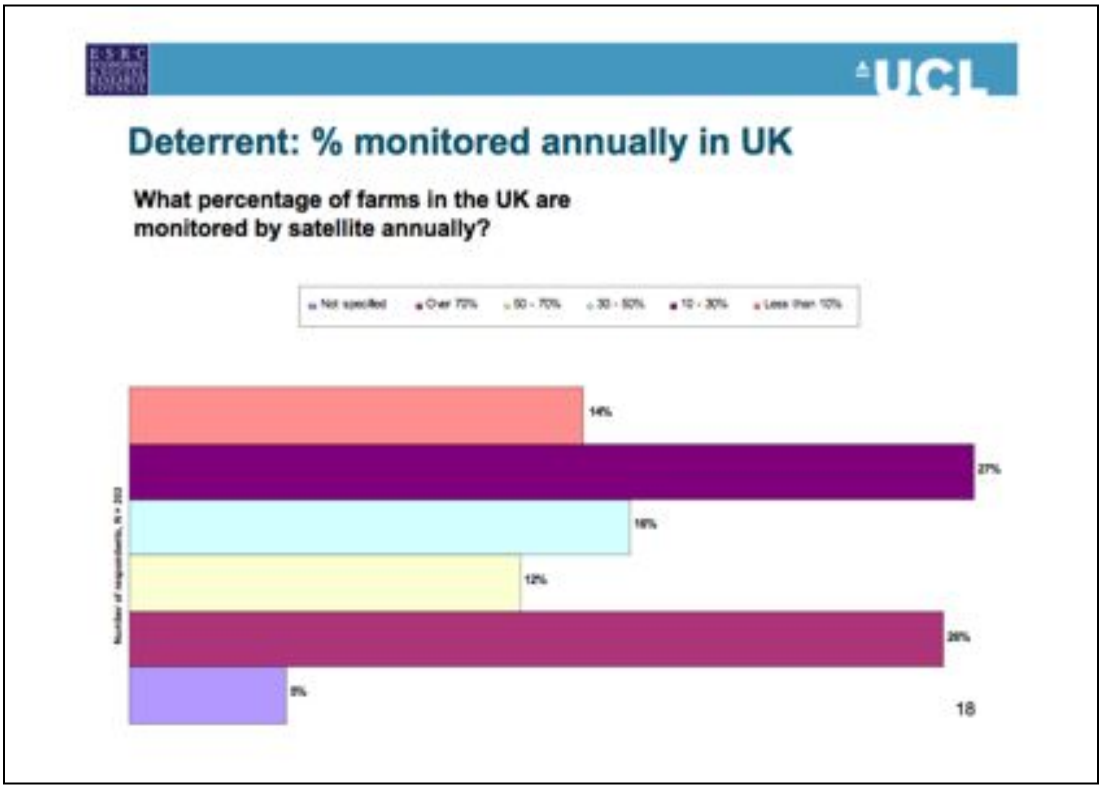
- potential for data changing of the imagery.
- the quality and accuracy of the imagery.
- whether the satellite was working correctly – was it even switched on?
- the experts interpretation of the imagery.
- the credentials of the Government expert working on the imagery.

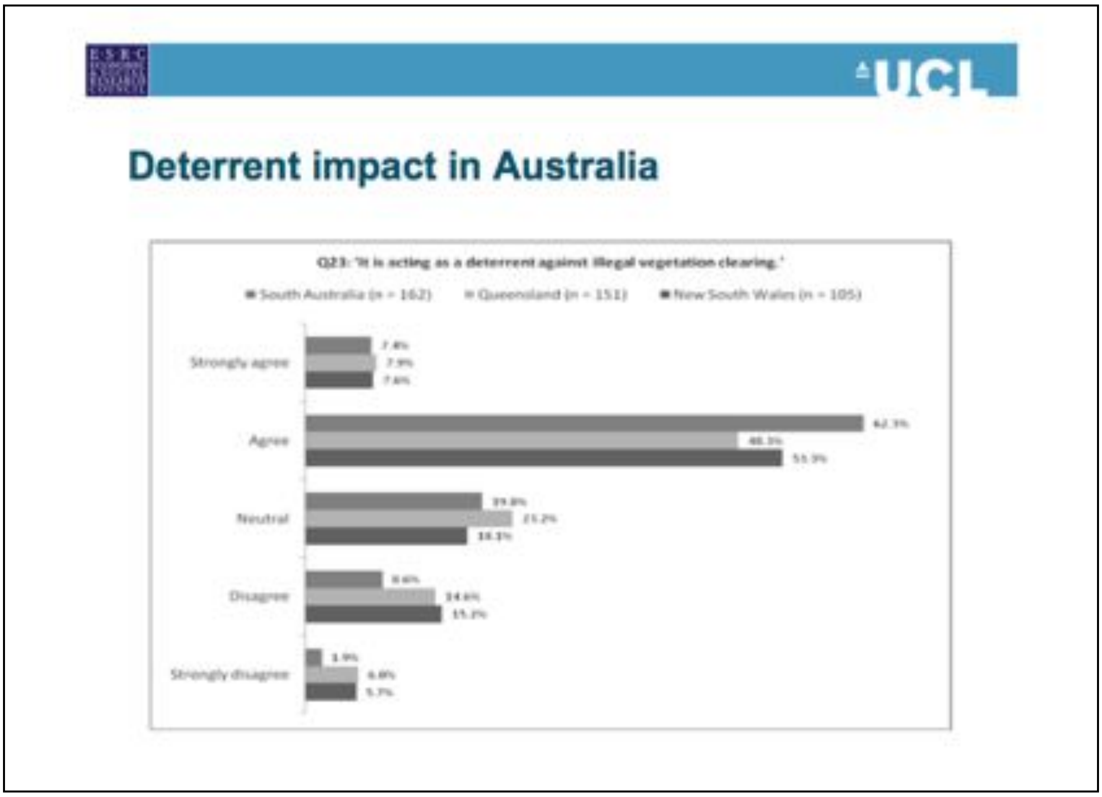
…but mainly legal procedure.

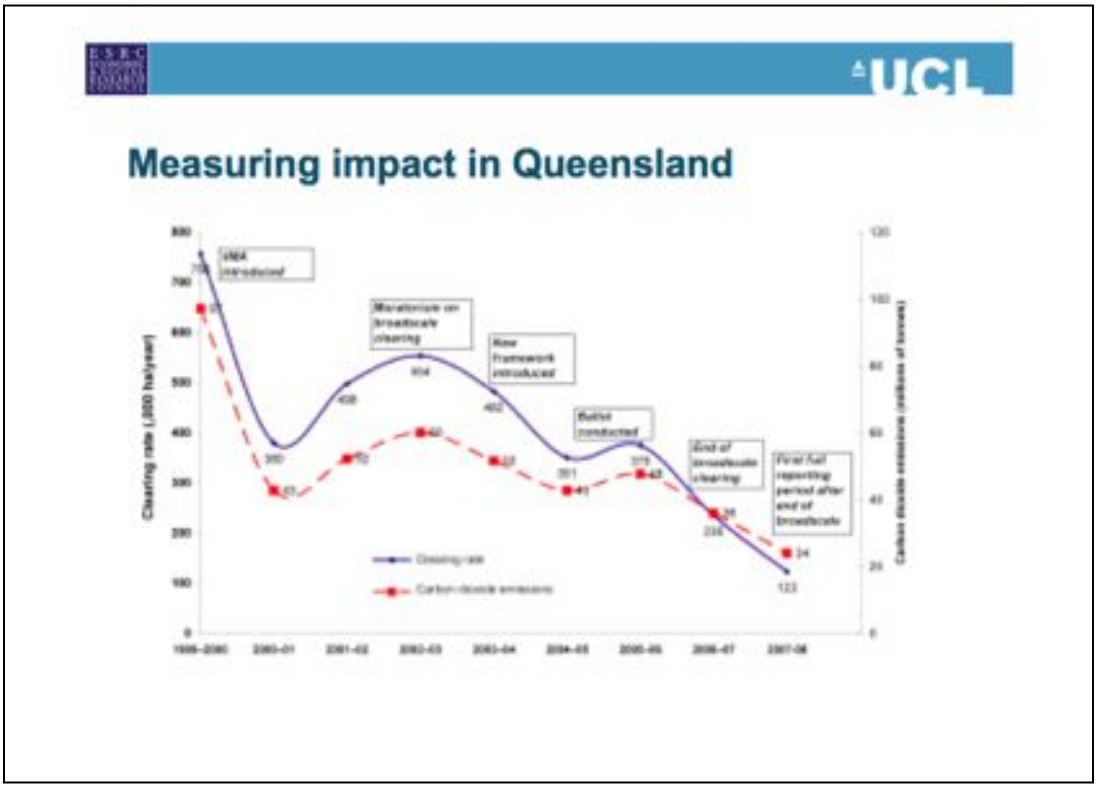
Standards – as to best practice

- British Standards Institution, '*Evidential weight and legal admissibility of electronic information*', BS 10008:2008 (2008).
- American National Standards Institute and Association for Information and Image Management, '*Legal acceptance of records produced by information technology systems*', ANSI/AIIM TR31-2004 (2004).
- International Organization for Standardization, '*Document management – information stored electronically – recommendations for trustworthiness and reliability*', ISO/TR 15801, 2nd edt. (2009).


UCL
Deterrent: % monitored annually in Australia
Q15: Estimate the percentage of farms in your state that are monitored by satellites annually under vegetation clearance laws
South Australia (n = 141)
Queensland (n = 146)
New South Wales (n = 92)
Less than 20%
20–49%
50–79%
80% or more

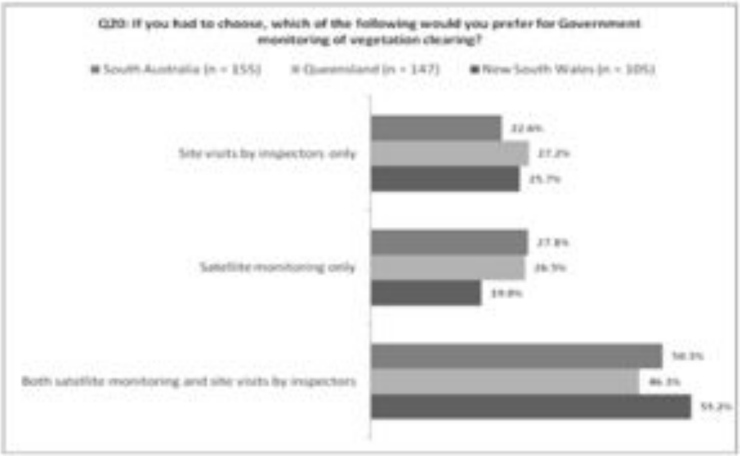

UCL
Deterrent: % monitored annually in UK
What percentage of farms in the UK are monitored by satellite annually?
Not specified
Over 70%
50 - 70%
30 - 50%
10 - 30%
Less than 10%
18


UCL
Deterrent impact in Australia
Q23: 'It is acting as a deterrent against illegal vegetation clearing.'
South Australia (n = 162)
Queensland (n = 151)
New South Wales (n = 105)
Strongly agree
Agree
Neutral
Disagree
Strongly disagree


UCL
Measuring impact in Queensland
Moratorium on broadscale clearing
New framework introduced
Ballot conducted
End of broadscale clearing
First full reporting period after end of broadscale
Clearing rate ('000 ha/year)
Clearing rate
Carbon dioxide emissions

UCL

Preferred method of monitoring



UCL

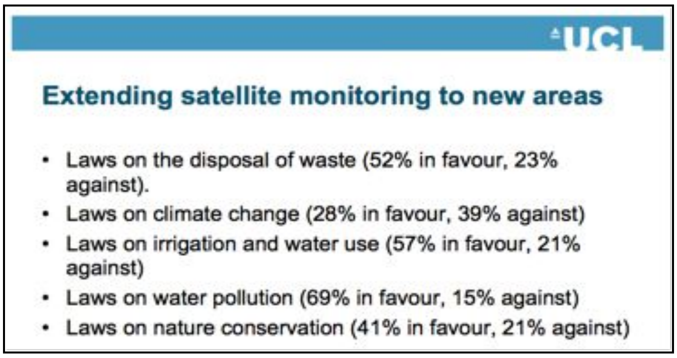
What did they like about satellite monitoring?

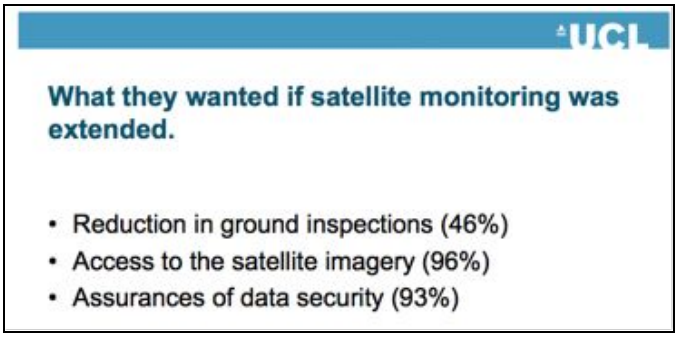
- It stopped dishonest people in the farming industry giving the law abiding majority a bad name (73%)
- It allowed them to operate on a fairer and more equal basis, assuming every farm was monitored (50%).
- It was a more consistent and accurate method than other means of checking (54%).

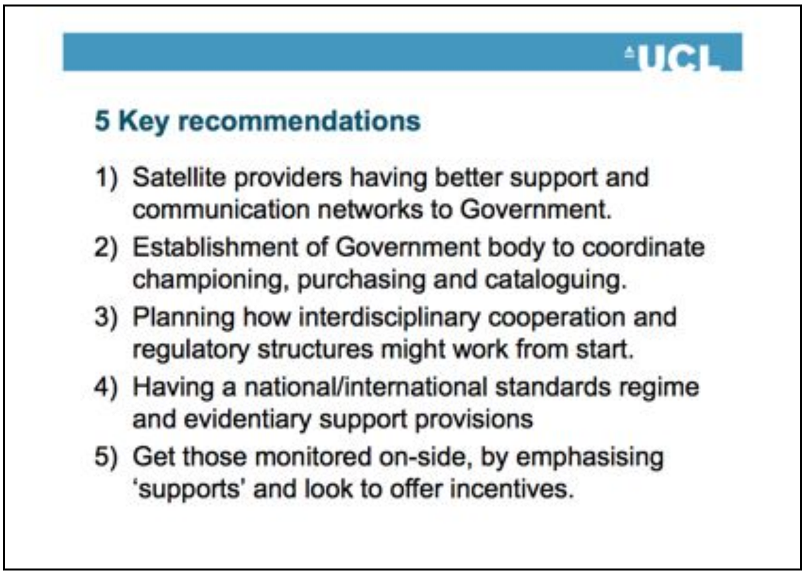
UCL

What concerns did they have?

- Not being given information on this (70%)
- Invasion of privacy (58%)
- That they weren't informed when they were monitored / 'Big-Brother' (84%)
- Data handling / trust in government (36%)







6.4 DISCUSSION

***Comment*:** At the UK Environment Agency detection is part of a bigger picture. About 30,000 environmental incidents are detected in the various disciplines. Around 1,000 infringers are prosecuted or cautioned, thus partially addressing the problem. Greater deterrence through prosecutions would be a real positive move. Use of satellites might create greater deterrence. Together with GPS and SatNav systems, this sort of evidence can work very well. This kind of evidence can be useful in some of the bigger landfill cases, where landfill sites are hidden away or filled surreptitiously over a long period of time. Satellite-derived information may be used not only as evidence in cases, but a really good deterrent, getting the message out that the satellites are there, and the Agency is able to use the evidence that comes from them.

Comment: Today much has been said about the ease of manipulating digital, which applies equally in the terrestrial environment. Has this had any effect in court proceedings?

Response: The chain of custody and what has actually happened is not generally under attack. In Australia the interpretation is often challenged, but not so much an original image that's been maliciously altered. That is quite a serious accusation to make against Government, and needs to be backed up with strong evidence. In Queensland, with the reverse burden of proof, to raise manipulation there must be some evidence of wrongdoing.

Comment: There is a very interesting article in the current edition of the Journal of Environmental Law, by Elizabeth Fisher, looking at environmental modelling. It addresses the extent to which environmental models are accepted on face value, despite all the underlying assumptions. It is beginning to explore why this hasn't been looked at before.

Comment: It should be noted that the Australian Government and the Information Privacy Commissioner considered privacy. They reported to the Department of the Environment that resolution of 3 cm was an acceptable monitoring level by satellite. Obviously systems are nowhere near that.

7. LAND SUBSIDENCE CASE STUDY

7.1 BACKGROUND MATERIAL FOR WORKSHOP

Sections 3.2 and 4.2 of this Workshop Report contain presentations that provide background for this Case Study.

7.1.1 The Hypothetical Scenario

Property A is the site of the office and a state of the art patented design warehouse owned by Four Level Ltd. (FL), a private defence contractor. Property B is adjacent to Property A and is the site of the office and warehouse of Glass Suppliers (GS), a plate-glass manufacturing company.

In January 2009, in order to increase the capacity of its storage facility by installing a basement, FL started excavating an area close to the boundary with Property B. The excavation and subsequent building works continued until March 2009. In April 2009, GS alleges that it observed cracks in the concrete foundations of its warehouse due to land subsidence. By September 2009, GS alleges that the degree of land movement caused damage to its stock and serious structural damage to its warehouse. GS alleges that the excavation by FL on Property A caused the land movement and claims damages.

There is satellite data available that covers both Property A and Property B. The data was processed as indicated in Technical Annex 7.1.2. The resulting information shows subsidence in the area of the excavation. Details of the subsidence and the technique used to measure the relevant land movement are also given in the Technical Annex. Two specialists were involved in the technical analysis of the data and its interpretation.

Aerial sensed information was also available. There are two sets, one dated December 2008 and another dated October 2009. These were produced by the government as part of its annual land mapping survey and made available to the public.

The ground evidence available was limited. Surveys were conducted in March 2008 for initial construction of the warehouse on Property A. No ground inspection has been carried out on

Property B because FL did not consent to have surveyors on its property. However there are surveys conducted by an expert engaged by GS on Property B, and also observing Property A from Property B in October 2009.

Both the aerial and land surveys support the satellite derived information.

7.1.2 Technical Annex

The satellite evidence was gathered from the ascending and descending orbits of the ESA satellites ERS-1 and 2 that produced satellite synthetic aperture radar (SAR)[18] data covering the period from January 2001 – June 2010. This was processed through the Permanent (or Persistent) Scatterer Technique (PSInSAR)[19] to identify permanent scatter points on both properties that over a series of images demonstrate deformation in the level of the land and buildings. PSInSAR facilitates detection of land movement at rates as low as 1 millimetre a year, depending on the number of radar images available, the type of radar sensor used, and the phenomena under study.

Analysis of the data shows land movement over an area of 500 metres by 500 metres, with the boundary of Property A and B at its centre. 20 measurement points were identified.

1. Using measurements at two monthly intervals the rates of change per year were:

January 2008 to June 2008	Rise at 0.2 cm
June 2008 to January 2009	No change

2. Change in area outside immediate vicinity of boundary:

to June 2010	No change detected

3. Change at Boundary of Properties:

January 2009 to February 2009	No change
February 2009 to March 2009	Drop of 0.2 cm
March 2009 to April 2009	Drop of 0.7 cm
April 2009 to May 2009	Drop of 0.2 cm
May 2009 to June 2010	Drop of 0.3 cm

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[18] Synthetic-aperture radar (SAR) is a form of radar in which multiple radar images are processed to yield higher-resolution images than would be possible by conventional means. Either a single antenna mounted on a moving platform (such as an airplane or spacecraft) is used to illuminate a target scene or many low-directivity small stationary antennae are scattered over a reception area, each imaging the target.

[19] Interferometric synthetic aperture radar, also abbreviated InSAR or IfSAR, is a radar technique used in geodesy and remote sensing. This geodetic method uses two or more synthetic aperture radar (SAR) images to generate maps of surface deformation or digital elevation, using differences in the phase of the waves returning to the satellite. Persistent or Permanent Scatterer techniques are a relatively recent development from conventional InSAR, and rely on studying pixels that remain coherent over a sequence of interferograms. In 1999, researchers at Politecnico di Milano, Italy, developed a new multi-image approach in which one searches the stack of images for objects on the ground providing consistent and stable radar reflections back to the satellite. These objects could be the size of a pixel or, more commonly, sub-pixel sized, and are present in every image in the stack. PSInSAR™ is an international trademark of Politecnico di Milano.

7.1.3. Questions to Discuss

1. Could the EO information be used in evidence in any legal proceedings relating to subsidence in this scenario?

2. What minimum standards must the EO information evidence meet in order to be admissible and probative in civil proceedings relating to land subsidence? What requirements must be met regarding:

- Collection of EO information;
- Processing of EO information (authentication, audit trail/custody chain); and
- Use of historical EO information.

3. What would the EO information be adduced to prove, and can it prove this?

4. Would the evidence act as primary evidence or merely corroborative evidence? Could this satellite evidence address the limitations of the aerial photography evidence with regard to ground truth requirements (if any) and act as an effective replacement for it?

5. Furthermore, what kind of expert evidence would be required with regard to the EO information, and additional causative aspects such as whether the land movement observed would have caused the damage?

6. Would the factors discussed above differ for different causes of action?

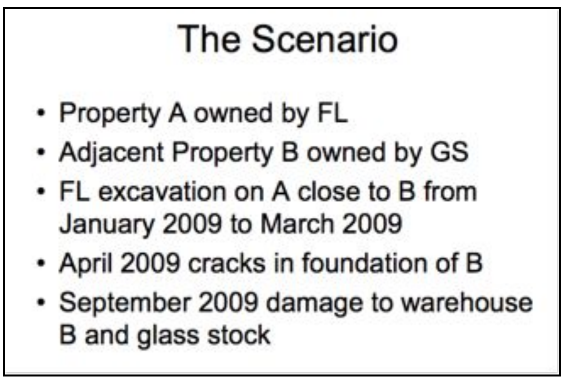
7. What are the potential limitations on the gathering and use of this EO information (particularly with regard to privacy, intellectual property rights, trade secrets, monitoring rules and national security)? What is the potential impact of these limitations (if any)?

8. Overall, do general principles emerge that could be applied to other cases?

7.2 PRESENTATION

Interaction between the technical and legal experts is a critical aspect of greater use of satellite-derived EO information as evidence. Further, the evidential requirements to be met by such information are fundamental to its use. To achieve both the desired interaction and to put the evidence to the test, a land subsidence scenario was devised and presented in a moot setting. The legal and technical arguments were separately presented and participants were invited to act as opposing counsel, expert or judge.

The scenario and the issues arising from them are as presented in the pre-workshop papers. While it is similar to the Rovigo case, it is not identical. Note that legal facts are not absolute facts, as was perhaps suggested this morning. It's about the margin of error.



Four Level Limited (FL) owns property A. It is adjacent to Property B, owned by Glass Suppliers (GS). FL excavates on its own land, but close to the boundary with Property B, between January and March 2009. In April 2009, cracks are discovered in the foundations of Property B's glass storage facility. By September 2009, there is damage to the warehouse and the glass stock in the warehouse.

GS Claim

- Cracks in April 2009 due to excavation
- Land movement continued to September 2009 also due to excavation
- Subsidence caused damage to warehouse B and stock of GS

GS claims that there were cracks in the foundation in April 2009. Counsel asserts that this was due to the excavation of Property A that caused the land movement, resulting in damage to the warehouse and stock of GS.

Available Information

- SAR data 500 by 500 metres; 20 Reference points; boundary of A and B at its centre
- Data for period January 2008 to June 2010
- PSInSAR used to process the information
- Government aerial data for Dec. 2008 and October 2009
- Ground survey Mar 2008; Oct 2009 from B

SAR radar data was analysed. It is asserted that it shows movement in the land, greater at the boundary of the two properties than in the area 500 metres by 500 metres surrounding it.

Data has been analysed from January 2008 until June of 2010. It shows an increase in the rate of subsidence just after the excavation. Further support for this contention comes from government aerial data obtained in December 2008 and October 2009. This is provided as corroborative evidence. GS's case is that the satellite evidence is sufficient.

There is also a ground survey in March 2008 FL, prior to excavation of their land. Finally, there is a land survey of October 2009, only from Property B because FL would not allow access.

Evidence Adduced

- Proven cracks and damage due to subsidence
- Raw SAR data from EO Provider
- PSInSAR analysis by Expert E1 and E2
- System security and custody
- Caliberation and accuracy of system

The evidence submitted is that the cracks are due to subsidence. GS's case is that subsidence occurred because of FL's excavation and for no other external reason. The case is supported by SAR data. The providers will present their permanent scatterer analysis. It is comparable to the data obtainable on other systems, with a good chain of custody. It has gone from one computer system to another.

If calibration and accuracy of the system is in issue, there is a certificate from an organisation that has developed a standard. It is not an internationally accepted one, but the organisation is in the business of calibrating and determining the accuracy of satellite systems.

System

- Certification of satellite system
- British Standard BS10008 covers: Management of the availability of electronic information over time;
- Electronic identity verification, including use of electronic signatures, and linking electronic identity to particular electronic information.
- It does **not** cover processes used to evaluate the authenticity of information prior to it being captured in the system.

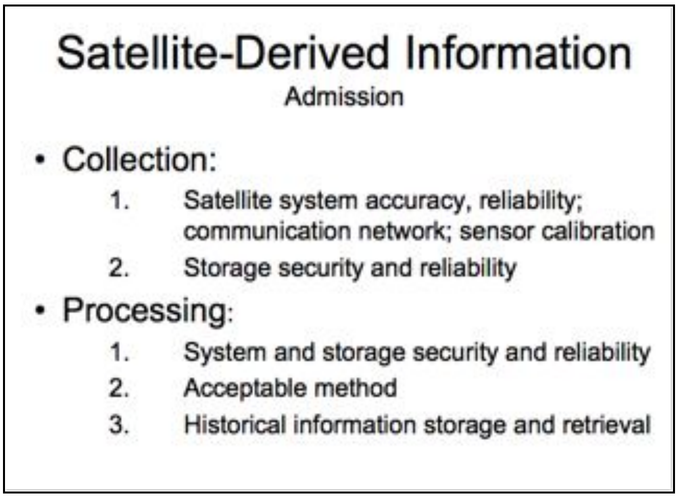
Standard BS10008, which covers the management availability of electronic information over a period of time, was not used.

Processing and Storage

- Objective measurement of the trustworthiness of their repository.
- Draft ISO 16363: The repository's written standard operating procedures and actual practices to ensure digital objects are obtained from the expected depositor. Examples of a Producer include persons, organizations, corporate entities, or harvesting processes.

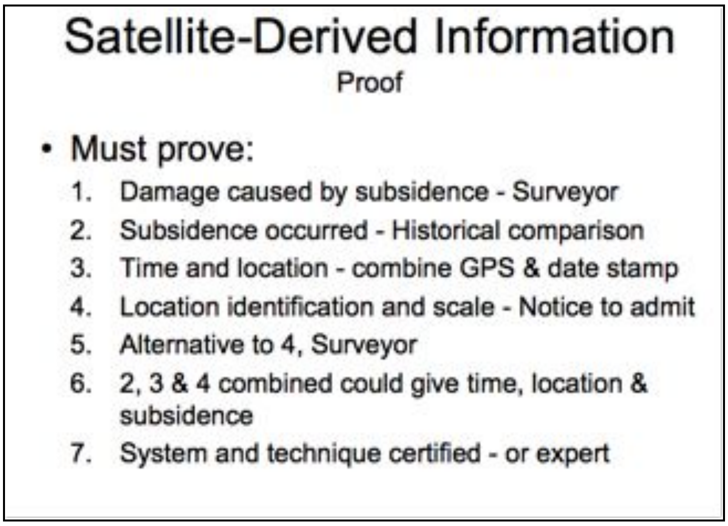
The draft ISO touches on processing, but is was not adopted for this case. The case is that the certification is adequate.

There is no system for identifying minimum qualifications. However, the education, knowledge, background, skill and experience of our experts have been established. The method has been peer reviewed. Methodology will be explained by the expert witness, who will also give an indication of how the technique distinguishes a level of movement over a period of time.



Participants are asked to consider challenging on several grounds. On admissibility, are system accuracy, calibration, storage and security adequate? Does the processing follow an acceptable method? What is an acceptable method?

The case differs from Rovigo to the extent that in Rovigo there was historical data going back 10 years. Here, there are about 2 years. Is that sufficient to show the stability of the ground prior to the excavation?



To succeed we must prove these facts. The surveyors' reports indicate that the damage was caused by subsidence. The 2 years of historical data is sufficient to show that the subsidence occurred because of the excavation, and for no other reason. There is time and location evidence.

The burden of proof might be reversed. A Notice to Admit that the system is accurate and that the land movement is as indicated by the satellite, might be served.

Evidence from surveyors and land measurements might be offered, as an alternative to proffering the satellite information. However, GS was not given access to Property A to do a proper survey of the land level.

Next, the expert witness will present the case: the evidence and why the historical data is sufficient. Typically 2 years is not enough. It depends on the quality of the measurement points. In an urban area, there would be about 400 measurement points per square kilometre, and here, in just 500 x 500 metres, we have 20. This is sufficient in this case because the very best points were selected.

It is important to note that there are two independent data sets. One is acquired along ascending orbits, and one along descending orbits. The combination of the motion of the earth and of the satellite makes it possible for an area to be imaged by two independent acquisition geometries. If the measurements are exactly the same, using two independent data stacks, it's like having two companies in charge of optical levelling surveys finding exactly the same displacements over the very same area of interest.

Another important point is that the dates of the acquisitions are beyond any reasonable doubt, because ESA confirms the time of the radar image. Typically a measurement point is characterised during a period when no event is occurring. The error and the number of points outside that threshold may be relevant.

In this case there are three images indicating movement. With two independent acquisitions and a typical error rate, to have the same results by accident is unlikely (in the order of 10^{-2}).

There are five points within the area of interest, showing almost exactly, the same. The expert opinion is that the probability that these kinds of results are generated by random noise is really extremely low, beyond 10^{-6}, so 1 in 1 million. The data are evidence of the fact that the displacement occurred in 2009.

7.3 Discussion

***Comment*:** Accepting that the damage has been caused by subsidence, there can be many causes of subsidence such as hot weather or trees growing nearby. We need to know that there are no other reasonable causes of subsidence. That would be a very important part of the evidence.

***Response*:** That point is covered by the choice of reference points. These reference points are the points in comparison to which the area of interest has moved. The five points are fixed, and the observations reveal that the movement has occurred at the boundary between the two properties. The only difference there is that the excavation took place, leaving no other rational explanation is subsidence at the boundary due to excavation, because the surrounding land did not move.

***Comment*:** Water extraction could cause the subsidence. There is no proof this particular property was not extracting water from its water table immediately below the property in that period alone, and hence the signal would have appeared.

***Response*:** The party alleging the cause is water extraction must adduce evidence of that fact. The expert witness is not giving evidence of the cause; merely that there was subsidence in this amount on the boundary of these two properties.

***Response*:** In this hypothetical scenario, determination of the cause will depend very much on the spatial distribution of the measurement points. Where there are 3 on property A and 2 on property B, and the time series show exactly the same behaviour so that there is indeed correlation, there is just one phenomenon rather than two independent phenomena taking place. Radar specialists provide the very best measurements to geologists, to geophysicists or structural engineers. But they are not the experts who can say a word about the reason for the subsidence.

***Comment*:** How many data sets were used? Would it not be nice to have a longer period before it happened, to exclude a general movement that is not caused by the excavation? And a question is, how accurate is your measurement?

***Response*:** The question is about the number of images. 20 images were used in this hypothetical scenario, but typically in real cases all available radar data are always used, no matter the numbers. For Rovigo, there were 120, and in another there were 300. For example, to decide to evacuate a section of a village where, say, 200 people live (and that's a real case), the information needs to be very reliable. In that case 3 independent data sets were used, showing exactly the same amount of motion in all 3 independent data sets. It is then up to the authorities to decide whether or not people can stay there. This is something that happened 6 months ago, and probably there will be litigation, because people don't want to leave their own houses.

***Comment*:** Is there a minimum number of reference points that need to be present?

***Response*:** The rule of thumb is 30, but it really depends on the area of interest and the quality of the measurement points. There also needs to be a reasonable data archive over time. It is important that there be regular acquisition over the whole of Europe and creation of a data archive.

***Comment*:** What makes this case difficult to take seriously is the lack of ancillary information, present in real world cases. In a subsidence case one would expect information about the weather, because a long period of dry weather could lead to subsidence. And it might be preferential, under one particular property for all sorts of reasons, due to geology, or due to construction techniques, or seismic information would be another. To present a case that only relies on satellite data is so different from the real world, where satellite data is always just a part of the evidence base.

Response: This point goes to causation, in other words, is it that the excavation is cause of damage. The satellite information is being accepted as evidence that there was subsidence. That is the area being explored in this Case Study. There was a discussion this morning about error margins, and maybe that aspect can be discussed.

Comment: The court needs to be convinced about atmospheric effects and how they have been taken care of, and reassured that there is nothing peculiar about the local topography that might give rise to these sort of features just as artefacts.

Response: In this case the problem is very local, so the area of interest is very small, just a couple of hectares, and as reported in the literature, atmospheric effects are very well spatially correlated. The double difference between the point of interest and the reference points outside of the area of interest were considered. And this typically is enough, at least for a very local area, to get rid of atmospheric effects.

Comment: The software program raises questions about how the figures that come out of the raw data are produced.

Response: The processing chain is very complex, involving some 1 million C code lines, certified to the extent possible, including under ISO 9000. The key question here is that at least in principle, for small areas, it's possible to re-generate the same results even if you don't run the 1 million line C code processing chain. That's an important fact.

Comment: Agreeing there is no fault-free software available, the aircraft industry for can be used as a model. In that industry, two separate softwares do the same analysis. If both come to the same result then it is okay. Otherwise the software is not fault-free.

Response: PSInSAR will probably become a standard tool, but it is not yet a commodity. Data is obtained from ESA, and processed using two independent processing chains developed by two research groups. If exactly the same results are produced, one can rely on the result. It is a problem when the two results tell two very different stories.

Comment: To establish tort liability there must be, first, a causal link between the fault of the Defendant and the damage. The causal link here has been based on exclusion, because there was no other event in the relevant period. Some doubt was expressed because no other potential causes were considered. Second, the extent of the damage should be shown. The technique here does not do so. Third, the responsibility of Company A is to be established.

Comment: None of the measurements have an error associated with them. In the absence of that evidence, it is difficult to know what the numbers mean. The method used has a certain heritage, but when does it work and when does it not work? And is this method being applied under conditions when it's absolutely known to work, and how close are the limits of it working? One would need to be able to make clear statements about those elements.

Response: It's very important to put in writing the level of reliability and the probability of false alarm you have in any measurement. Usually a report in litigation is based on more than 5 measurements. So this is a very hard situation.

Comment: The causal components have been questioned. But, using some slightly wider-area techniques would eliminate some of those objections. For example, with water extraction, or mining, or some geological fault, if the area beyond the 500 metres boundary or the locale of the buildings was stable in the perimeters, the causal connection is strengthened.

Response: That is why for example in Rovigo a 20 sq km area was used.

7.4 ISSUES IDENTIFIED BY LAND SUBSIDENCE CASE STUDY

7.4.1 Requirements of EO Information

Here a company produced the EO information, as graphs and colour interferometry images demonstrating the variance in the height of specific areas of land and structures identified by the permanent scatter points.

Authentication of EO information, from satellite acquisition of data to generation of EO information, is critical in admission of EO information as evidence in court or before a tribunal. The court is not specialised in analysing EO information, and relies on the authentication by experts and those involved in the control of the data and their processing.

In this case there is satellite data available covering the period January 2008 to June 2010. There are no rules regarding the use of historical EO information. What is a reasonable period depends on the specific situation. In the *Rovigo* case the satellite data covered a period of about eight years (1992 to 2010) and the evidence was admissible in court.

7.4.2 How to Prove Subsidence

EO information would be adduced to prove change or lack of change in land movement of land over an extended period. The standard method to ascertain land movement is the PSInSAR technique with a linear motion assumption (only targets with a linear motion pattern are measured). The technique can provide information about how motion patterns evolve in time and space. If rapid motion patterns occur (as e.g. in the case of mining activities) more advanced processing can be applied; a customized service available from most PSInSAR providers.

7.4.3 Primary or Corroborative Evidence

The EO evidence is often used as corroborative evidence. EO images identify suspicious activity. It can be combined with other evidence, such as aerial photographs or ground inspection. This was not a problem in the *Rovigo* case.

However, aerial photography evidence is readily available, but buying satellite data may take time. In cloudy conditions, EO images are not clear enough. In this case there are two aerial photographs available. They were taken on two dates.

EO evidence is a first step in pro-active investigation. In this case it was more a retroactive investigation. EO evidence can be an effective replacement in the pro-active investigation. But on suspicious spots, ground detection or aerial photography may be required.

7.4.4 Expertise

In this case processing of the satellite data was carried out by two staff members, a senior staff member qualified in the analysis of satellite data, and an assistant. This expertise is required to analyse the satellite data. But to answer the question whether the observed land movement would have caused the damage, an expert surveyor would be necessary.

7.4.5 Causes of Action

The admissibility would not differ for different causes of action. GS claims damages in a civil proceeding. It would not differ if the action were in a criminal case or administrative proceeding. The only factor that would differ is the standard of proof in accordance with the burden of proof.

7.4.6 Potential Limitations

An issue is whether collecting EO images in this case breaches privacy. Satellites and aerial optical cameras cannot look into buildings. As long as satellites and aerial sensors detect and measure non-optical radiation, such as heat and other waves, particular considerations apply in determining whether there is there is a breach of privacy.

The government on security grounds can limit taking aerial photographs. The term "security" includes public health, public order, morality, and economic interests. In this case aerial photographic evidence is available. These were produced by the government as part of its annual land mapping survey and made available to the public.

An issue in this case maybe whether aerial photographs, made available to the public, breach the privacy of FL. Especially when FL did not consent to have surveyors on its property. However there are surveys conducted by an expert engaged by GS on Property B, and also observing Property A from Property B in October 2009.

7.4.7 Conclusions

1. EO information can be used in evidence in any legal proceedings relating to subsidence in this scenario. EO information can be combined with other evidences, such as aerial photograph evidence.

2. Privacy and intellectual property right of TRE may be obstacles to use. However, the evidence remains admissible in any legal proceeding.

3. To be probative, EO information needs to be verified and authenticated. Its interpretation generally requires expert evidence.

4. To measure the damage caused by land movement to the warehouse, ground detection is necessary.

8. OIL SPILL CASE STUDY

8.1 BACKGROUND MATERIAL FOR WORKSHOP: SATELLITE CAPABILITIES FOR OIL SPILL DETECTION AND POLLUTER IDENTIFICATION[20]

8.1.1 Summary

CleanSeaNet is the near real-time European satellite oil detection and monitoring service set up and operated by the European Maritime Safety Agency since April 2007. On-site verifications carried out by the Member States have proved that the service is very efficient in detecting oil spills. As vessel traffic information is available in CleanSeaNet, the service is able to detect and identify vessels that are discharging. Proving the nature, legal or illegal, of the discharge detected by CleanSeaNet requires that additional evidence is collected on site or

[20] Author: Marc Journel, European Maritime Safety Agency. See also his presentation in Session 3.4.

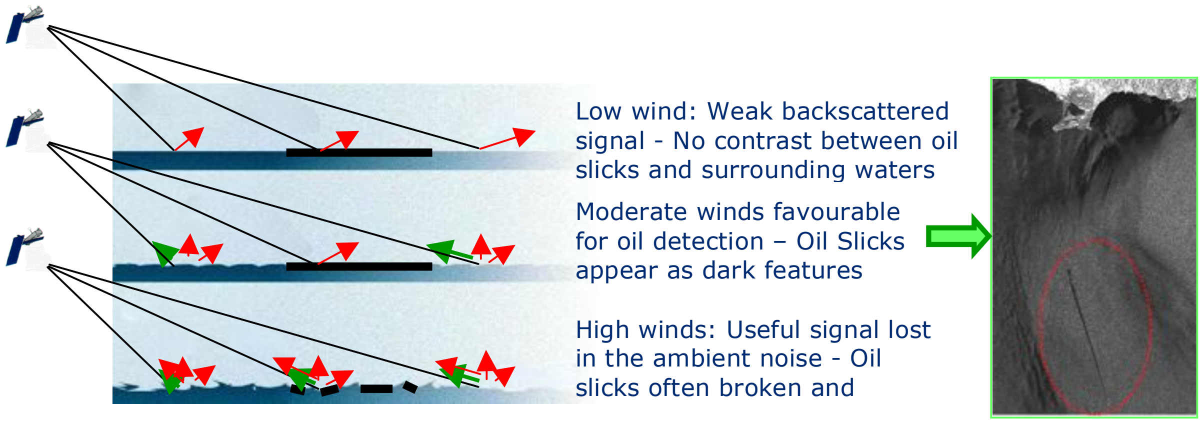
in port. Nevertheless, a possible spill detected by satellite may be considered sufficient to constitute a suspicion that a ship has been engaged in an illegal discharge and to request an inspection in port. More and more ships are detained and fined as the result of inspections triggered by CleanSeaNet.

8.1.2 Satellite Capabilities

In the 1980s, many European coastal states developed marine pollution monitoring capabilities based on airborne surveillance systems using low flying aircraft. Side-Looking Airborne Radar (SLAR), which is able to detect a large variety of pollutants (such as oil spills) and other phenomena on the sea surface, is the main detection equipment. Its use, in combination with other sensors like Infrared/Ultraviolet Scanners (IR/UV), Microwave Radiometers (MWR) and Laser-Fluorescence Sensors (LFS), provides the spectral signature of detected substances. It is possible to distinguish not only mineral oil from other substances, but also to differentiate between different types of oil, and to estimate the oil spill thickness and thus the volume of the spill.

It should be noted that despite progress made on developing remote sensing equipment, visual detection by experienced operators remains a key element in confirming spills. Many European countries use the Bonn Agreement Oil Appearance Code that correlates apparent oil colour and slick thickness. In some Member States, visual observation is considered sufficient for bringing a suspected vessel into port for further investigation, and is accepted in court as the main piece of evidence.

Satellite Synthetic Aperture Radar (SAR) imagery became available in the 1990s.[21] SAR sensors detect the dampening effect of oil on the sea surface. A smooth surface will appear as a black pattern on the SAR image, whereas a rough surface will be much brighter. Even very thin oil films, some measuring just micrometers, can be detected from space. This process is, to a large extent, independent of weather and visual conditions and allows the detection of oil pollution through cloud cover.



The development of satellite oil detection and monitoring techniques offers new possibilities to monitor wide areas at regular time intervals in a cost efficient way.
However, by the mid 2000s, few European countries had integrated a satellite component in their national response chains to complement aerial surveillance.

21 Launch of the 2 first European SAR equipped satellites ERS1 (1990) and ERS2 (1995) and of the Canadian satellite RADARSAT1 (1995).

In 2005, the European Parliament and the Council adopted Directive 2005/35/EC, which incorporates international standards for ship-sourced pollution into Community law, in order to discourage illegal discharges through the application, by Member States, of adequate penalties to polluters. The Directive, which entered into force in 2007, tasked EMSA to "work with the Member States in developing technical solutions and providing technical assistance in actions such as tracing discharges by satellite monitoring and surveillance."

The Agency has set-up and operates, since April 2007, the first near real time[22] Europe-wide satellite oil detection and monitoring service called CleanSeaNet. Authorities using CleanSeaNet in the Member States are alerted less than 30 minutes after satellite overpass when a possible spill has been detected and whether the spill can be correlated with an identified vessel.

CleanSeaNet uses three polar orbiting SAR satellites: ENVISAT, RADARSAT-1 and RADARSAT-2. ENVISAT provides 405 km swath coverage, and RADARSAT-1 and -2 provide 300 km. Swath coverage refers to the width of the land strip covered by the radar at each overpass. The frequency of observations for polar orbiting satellites is significantly greater at higher latitudes than at the equator. Therefore, having access to three wide swath capable satellites mitigates orbit constraints and increases CleanSeaNet flexibility for surveillance operations in support of illegal discharge response chains. European waters can be covered several times per day according to the needs of each individual Member State.

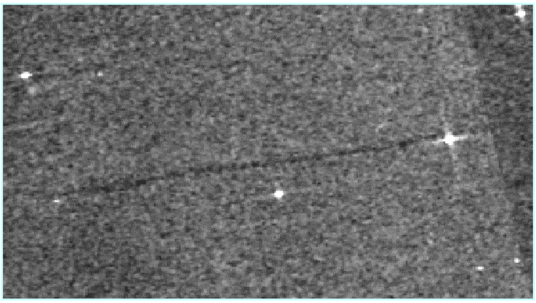
Time is critical for catching polluters in the act. The shortest possible delay between satellite detection and alert is essential for a rapid response by coastal states. It was possible to achieve this through access to a network of ground stations. When ENVISAT or RADARSAT satellites pass over European waters, they are always within range of the ground stations in the CleanSeaNet network. As a result, data can be regularly acquired and simultaneously downloaded to the receiving station. SAR data require complex processing before they can be used for oil detection. Being able to deliver analysed SAR images in near real time and to quickly inform Member States of the location of potential spills, is a real challenge. Image acquisition, processing and analysis within the CleanSeaNet service is contracted to a Consortium of European companies (KSAT, e-GEOS and Edisoft), and it is a contractual obligation that all CleanSeaNet products are delivered in less than 30 minutes.

Nevertheless, it is important to note that current sensors do not detect "oil spills" but "possible oil spills". This is due to the fact that SAR satellite images cannot provide information on the nature of a spill (mineral oil, fish or vegetable oil, other look-alikes). Discrimination between oil spills and look-alikes require more information and most often on site verification.

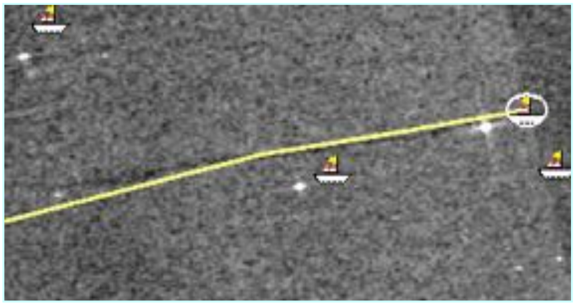
The first three years of CleanSeaNet operations have demonstrated that SAR satellites are efficient for the detection of oil spills. During the period 16 April 2007 to 31 December 2009, CleanSeaNet detected 7,193 possible spills. Of these, the Member States verified 1,997 on site and 542 (27%) were confirmed as being mineral oil. The overall rate of confirmation is not representative of the real performance of the service. A more detailed analysis for 2009 shows an increase of the confirmation rate from 25% to 38% when aircraft checks spills. This rate reaches 51% if the aircraft checks the spill no later than 3 hours after satellite acquisition. In contrast, confirmation rates drop when other assets are used: only 8% of the spills checked by patrol or merchant vessels were confirmed.

22 Satellite SAR data received need to be processed before they can be used operationally. Consequently, data availability will always be subject to a small delay. Near Real Time implies that this delay is reduced as much as possible. For the purposes of CleanSeaNet, the near real time limit has been successfully reduced to 30 minutes.

The CleanSeaNet network is able to detect and identify vessels that are discharging some kind of substance, whether legally or illegally. Discharges detected by CleanSeaNet appear as long and linear dark features on radar images. In addition, like any radar, SAR sensors are able to detect ships due to the reflection of metallic elements on the vessels. A ship will appear as a bright dot on the sea surface. When a long and linear spill is detected trailing in a ship's wake, there is little doubt that the ship was discharging at the time of satellite acquisition. Identifying the vessel can be done either by on-site verification or by using vessel traffic monitoring information systems. More and more European countries have developed integrated surveillance systems of which vessel traffic information is one component. AIS information collected by the coastal stations in the Member States is made available in CleanSeaNet via SafeSeaNet as a layer displayed on top of SAR satellite images. The two images below show a typical example of a possible discharge linked to an identified possible polluter.



Zoom on a spill detected by CleanSeaNet[23]

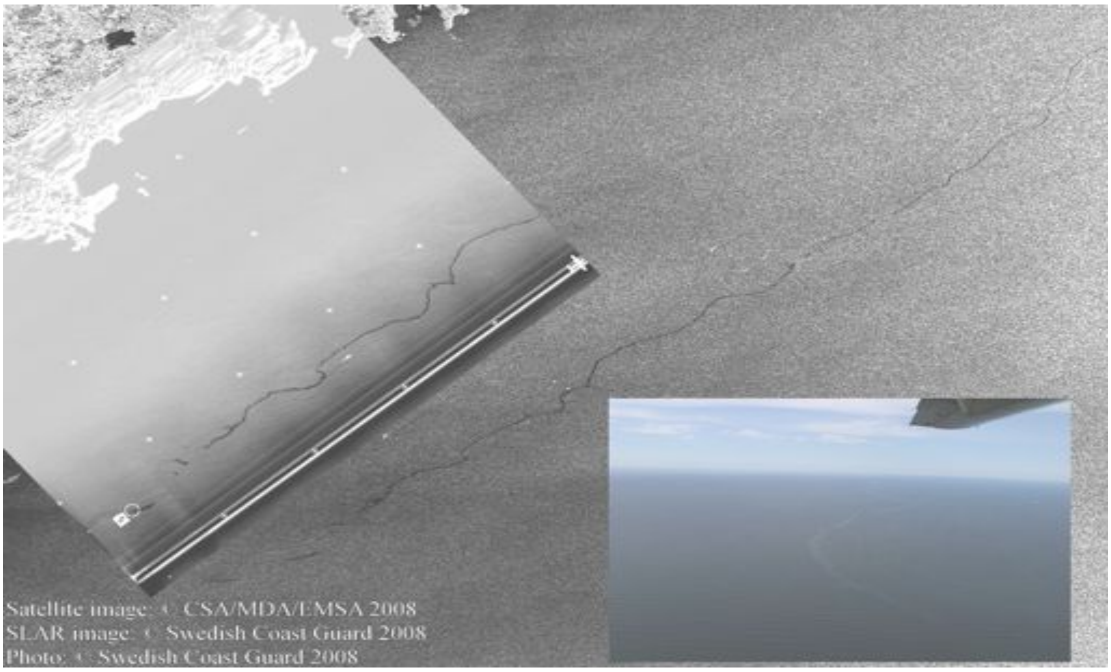


The same spill overlaid with AIS information

The use of hind-casting oil drift modelling tools combined with vessel traffic information further enhances the capabilities of the authorities in the Member States to identify polluters. Backtracking of spills and intersecting the trajectory with vessel tracking data limits the number of potential polluters and allows authorities to carry out more in-depth checking of suspicious vessels.

Proving that a detected discharge constitutes a MARPOL violation requires complementary evidence. Enforcement actions undertaken by the Member States are based on the evidence collected on site or in port. When evidence is collected on-site, CleanSeaNet can be used to bring corroborating evidence, for example to demonstrate the full extent of a spill or to demonstrate a clear link between the spill and the polluter.

23 The echo of the vessel is not exactly in the alignment of the track. The offset is due to the Doppler Effect that comes from the way SAR radars are designed. Vessels symbols are also not matching exactly the spots. This is due to the fact that AIS positions are transmitted by the vessels every 6 minutes and do not coincide with the time of acquisition.



A possible spill detected on a SAR satellite image may be considered sufficient to constitute a suspicion[24] that a ship has been engaged in a discharge and provide the basis for further investigation. More and more Member States use CleanSeaNet detections to trigger an inspection in the next port of call of the suspected vessel whether or not on-site verification activities have been carried out at sea. A number of polluters have been detained or fined on the basis of evidence collected during such inspections like in the following recent example: A discharge originating from an identified vessel is reported by CleanSeaNet off Sicily on 18 August 2010. No on-site verification has been carried out but Italy requested an inspection in the next port of call. Information reported by the authority of the next port of call clearly proves that the ship has been illegally discharging.

8.1.2 HYPOTHETICAL SCENARIO

Despite protests by shipping and environmental interests, the port of Haven in Country A in January doubled its berthing, to manage demand.

Company *MakeProfit*, registered in Country B, owns the container vessel *Dark Sea*, registered in Country C. *Dark Sea* is old and poorly maintained. According to one of the crew, Nga Duc, the ship's master, Captain Salt, said he had pointed this out to MakeProfit's CEO, Shirley Doller, who had told Salt to "make do". Salt recounted that she had also instructed him to keep berthing costs "at the level they were before". The only way Salt can do this is to spend less time in port. This leaves little opportunity to evacuate properly the fuel oil waste and engine lubricant residues (slops) that accumulate in larger than normal quantities on the vessel because of its condition.

Unusual atmospheric conditions arose in February and continued into March, when *Dark Sea* set out for Haven from Cape Town. The conditions, caused by volcanic ash, left coastal

[24] Article 6 of Directive 2005/35/EC of 7 September 2005 on ship-source pollution and on the introduction of penalties for infringements provides that if "*information gives rise to a suspicion that a ship which is voluntarily within a port or at an offshore terminal of a Member State has been engaged or is engaging in a discharge of polluting substances into any of the areas referred to in Article 3 (1) that Member State shall ensure that an appropriate inspection ... is undertaken*". Areas listed in the article 3 of the Directive include the high seas.

surveillance aircraft grounded. Knowing that aircraft were the chief means of detecting discharges, Captain Salt apparently decided to evacuate slops directly into the sea en route to Haven. It seems this was done at night on 21 March 20 kilometres off the coast of Country E, in waters where ships frequently wait before proceeding on to Haven so as to reduce their time at berth. It is common knowledge that some ships use the waiting time to flush their tanks in this area of the sea, which lies outside Country E's territorial waters but within its declared Exclusive Economic Zone (EEZ). This area is regularly monitored with SAR images.

Salt then made for Haven at 14:00 on 22 March, leaving behind a patchy slick extending for 2 kilometres within the EEZ. The slick went on to beach in Countries E, F and A. Coastal fishermen from these countries are prevented from fishing in the affected area for a period of two weeks, so losing revenue.

8.1.3 Other Relevant Facts

SAR and optical images from two different satellite systems are available for the period before, during and after this incident, as well as AIS data. The *Dark Sea* had left the area before any surface vessel could the affected area to investigate.

Country C disputes Country E's EEZ. Countries A and E are EU Member States. A is a civil law jurisdiction with an inquisitorial tradition, while E is a common law jurisdiction with an adversarial tradition.

8.1.4 The Brief

The maritime surveillance authority, state prosecutor of Country E, and FishHelp (the association representing fishermen's interests of countries E, F and A) have asked you to advise on their course of action, on the basis of the evidence available. The brief for the consultation identifies the following issues:

1. Surveillance means normally available and the practical value of the evidence in the circumstances
2. Providers of satellite evidence and the scope, accuracy and reliability of their data, especially AIS and the two systems, SAR and optical
3. Sample collection techniques for the slops and experience in similar circumstances
4. Evidential law – admissibility and weight of the types of evidence concerned in relation to criminal <u>and</u> civil proceedings
5. Authorities to be involved that are responsible for surveillance and verification under legislation based on MARPOL and European regional conventions on sea pollution
6. Tribunals with jurisdiction
7. Initiation of proceedings and locus standi
8. Applicable substantive and procedural law

8.1.5 Notes

Port of Haven in Country A: Civil Law, EU Member, Eur

MakeProfit (owns Dark Sea) registered in Country B, Eur

Dark Sea registered in Country C: not party to MARPOL

Discharge in EEZ of Country E: Common Law, EU Member

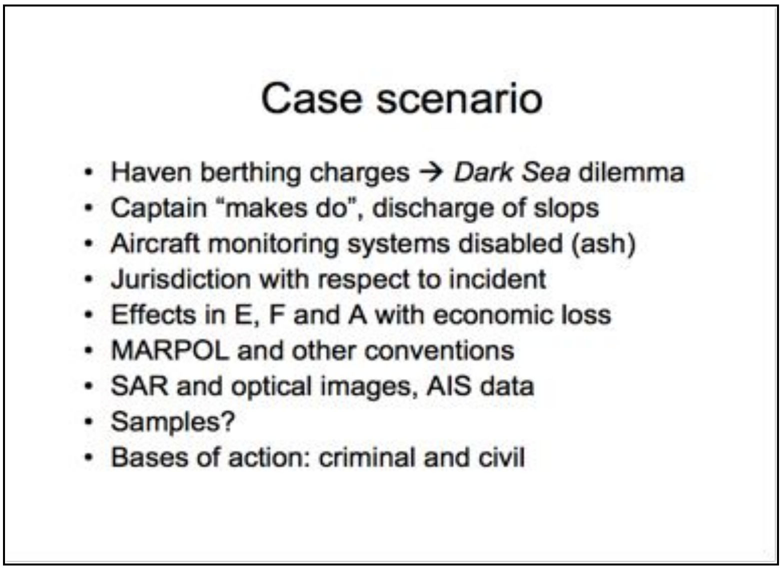
Slick lands in: A (MARPOL & Party to European conventions on sea pollution)
E (MARPOL)
F (MARPOL & Party to European conventions on sea pollution)

8.2 PRESENTATION

A second hypothetical scenario concerning oil spills was devised for discussion from the perspective of different parties enforcing anti-pollution laws, or who suffered damages due to the spills. This session explored the use of satellite-derived information as evidence in different circumstances and for different purposes.

This case study looked at oil spill, using satellite-derived information.

An oil spill incident has occurred at sea. Represented here are a prosecutor in a victim state, and fishermen who have suffered as a result of the spill. A technical expert is assisting.[25] Participants were asked to act as lawyers and technical experts in a consultation, to define strategy. Whether there is a case to take to court and if so, to which court, with which chances of success, and using what evidence. Criminal as well as civil proceedings are foreseen.



The Port of Haven has raised its berthing charges. The captain of the Dark Sea, Captain Salt decides, given the ship owners' financial concerns, to discharge slops at sea. If satellite data is the primary form of evidence, will it be sufficient? Will additional evidence be needed?

During this period volcanic ash made observation flight impossible. Because this is a sea incident, and by nature international, here may be jurisdictional aspects. The MARPOL convention is relevant, and perhaps others. There is satellite technology employed, along with

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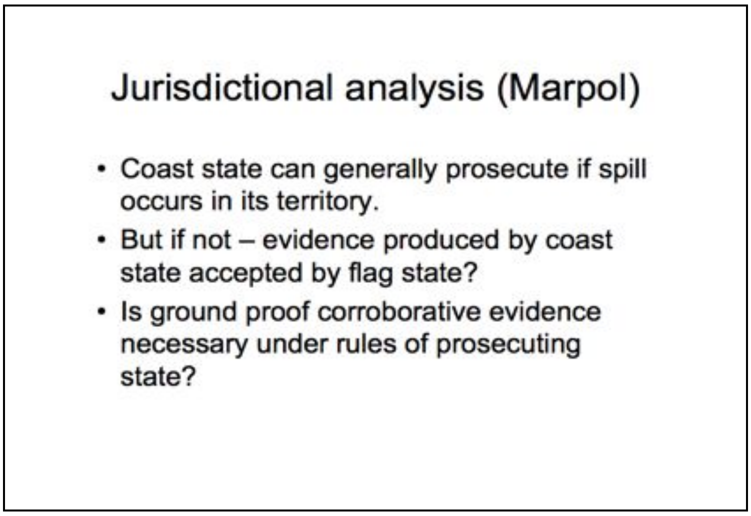
25 The technical expert is Marc Journel from the European Maritime Safety Agency.

AIS tracking data. Sampling of the spill is to be considered.



Under MARPOL there are various rules of jurisdiction. The following chart sets out the characteristics of the various parties and countries in this Case Study.

CHOOSING JURISDICTION(S)

Country:	A	B	C	D	E	F
UNCLOS	Port of Haven, Coastal		Flag State of Haven		Coastal	Coastal
MARPOL Party	Port of Haven; yes	yes			yes	yes
EUR *	yes	yes				yes
EU Member States	yes				yes	
IMO, ILO, etc.				IMO, Disputes EEZ of Country E		
Civil or common law	Civil				Common	
Party	Victim (slick)	State of Owner Co. Registration	Flag State of Haven		Victim (slick, discharge in declared EEZ)	Victim (slick)

* Party to European conventions on sea pollution

Where will proceedings be initiated? Participants are invited to address three areas. The first is strategy, choice of forum. The second relates to evidential issues, and the third to enforcement, and how the economic loss can be recovered.

Evidential analysis

- Which means of surveillance are normally used, and how, in conjunction?
- Ground proof corroboration indispensable? Which? Cf. Normal aircraft corroboration not available in this scenario
- Variations in civil/administrative and criminal proceedings?
- Authorities to involve and risks?
- Other showstoppers?

The first question is which is the best place to take proceedings.

8.3 DISCUSSION

Extensive discussion of jurisdiction and forum shopping took place. The issues raised are of significance in any claim or prosecution. However, they are not the focus of the present Study that is concerned with evidential issues. These do vary from jurisdiction to jurisdiction and further examination of these variations will be of value, as indicated elsewhere in this Report.

***Comment*:** The ship has arrived in Country A, therefore best to proceed in Country A, and bring civil and criminal proceedings. Bring criminal action against the Master for ordering the chief engineer to open the slop tanks. There is also an environmental crime because the slops have arrived on the beach. Automatic Identification System, (AIS), data and the SAR image can identify and potentially link the vessel to the spill.

***Response*:** It is not so simple because A is the port State, but where did the pollution occur? That information is needed first. Also, the flag State always has precedence for prosecution, under United Nations Convention on the Law of the Sea, (UNCLOS). So there is a competition for jurisdiction, but proceedings can be started in A.

***Comment*:** The flag State must be informed of action against the vessel. The slick went on the land in countries E, F and A. Country A can take its own action, and need only inform the flag State, which can take other action.

***Comment*:** Pollution occurred 20 km off Country E, while the ship was en route to Country A. The country affected in the first place is not A, but E. The oil has been drifting towards A and F. When the oil reaches A, the ship may already be in A, or have called in A and left. The first question is, where is the spill and what are the consequences. The other facts to be determined are whether Dark Sea is the source of the oil and what damage is caused.

***Comment*:** A central question is the how to collect and proffer the evidence on damage and link to the vessel. Evidence is needed to show the slick discharged off E is the same oil as reached the coast.

***Comment*:** The slops were discharged at night, on 21st of March, when optical data is not useful. The boat makes for Haven at 14.00 on the 22nd of March, so sometime in the morning of the 22nd of March, it is possible to think about optical data. There is no indication of the period of time for the discharge.

SAR data will probably be the major evidence base. It is useful for oil slick detection only at a relatively narrow window of wind speeds, and wave conditions. If it is very smooth, the oil spill cannot be detected, nor can it be in high waves. Therefore, wind information is necessary, which may be available from coastal and meteorological stations. Instruments on ESA satellites, and on other satellites can give wave and wind information at the sea surface. The spatial resolution of that data is not nearly as good as optical imagery. But other satellite data can provide some of the wind and wave characteristics, to allow the SAR data to be used. The combination of data is fundamental to this case.

The scenario states that there were unusual atmospheric conditions from February to March. Radar data are dramatically affected by the state of the atmosphere. Jan-Peter Muller did many studies on the impact of the atmosphere on radar and where there are false activities. The unusual atmospheric conditions would distort and could make SAR data are absolutely unusable.

Response: The image to use is the SAR image. The scenario states there are SAR images and optical images before, during and after the incident. Optical images are not used for routine monitoring. An optical image from ESA or other archive is obtained if there is activity detected. Its use is complementary.

There are suitable wind conditions for detection. This is not a narrow window; in most cases there are good detection conditions. If there is a low wind area, and close to it a little bit more wind, which is very often the case, then if the spill starts in the windy area it can still be seen in the low wind area. In high wind conditions, very heavy fuels remain, even with storms of 25 m/sec, which is 15 knots. SAR is not that limited and a SAR image is a very good detection tool.

If atmospheric conditions have affected the SAR image the quality of the image can be assessed. The vessel is seen as a bright spot, and the coastline is very clear. Images can be processed to optimise how they look. That is not manipulation but treatment**.**

Look-alikes, such as algae, are a problem. With an oil slick what is observed is smooth water. All that can be said is that there is smooth water detection algorithm. The point about look-alikes and false positives, is the shape of the images. A bright spot at the front followed by a long line behind is unlikely to be from anything other than a ship with a trail of oil. [Note: Causal link established by exclusion – see discussion of Case Study I.]

Response: In this example, there is a question whether the ship was stationary or en route when the spill occurred. The image would look different in each case. Also when oil spills stops drifting, it has a special appearance, and a course predictable using oil drift modelling tools. The great advantage of SAR images is the wide coverage area, not high-resolution. The location and movement of the spill are of interest. At 20 km from the coast additional information may be obtained by inspection and samples of the spill. The satellite provides a full picture of the extent of the spill, (not the volume, for which more information is needed), and whether it was a discharge from the vessel. Some questions remain, like the source of the spill, which may need additional evidence.

Comment: Here the ship is not moving when it creates the spill. Is SAR the only evidence available?

Response: There will be the Automatic Identification System (AIS), Long Range Identification and Tracking, (LRIT), or vessel monitoring system of a coastal state, using a radar station. What's important is any type of vessel traffic information. The type of information is not important, as long as the vessel and its route can be monitored, tracked and identified. The vessel can also be linked to spillage using backtracking modelling, to connect the echo of the vessel to the spill.

Comment: Satellite information is insufficient to tie the particular oil spill to the ship.

That would need some in situ chemical analysis. A witness is needed to show that it came from the particular ship.

***Response*:** Chemical analysis is very complex. The spill is bilge water, a mixture of oil, lubricants, and possibly other substances. It will be very difficult to have a clear answer. In an accidental spill, like Erika [tanker spill off France, December 1999], there is a product that is clearly identified, and the spill and the sample products can be shown to be similar. This is the same type of product. It is difficult to identify them as the same product.

There is a network called Bonn-OSINET (The Bonn Agreement Oil Spill Identification Network of Experts), with specialised laboratories. There is also CEDRE in France, (Centre of Documentation, Research and Experimentation on Accidental Water Pollution), and organisations that know how to do the spectral analysis of the product and to tell if it matches or not. If pollution occurs in port, in some cases it works. But when there is pollution on the high seas, it is more difficult to show the sample is taken from the spill.

***Comment*:** Slops are a mix of several products. It is quite difficult and very expensive to make the chemical analysis. If samples are taken on the beach, the link with the vessel is harder to establish. There have been several precedents in the UK with sampling, and every vessel has been released with no convictions, because the proof with sampling has not worked.

***Comment*:** Is there a spectral technique that analyses the chemical composition of the spill? Once it starts to move, the spill will mix with other oil, and therefore becomes corrupted.

***Response*:** There is a remote sensing technique that is being operationally applied by oil companies. It was developed in the 1980s, called fluorescence spectroscopy. It uses laser that can operate in day and night, and it can differentiate between oil and algae and different types of oil.

9. QUESTIONS RAISED

In the course of the Workshop a number of issues were identified that had not been previously contemplated, as well as some that the Study had anticipated. This session brought together the major themes that had emerged during the day.

Part II of this Workshop Report deals with issues identified, areas for further study, actions and conclusions.

9.1 DISCUSSION

***Comment*:** A major theme has been that irrespective of jurisdictional difference in admissibility and rules for establishing a fact, all require that evidence be reliable and accurate. The question remains how a process, structure, rules or code of conduct can be constructed to meet those requirements that are universally applicable and to make satellite-derived information more readily useable as evidence internationally.

***Response*:** There appears to be a distinction between different interpretations of the same imagery. Deliberate alteration of images rarely occurs, it is usually easily detected, and is not of great concern. But there will be cases where experts reach different conclusions, irrespective of what an audit trail shows. The tribunal will decide which expert’s method is more convincing.

Having codes of practice is very sensible. It guides the court, and judges want to know if best practice is followed or not. There is merit in codes at the European, international level, or national level. Much of the work is already done, because most of the codes that exist are quite relevant.

Comment: Education and communication among disciplines has been a recurring theme. The lack of a common language and understanding may be because this is an emerging area. The question is how quickly chartering may emerge in this field. In more established areas, chartering has an important role in determining standards of behaviour and what gets done.

Comment: To take a step back, data integrity is the issue. What is needed is to assure the digital data is original. This is also important for archives. A quality seal could be provided to the archive, so that a judge can say, 'Well, this data, this information derived or comes from an archive which has this European quality seal, so that we can be sure that there is no manipulation, or that we can trace back to a kind of original.' This idea was recently developed in a workshop co-organised by the European Space Policy Institute, International Institute of Space Law, and the International Society for Photogrammetry and Remote Sensing.

Comment: There may be too much emphasis on the data itself. Although it would be desirable to certify the data by a central organisation, the discussion today has been about the information derived from the data. It is the information that is challenged. There has not been any indication of doubt about the date, the timing or the authenticity of the data itself. Questions arise at the level of the information service, as in the land subsidence case, such as how it is processed, what kind of software is used for the processing, and so on. What has emerged is the need to have the information services standardised, or certified.

Comment: At EMSA the practice is to give service providers access to the data, which is retained by EMSA. In the next generation system EMSA will add MD5 signatures to all files delivered. If necessary it can compare the original with the files sent by the service provider. The only potential weak point in the chain is when a private ground station acquires the data. However, there is a certification process, ensuring a level of quality.

Comment: There is a risk that not everyone will accept regional or national standards. Any standard must be international.

Comment: Compliance with obligations under the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation (REDD) can most effectively be verified by remote sensing information. There are plans to set up a REDD mechanism, including requirements for measuring, reporting and verification of emissions from forests. That will need data systems that can facilitate comparing emissions over time. It will be difficult to measure reductions in those countries where there are no data archives in place. In designing the system, the broader perspective in an international context has to be considered, recognising not all countries are in a position to develop the systems.

Comment: There appears to be a progression in use of earth observation data, and the legal environment seems to be the most demanding where evidence is presented. The regulatory framework may be failing in a prosecution situation. Australia appears to have a more favourable framework for the use of satellite-derived information as evidence. This suggests that the regulatory regime in which the data is used is a natural precursor to its use in the judicial context. The CAP regime appears to support that proposition.

The situation with EMSA is equally interesting. EMSA exists because of several directives, and it is using satellite data because it is written into the Directive. It wasn't something that people in EMSA decided to do on its own merits. With GMES, regulations have to be developed hand in hand with the technology and the methodology to get it accepted. Acceptance comes about by communities working together. Availability is another contributing factor to acceptance, as in the case of Google Earth.

Agreed best practice [guidelines] will promote use of satellite-derived information as evidence. Some treaties and regulations are unenforceable because the principles are agreed without verifying the means to implement them.

The starting point is to have a commonly accepted source of data that is universally trusted. It need not be perfect and not useable as evidence, but provides a common basis for testing other measurements and reference point for questions. Probably the first place in the international framework where earth observation data will come to play, even before its use as a tool for verification, is as a common table that is understood and accepted and available. That is the starting point for all these things that later lead to acceptance in the judicial framework.

***Comment*:** The International Research on Permanent Authentic Records in Electronic Systems, (InterPARES), is an international project developing standards for the preservation of electronically stored data. Standards continue to be tested in court by cross-examination.

***Response*:** Standards are similar to established business practices and overcome any issue related to admissibility. Once a standard is established, the lawyer's task is to show the data does not conform to the standard. It will be a difficult task to establish the standard is wrong.

***Comment*:** Standards are useful not only for court, but to guide best practice to improve evidence. What is clear about some of the things looked at today is that satellites do not provide a perfect form of evidence. Corroborative evidence is needed in most cases.

***Comment*:** One main conclusion is that there is more space activity than the man in the street or the detached observer is aware of, and there's less legal knowledge than desirable. Therefore, it is important to draw up some kind of guidelines on the state of evidence and the production of satellite images in courts, mainly to help the judges, who are asking for this.

***Comment*:** Different experts can interpret satellite evidence differently. There should be examination of what conditions could lead to greater consistency and whether the tribunal should appoint expert witnesses.

Two aspects that have not been addressed in depth today, are cost-benefit analysis and privacy. It will greatly help convince users and increase use if space data if it is shown to be an economic alternative to aerial photographs, ground inspection or radar images.

In US cases, thermal images have been found by many courts not to invade privacy. However, the issue is gaining importance, particularly where individuals are concerned.

10. ISSUES IDENTIFIED

In the course of the Workshop and further discussions, certain issues that need greater study or resolution were identified. The following list is not necessarily exhaustive, but provides an indication of the major concerns expressed. Comments in relation to each are intended to provoke further discussion and reflection. Some proposals that relate to a number of the identified issues are also covered under the section Plans for Further Action Research and Study.

10.1 EDUCATION AND REDUCTION OF TECHNOLOGY GAP

There is a need to understand and clarify different perceptions of the nature of the data. Satellite-derived data was characterised by some lawyers as "electronic evidence." This is such a broad term that it is unhelpful. It may be a reference to a matter that is detected by an electromagnetic process. An example may be radar detection of speed. Evidentially this is direct evidence, much as the reading on a speedometer, not subjected to any process. Apart from showing the correct operation and calibration of the instrument, nothing more is needed.

Another example would be a reference used as a synonym for "digital," raising issues of undetectable alteration. Depending on the nature of the data and the information sought, varying degrees of processing can be necessary to generate intelligible information from the data. This too may introduce errors that need to be taken into account.

An important task of the Study is to focus discussion on relevant issues and facilitate understanding between and among technicians and lawyers, better understanding of the technology and awareness of different perceptions.

10.2 ESTABLISHING A COMMON LANGUAGE

On a related topic, there is no common language between and among technical and legal participants. For example, it was pointed out that highly scientific technical people might be a bemused to hear that some of the data they produce is simply *hearsay* or *circumstantial*.

The hearsay rule that operates to exclude second-hand information as evidence is largely a common law concept. The rule is all but abolished in the US and UK. What is important is the relevance of information and whether it can contribute to establishing a fact in issue.

A common language will help avoid misunderstandings and encourage greater communication between specialists in the different disciplines. This may be achieved by producing a glossary or dictionary of terms accessible both to scientists and lawyers.

10.3 NEED AND PROCEDURES

There is also a lack of sufficient appreciation of capabilities and requirements of each group between scientists, academics, commercial earth observation system operators, data suppliers, lawyers and clients. An understanding of the process in which each discipline is engaged is also absent. Some of the proposals for future action will alleviate these shortcomings.

10.4 SUBJECT OF CERTIFICATION

The features or matters that need to be certified from an evidential perspective are not generally clear to suppliers of data and processed information. These include management systems (some addressed by ISO standards), credentials and qualifications of those who might act as expert witnesses to the techniques used in collection and processing data. There is also uncertainty about the method and relevance of verification and validation. For example whether it is sufficient or necessary to show techniques are "accepted" within the relevant technical community, and what impact such validation has on treatment of the information as circumstantial or hearsay evidence.

Such questions highlight the need for better and clearer communication of the needs of lawyers to the technical community.

10.5 VERIFICATION, VALIDATION AND CERTIFICATION

The technical community in particular regard verification, validation and certification as key to establishing reliability of information. This is particularly relevant in less transparent cases such as radar, where the meaning of the information is not immediately clear.

The need to interpret the data poses other questions. For example, whether there is need for several data sets, or for additional means of verification. Ease of manipulation and change of data need to be examined. Accuracy and timing may be important, as may be time stamping data. The need for ground truth to compare satellite data is a further aspect of verification and validation that must be considered. It may also be desirable to have a certification process or standard qualifications for experts.

There continues to be a strong argument for investigation of alternative methods of certification, verification and data standards, outlining merits and drawbacks. Any standards or certification systems need to be at an international level, not least to facilitate use of data from different systems for validation purposes.

10.6 QUALIFICATION OF INFORMATION

Processed information, such as that being discussed here, will generally carry certain qualifications. Different systems may generate slightly different results and processes can also have inherent errors. There must be clarity on how information is qualified, for example in relation to differences in results due to analysis techniques used, what errors may be present and their impact on the information.

10.7 DIFFERENCES IN APPLICATIONS AND SYSTEMS

Difference in the applications for which the information is generated and used must be accommodated. There is likely to be a need to set criteria for different applications, for example the number of reference points for PSInSAR for subsidence, comparison with analysis using different techniques, how many data sets should be used.

11. ADDITIONAL AREAS TO BE EXAMINED

Certain themes emerged during the Workshop, pointing to areas that would benefit from additional study. These areas will indicate the direction for further studies.

11.1 RELIABILITY

11.1.1 Technical Systems

EO evidence must be reliable. A number of factors affect reliability, and a tribunal needs to be satisfied on each. These range from calibration to functional characteristics of sensors. One approach to ensuring and demonstrating reliability would be to establish a certification regime with specific criteria to be met.

In addition, in all evidential applications information needs to be date and time stamped. Either the system or the collection process should provide this information.

11.1.2 Transfer and Storage

Both the communication system and storage arrangements should be secure and free of elements that may alter or lose the data and information collected. Standards and audit procedures can provide the necessary assurance. There is currently a Draft ISO[26] standard dealing with storage of data being reviewed.

11.1.3 Processing

An expert witness usually presents the method and results of processing. Although in many circumstances expert evidence remains necessary, its scope and focus can be reduced. Any criteria established for processing data into useful information and evidence will be dependent on the application to which it relates. Differences between the characteristics of applications can point to necessary variations in criteria to be met in each class of case.

11.2 RULES OF EVIDENCE

Jurisdictions differ in their evidential rules and laws. Analysis of such rules in a large number of jurisdictions will better facilitate the development of rules and criteria applicable internationally. A question arises whether one or a number of standards or guidelines will best serve the greater use of satellite-derived information as evidence.

11.3 APPLICATIONS

Common principles apply to the use of satellite-derived information as evidence, irrespective of the application. However, both in terms of the technical capabilities and processes used and the character of the facts to be established, different applications have specific characteristics that need to be accommodated. This feature became evident in the course of the Workshop and on discussion of the Case Studies. Therefore, at this stage of development of techniques and the law, it is likely to be more productive to examine the requirements of particular applications.

12. AREAS FOR FURTHER STUDY, ACTIONS AND CONCLUSIONS

The Workshop identified a number of topics and areas that need further attention in relation to the greater use of EO information as evidence.

12.1 AWARENESS

From the outset the Study Team and ESA were conscious of the need to create awareness of the potential for use of satellite-derived Earth Observation information as evidence among lawyers, and to make the technical community familiar with the needs of lawyers and courts. The Workshop not only confirmed this need, but also helped identify the particular nature of the needs of each group.

12.1.1 Opportunity to Exchange Information

There appeared to be strong support for further opportunities to exchange information and continue the dialogue. It is certainly the intention to do so and to devise effective methods for

[26] ISO 10008.

this to take place. The case study format may work well, perhaps with tighter direction focusing on limited issues to be explored in depth.

A series of seminars can also be useful to identify topics and to develop a common language. This will facilitate better understanding of the capabilities and needs of each group, thus fostering greater awareness of what is desirable and what can be achieved.

12.1.2 Common Language

An important aspect of creating awareness is the ability to understand and communicate the current position and future needs. It rapidly became clear that there are few concept on which there is shared understanding between the groups and, at times, within each group.

As exchanges between the groups increase a more uniform use of expressions will emerge. However, this will take time and a more concerted and formal approach may be desirable. There are several glossaries that include EO terminology and expressions as well as acronyms, mainly aimed at technicians.[27] The development of glossaries giving definitions useful to technicians and lawyers alike can be a worthwhile exercise to undertake.

12.2 NATURE AND COMPONENTS OF EVIDENCE

12.2.1 Evidence and Error

In the course of the Workshop it became apparent that there are some misconceptions about the nature of evidence and of the legal process of establishing a claim or a crime. Evidence is the set of facts that need to be established to support a claim or prosecution. The process of establishing those facts is commonly referred to as "proof."

However, the term "proof" may be misleading. In legal proceedings, irrespective of jurisdiction, two stages are involved. First, evidence is given of the facts necessary to establish the claim, or the occurrence of the crime. No legal system requires that the underlying facts be shown to be incontrovertible. In other words, it is not necessary to show the fact to be true. At most it has to be shown that the event, action or circumstance occurred "beyond a reasonable doubt." This is less than the level of certainty required for "truth."

It follows that lawyers do not deal in "truth," but an approximation of the truth, depending on whether they are involved in civil or criminal litigation. Each fact is established subject to a level of error, albeit not readily quantifiable. The task of the court is to determine whether the evidence offered meets the requisite level of certainty. To this extent, the task is no different from that of the scientist in dealing with error in data. However, the scientist has a method of quantifying the error, whereas the court, with non-scientific evidence, has no quantitative method for assessing evidence.

The second stage of the legal process is to demonstrate that the fact established was the cause of the occurrence that gives rise to the relevant legal right or liability. Causation may be shown by expert evidence, ie opinion of a specialist in the relevant field, by natural inference or other means.

[27] See for example, ESA Earthnet Online: http://envisat.esa.int/earth/www/object/index.cfm?fobjectid=1397; International Astronomical Federation: http://www.iafastro.com/index.html?title=Glossary; NASA Earth Observatory: http://earthobservatory.nasa.gov/Glossary/?mode=all; Natural Resources Canada: http://www.ccrs.nrcan.gc.ca/glossary/index_e.php?term=Tech&choice=B.

To enable technicians to supply useful information to the legal community, an understanding of these concepts and distinctions is important. Again, interaction between the groups as well as seminars and workshops can be valuable tools in gaining such understanding.

12.2.2 Combination of Satellite-derived Information

The Workshop underlined the desirability of a holistic approach to satellite-derived EO information as a source of evidence. Data from Geographic Positioning Systems (GPS) and time-stamping data may be vital elements in authenticating evidence. This aspect of legal relevance and the technical means of generating and combining reliable information need to be investigated. A question that arises is how to treat information that may be regarded as machine-generated reliable evidence, when combined with information that is processed and is subject to interpretation by an expert. If they are discrete, each establishing a different relevant fact, no difficulty should arise. The problem will only become relevant where together they are evidence of one fact.

Examination of situations and matters in which such combination of information takes place would be a useful exercise.

12.3 QUALITY OF EVIDENCE

To be of value, evidence must be relevant and reliable. In the context of satellite-derived EO information, each element involved in the collection, transmission, storage and processing of the data must be reliable. The information must faithfully represent what is observed.

The Workshop deliberations support the proposition that the way forward to creating the conditions for the use of satellite-derived information as evidence lies in the establishment of criteria for the collection, storage, handling and processing of satellite-gathered data. It is contended that an international code will be most generally accepted and used.

An approach that may be taken is to investigate the criteria to ensure admission and probative value. This can be done in the course of establishing standards applicable to satellite Earth observation data. To facilitate use as evidence, such standard will need to address reliability and security of the data and its processing.

12.3.1 Standards and Certification

One means of ensuring reliability is to have a set of standards to which the data and the processes conform. Groups within and outside ESA are already working on standards. Any additional work done in this area will complement the activities of those groups and ensure that the development of any standards takes account of legal requirements for the use of satellite-derived information products as evidence.

Areas of focus will include identifying the core criteria to be met in the collection, storage (which may include compliance with ISO/DIS 16363), handling and processing of data from inception to the end product as evidence.

- *Collection* covers sensor reliability and accuracy, involving calibration and system error assessment;

- *Storage* covers security, including stability, of the systems and media and custody procedures of the depository;

- *Handling* covers access to the data, passwords, transfer and tracking of custody and manipulation; and

- *Processing* covers the changes and manipulations to which the data is subjected, the algorithms used and the qualifications and experience of operators responsible for processing the data.

An ideal position will be to establish an internationally recognised and accepted body with defined procedures to certify conformity with the relevant standards.

12.3.2 Expert Witnesses

Greater use of satellite-derived evidence may be further facilitated by identification and definition of core qualifications of experts. These will be individuals with the minimum skills and knowledge needed to interpret satellite-derived information. A first step would be to determine whether such core qualifications can be identified to apply to all experts, with additional specialised skills for each area of application.

12.3.3 Risk of Alteration

The ease with which satellite-derived information might be deliberately falsified needs careful consideration. The risk of such manipulation should be assessed both at the raw data level and during processing.

12.4 ADDITIONAL APPLICATIONS

The Workshop considered two different applications as Case Studies, namely land subsidence and oil spill. It was evident that not only the technical capabilities required for each, but also the nature of the facts to be established, differed widely. From a technical perspective the land subsidence case study required analysis of historical data, as well as observations using a specific technique. The oil spill case study relied on frequent contemporaneous observations and an ability to distinguish look-alikes.

In Case Study I, the underlying fact to be established, subsidence, was readily observable and measured by satellite. In Case Study II an important fact, the identification of the oil and its link to the vessel, necessary for establishing liability, is not yet observable by satellite. It may, therefore, be more productive to focus on specific applications that more readily lend themselves to the use of satellite-derived information as evidence.

Applications that may be considered further include water rights, geotechnical information used in urban planning and major construction projects and wetland management. Other applications that may be considered are detection of activities by warlords, illegal diamond mining and environmental security, such as compliance with requirements for REDD.

13. APPENDIX: WORKSHOP PROGRAM, PRESENTERS, MODERATORS, RAPPORTEURS AND ATTENDANCE

WORKSHOP
EVIDENCE FROM SPACE

ISPL ESA STUDY
THE USE OF SATELLITE-DERIVED INFORMATION AS EVIDENCE

UCL ESRC PROJECT
ON THE USE OF SATELLITE INFORMATION IN AUSTRALIA

WILKINS OLD REFECTORY, UCL, GOWER STREET, LONDON WC1E 6BT
TUESDAY 5 OCTOBER 2010

WORKSHOP PROGRAMME

8.15 ***Sign in*** *– Coffee and tea will be provided*

8.45 ***Welcome and Introduction – Overview of Project***
Workshop Chairman: Mark Doherty
ISPL Director: Sa'id Mosteshar — Key issues in use of EO information. Evaluation of previous research. New research under the Study.

8.55 ***Methodology – Rules of Evidence***
Moderator: *Luc Govaert*
Presenter: *Kevin Madders* — Relevant principles of evidence, practical issues including authentication, audit trail, processing reliability and security

9.25 ***Systems Capabilities – Satellite and Data Processing Features***
Moderator: *Gordon Campbell*
Presenters: *David Morten* — Satellite capabilities for land motion measurement
Robert Gurney — Calibration and system reliability
Marc Journel — Satellite capabilities for oil spill detection and polluter identification

10.15 **Coffee**

10.30 ***Cases using EO Information - Space and Aerial Information***
Moderator: *Tanja Masson-Zwaan*
Presenter: *Alessandro Ferretti* — Cases, including Rovigo
Simon Kay — Agricultural Subsidy Claims, Verification, Fraud and Expert Evidence
Egbert Jongsma — Cases prosecuted

11.15	***Jurisdictional Treatment – Case Reports and Regulatory Experience – Comparative Perspectives***		
	Moderator:	*Kai-Uwe Schrogl*	
	Presenter:	*Sa'id Mosteshar*	UK and US
		Kevin Madders	Belgium, The Netherlands
		Lucien Rapp	France
		Johanna Symmons	Germany
		Maureen Williams	International law

12.30 **Buffet Lunch** *in the Wilkins North Cloisters*

13.30	***UCL ESRC Project*** *– Use of Satellite Information in Australia and Lessons Learned*		
	Moderator:	*Richard Macrory*	
	Presenter:	*Ray Purdy*	Use of satellite derived information, perceptions and impact

14.30 **Case Study I –** ***Land subsidence***
Moderator: *Luc Govaert*
Presenters: *Sa'id Mosteshar and Alessandro Ferretti*

15.30 **Tea**

15.45 ***Case Study II – Oil Spill***
Moderator: *Gordon Campbell*

Presenter: *Kevin Madders and Marc Journel*

16.45 ***Questions Raised – Issues Identified, Areas for Further Study, Actions and Conclusions***

Moderator: *Sa'id Mosteshar*

Panelists: *Gordon Campbell, Luc Govaert, Robert Gurney, Tanja Masson-Zwaan, Ray Purdy, Kai-Uwe Schrogl, Maureen Williams*

17.15 ***Closing report and concluding remarks*** - *ESA Project Managers and Institute Director*

ATTENDANCE LIST

Moderators and Presenters

Gordon Campbell	Directorate of EO Progs, Project Manager, ESA ESRIN
Mark Doherty	Head of Exploitation Division, ESA ESRIN
Alessandro Ferretti	Chief Executive Officer, TRE
Luc Govaert	Project Manager, ESA ESRIN
Professor Robert Gurney	Director, ESSC, Reading University
Egbert Jongsma	Audit Manager, Netherlands Court of Audit
Marc Journel	Satellite Based Monitoring Services, EMSA
Dr Simon Kay	Head of Unit, Joint Research Centre, MARS
Professor Richard Macrory	Director, Centre for Law and the Environment, UCL
Professor Kevin Madders	Systemics Network International; KCL; ISPL Faculty
Tanja Masson-Zwaan	President IISL; Deputy Director, IIASL Leiden; ISPL Faculty
David Morten	Managing Director, Fugro NPA
Professor Sa'id Mosteshar	Director, ISPL
Ray Purdy	Deputy Director, Centre for Law and the Environment, UCL; ISPL Faculty
Professor Lucien Rapp	Toulouse University; ISPL Faculty
Professor Kai-Uwe Schrogl	Director ESPI; ISPL Faculty
Professor Maureen Williams	University of Buenos Aires/Conicet; Chair, Space Law Committee, ILA

Rapporteurs

Susan Barham	Partner, Barlow Lyde & Gilbert
Klaus Becher	Space Policy Consultant; ISPL Faculty
Dr Hervé Borrion	Science Manager, Jill Dando Institute of Crime Science, UCL
Dr Andrew Brearley	Debris Policy Specialist
Richard Graham	Senior Associate, Bird & Bird; ISPL Faculty
David Halbert	Technical Project Manager, Infoterra
Dr Stephen Hobbs	Director, Cranfield Space Research Centre, Cranfield University
Mikael Kamp Sørensen	Director, GRAS
Yeliz Korkmaz	Researcher, Leiden University
Professor Jan-Peter Muller	Image Understanding & Remote Sensing, Space & Climate Physics, UCL
Matxalen Sánchez Aranzamendi	Resident Fellow, ESPI
Neil F Stevens	General Counsel, Atrium; ISPL Faculty
Professor Geoffrey Wadge	Chairman, Monserrat Science Committee; NERC-ESSC
Ilaria Zilioli	Contracts Officer, ESA; ISPL Faculty

Participants

Maria Adams	Head of Future Missions, UK Space Agency
Jonathan Amos	Science Correspondent, BBC News
Philip Annetts	Department for Environment Food & Rural Affairs, DEFRA
Tony Ballard	Partner, Harbottle & Lewis, ISPL Trustee
Cristina Barreau	Environmental Lawyer, Surfrider Foundation Europe
Darcy Beamer-Downie	General Counsel, Airclaims Ltd
Dr Ulrike Bohlmann	Legal Administrator, ESA
Rasmus Borgstrøm	Geographic Resource Analysis & Science Ltd., GRAS
Ann Brosnan	Head of Serious Casework, Environment Agency UK
Alan Brunstrom	Integrated Applications Promotion IAP, ESA
Giovanni Cannizzaro	Businness Development, Telespazio
Marco Cattadori	Booz & Co
Dario Cau	Captain, Italian Coastguard ITCG
Antidia Citores	Law and Lobbying Coordinator, Surfrider Foundation Europe
Robin Cleverly	Law of the Sea Consultant, UK Hydrographic Office
Vivian Contin-Williams	International Lawyer
Willibald Croi	Project Manager, Applications, LuxSpace
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Julien Delanoe	ESA Climate Office
Martin Ditter	Project Manager, ESA Harwell Centre
Samantha Duckett	Helical Bar
Ruth Eldon	ISPL Workshop Administrator
Yanal Abul Failat	Student, Kingston University
Chris Forsyth	Partner, Freshfields Bruckhaus Deringer
His Honour Simon Goldstein	Retired
Caroline Grace	Grace & Co
Geoffrey Hall	Principal & Director, Moreton Hall Associates
Lars Boye Hansen	Geographic Resource Analysis & Science Ltd., GRAS
Professor Ray Harris	Emeritus Professor of Geography, UCL
Elizabeth Hiester	Solicitor, former Partner, Clifford Chance
Dr Richard Hilton	Business Development Manager, Space Services, Infoterra Ltd
DS Steve Hubbard	Deputy Project Manager, Op Javelin, Metropolitan Police
Sam Hutchinson	Helical Bar
Professor Bhupendra Jasani	Visiting Professor, Department of War Studies, King's College London
Dr Shaida Johnston	Science & Technology Policy, Law Department, George Washington University
Professor Rónán Kennedy	Faculty of Law, National University of Ireland, Galway
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Dr George Leloudas	Gates and Partners
Christian Lindqvist	Telenor
Harold Linke	Manager Software and ICT, HITEC Luxembourg
Stephen Mason	Barrister, Visiting Fellow, BIICL
Florent Mazurelle	European Security Policy Administrator, ESA
Mr Justice Sir Richard McCombe	
DCI Mick Neville	Project Manager, Op Javelin, Metropolitan Police
Sekai Ngarize	Senior Science and Policy Advisor, DECC
Pat Norris	Logica

Rolf S Olofsson	Partner, White & Case
Chetan Pradhan	Vice-Chairman / Account Manager, Earth Observation, Logica
Mads Olanders Rasmussen	Geographic Resource Analysis & Science Ltd., GRAS
David Slater	Cambrensis Environmental Consultancy
Chiara Spena	PhD Candidate, University of Rome 'La Sapienza'
Dr Jerry Stanley	Director, Rondle Ltd
Dr Jill Stuart	Department of Government, Politics of Outer Space, LSE
Christian Tøttrup	Geographic Resource Analysis & Science Ltd., GRAS
Wouter Veening	Chairman & President, Institute for Environmental Security
Robert Volterra	Partner, Latham & Watkins
Luc Willems	Deputy Secretary-General – Benelux, Telindus
Michael Williams	External Relations Manager - Group on Earth Observations, GEO Secretariat

ANNEX 2

THE USE OF EARTH OBSERVATION INFORMATION AS EVIDENCE IN THE PROSECUTION OF HUMANITARIAN CRIMES

TABLE OF CONTENTS

1. INTRODUCTION[1]

Earth Observation satellite data has in the last several decades been used increasingly to monitor human rights violations, and in the aftermath of natural disasters. It has been used in national, regional and international litigation in such areas as insurance claims, in the enforcement of EU Common Agricultural Policy, and in inter-state territorial or boundary disputes. This Annex focuses on a specific application. Earth Observation satellite information (EO information) has the potential to be more widely utilised in the prosecution of serious criminal cases. This is particularly so given the type of evidence needed, where data collection may be dangerous, vast territorial areas are involved, events may be changing rapidly and where topographic imagery may be able to indicate the destruction of villages or the presence of mass graves.

That potential may be limited by issues of availability and reliability, by data cost and the violation of human rights including the right to privacy, in gathering and analyzing such data.

The International Criminal Court (ICC) has jurisdiction over the "most serious crimes of concern to the international community as a whole": the crimes of genocide, crimes against humanity, war crimes, and the crime of aggression.[2] This Annex focuses on the ICC, but refers to examples relevant to the other two Tribunals that also prosecute these serious crimes, and operate under similar rules and guidelines. These are the International Criminal Tribunal for Rwanda (ICTR) and the International Criminal Tribunal for the Former Yugoslavia.

This Annex explores the potential uses of satellite EO information as evidence at the ICC, considers instances when such data has been used in analogous situations in order to consider the feasibility of such uses, and examines the technical capabilities of EO information to meet legal needs for evidentiary purposes.

The ICC and its evidential practices are considered, and the potential of EO information as evidence is analysed. Situations in which EO information has been used in the monitoring of human rights violations and other domestic, regional and international cases are compared in relation to the specific requirements of such evidence. Finally, the benefits and potential limitations of the use of EO information as evidence are considered.

The types of crimes examined in this Annex may, of course, be prosecuted in Courts other than the ICC. However, the nature of the evidence required for their successful prosecution will be broadly the same. Therefore, although the ICC is the primary focus of this Annex, its findings and observations have general application.

In particular, where the relevant acts can be prosecuted in domestic courts, the same or similar facts will need to be established. For example, to prosecute a warlord in the jurisdiction in which the warlord is active, the exact charges may be different, but the underlying acts and proof of those acts will rely largely on the same information. Therefore, the factors affecting the use of EO information apply equally to domestic prosecutions as they do to ICC prosecutions.

Further, crimes committed by warlords and their followers fall broadly into the same categories as crimes against humanity, war crimes, genocide and crimes of aggression. In this Annex warlords are not the subject of specific analysis as a class of perpetrator, but the issues addressed apply equally to such perpetrators as to others.

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[1] ISPL gratefully acknowledges the kind assistance of Olaf Kranz of DLR and Eya Macauley of the ICC for their review of this Annex. ISPL alone is responsible for any remaining errors or omissions.

[2] The Rome Statute of the International Criminal Court, Rome, 17 July 1998, hereafter "Rome Statute", Art. 5.1.

2. THE INTERNATIONAL CRIMINAL COURTS

The main Courts dealing with international crime are the described here, along with their geographic and temporal jurisdictions, and their rules of evidence.

2.1 THE ICC

The ICC is a permanent, treaty based, international criminal court established to help end impunity of the perpetrators of the most serious crimes of concern to the international community. It is an independent international organisation, and is not part of the United Nations system. Its seat is at The Hague in the Netherlands.[3] It has jurisdiction for crimes committed after its formal establishment in 2002.[4] Its criminal jurisdiction is limited to the most serious crimes of concern to the international community as a whole, specifically genocide, crimes against humanity, war crimes, and the crime of aggression.[5]

The ICC is intended to be complementary to national criminal justice systems, exercising its jurisdiction only in cases where States do not exercise their national jurisdiction, because they are unable or unwilling to do so.[6] It is governed by the Rome Statute of the International Criminal Court (Rome Statute). A majority of the world's states have either ratified or at least signed the Statute .[7]

The ICC has opened investigations and issued indictments relating to 7 different situations.[8] A vast range of crimes are alleged under the indictments, including wilful killing; inhuman or cruel treatment; using children under the age of fifteen years to participate actively in hostilities; sexual slavery; pillaging; murder and intentionally directing an attack against a civilian population.

2.2 THE ICTR

The ICTR was created by the UN Security Council on 8 November 1994[9] to address crimes arising during the Rwanda conflict.[10] Its governing Statute is annexed to Security Council Resolution 955. Its Rules of Procedure and Evidence[11] establish the necessary framework for the functioning of the judicial system. In 1995, the Security Council decided that the seat of the Tribunal would be located in Arusha, United Republic of Tanzania.[12]

The ICTR prosecutes "Persons Responsible for Genocide and Other Serious Violations of International Humanitarian Law Committed in the Territory of Rwanda and Rwandan Citizens responsible for genocide and other such violations committed in the territory of neighbouring States",[13] occurring between 1 January and 31 December 1994.[14]

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3 On 17 July 1998, 120 States adopted the Rome Statute, the legal basis for establishing the permanent International Criminal Court. Entered into force on 1 July 2002 after ratification by 60 countries.

4 Rome Statute, Art. 11.

5 Rome Statute, Art. 5.

6 http://www.un.org/icc/crimes.htm, accessed 4 January 2012.

7 139 signatories and 120 parties by the end of 2011. United Nations Treaty Database entry regarding the Rome Statute of the International Criminal Court. www.treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XVIII-10&chapter=18&lang=en

8 The Democratic Republic of Congo, the Central African Republic, Uganda, Sudan (Darfur), Kenya, Libya and the Republic of the Côte d'Ivoire.

9 Established by the Security Council acting under Chapter VII of the Charter of the United Nations, the International Criminal Tribunal for the Prosecution of Persons Responsible for Genocide and Other Serious Violations of International Humanitarian Law Committed in the Territory of Rwanda and Rwandan Citizens responsible for genocide and other such violations committed in the territory of neighbouring States, between 1 January 1994 and 31 December 1994" http://www.un.org/ictr/statute.html, accessed 2 Jan 2012.

10 Resolution 955.

11 Adopted by the Judges in accordance with Art. 14 of the Rome Statute.

12 By resolution 977 of 22 February 1995.

13 The ICTR completed 69 cases as of 31 December 2011; 5 are in progress, one defendant is awaiting trial.

14 http://www.un.org/ictr/statute.html, accessed 4 January 2012.

2.3 THE ICTY

The ICTY was created in 1994 by the UN Security Council. Its jurisdiction extends to the territory of the former Socialist Federal Republic of Yugoslavia, including its land surface, airspace and territorial waters, beginning 1 January 1991.[15] The ICTY is concerned with serious crimes in the former Yugoslavia.[16]

The crimes brought before the Courts are outlined below, along with a summary of evidentiary issues relating to their prosecutions, and definitions of the major categories of crimes involved. In addition, two specific classes of person are dealt with in this Annex, and definitions are included.

2.4 DEFINITION OF CRIMES WITHIN THE JURISDICTION OF THE COURTS

Genocide is defined as any of the specified acts "committed with intent to destroy, in whole or in part, a national, ethnical, racial or religious group, as such".[17]

A *crime against humanity* is defined as one of the specified acts "when committed as part of a widespread or systematic attack directed against any civilian population, with knowledge of the attack".[18] Specified crimes in this category include murder, rape, and torture, among others.

War crimes are defined as "grave breaches of the Geneva Conventions of 12 August 1949", namely any of the acts specified in the Statute against persons or property protected under the provisions of the relevant Geneva Convention, and any other specified "serious violations of the laws and customs applicable in international armed conflict, within the established framework of international law".[19] Acts covered by this definition might include killing of prisoners, ill treatment of civilian residents, or deportation of civilians to slave labour camps.

2.5 DEFINITIONS OF REFUGEE AND INTERNALLY DISPLACED PERSON (IDP)

Refugee status has been the source of some controversy. It has been defined in various national, regional and international instruments.

According to the 1967 Protocol,[20] the term "refugee" shall apply to any person who:

> Owing to well founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable or, owing to such fear, is unwilling to avail himself of the protection of that country; or who, not having a nationality and being outside the country of his former habitual residence, is unable or, owing to such fear, is unwilling to return to it.

The most commonly applied definition of an internally displaced person is:[21]

> Internally displaced persons are persons or groups of persons who have been forced or obliged to flee or leave their homes or places of habitual residence, in particular as

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15 Statute of the International Criminal Court for the Former Yugoslavia, Art. 8.

16 The ICTY lists 99 cases on its website. http://www.icty.org/sid/10095. The closure schedule of cases before this Tribunal can be found at http://www.icty.org/sections/AbouttheICTY, accessed 2 January 2012.

17 Rome Statute, Art. 6. See also T. Marcus Funk, 2010, *Victims' Rights and Advocacy at the International Criminal Court*, Oxford University Press, p.1.

18 Rome Statute, Art. 7.

19 Rome Statute, Art. 8.

20 Article 1 A (2) of the 1951 Convention Relating to the Status of Refugees, as amended by Article 1 (2) of the 1967 Protocol. *Handbook on Procedures and Criteria for Determining Refugee Status under the 1951 Convention and the 1967 Protocol relating to the Status of Refugees*, HCR/IP/4/Eng/REV.1, Reedited, Geneva, January 1992, UNHCR 1979.

21 Francis Deng, former UN Secretary-General's Representative on Internally Displaced Persons, stated in OCHA, *Guiding Principles on Internal Displacement*, Introduction, s. 2., http://www.unocha.org/search/node/guiding%20principles, accessed 4 January 2012.

a result of, or in order to avoid the effects of armed conflict, situations of human rights or natural or human-made disasters, and who have not crossed an internationally recognised State border.

2.6 EVIDENTIARY PROCEDURES AND RULES OF THE COURTS

The Courts, guided by their governing Statutes, rule on the relevance or admissibility of evidence submitted. It is seen as particularly important to give victims of the alleged crimes an opportunity to give testimony of their experiences – though the range of additional forms of evidence submitted in ICC cases is vast. Given the nature of the crimes under consideration, evidence may relate to mass burials; destruction of civilians' dwellings (e.g. villages) or livelihoods and sustenance (e.g. crops or livestock); the forced mass displacement of peoples (refugees and IDPs); looting; rape; or the conscription of child soldiers.

The standards of proof employed at the various international courts are broadly similar, although not identical. There is also a broad similarity in the standard of proof for investigation and the issue of a warrant, as compared to that for conviction.

2.6.1 The ICC

As has been stated, the ICC is complementary to the courts of national jurisdictions.[22] It applies, first, the Rome Statute, Elements of Crimes[23], and its Rules of Procedure and Evidence.[24] Second, it applies, where appropriate, applicable treaties and the principles and rules of international law, including the established principles of the international law of armed conflicts.[25] Failing that, it applies general principles of law derived by the Court from national laws of legal systems of the world, provided that those principles are not inconsistent with the Statute and with international law and internationally recognized norms and standards.[26] The Court may apply principles and rules of law as interpreted in its previous decisions.[27] Finally, the rules must be applied without discrimination.[28]

It should be noted that nowhere in this body of law is EO information specifically excluded as evidence. Admissibility will follow from the general rules of reliability, relevance and probative value in application at the Courts. Its specific admissibility is therefore not an issue, and will follow the general rules of admissibility.

Evidence may be submitted to the Court by the parties, and may be requested by the Court.[29] It may include information requested by the Prosecutor from States. In some cases the Court may request that evidence be collected by a State, or that evidence be collected within the territory of the State.

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22 Rome Statute, Art. 1.

23 ICC-ASP/1/3(part II-B), 2002, http://www.icc-cpi.int/menus/icc/legal%20texts%20and%20tools/official%20journal/elements%20of%20crimes.

24 Rome Statute, Art. 21.1.(a). "The Rules of Procedure and Evidence are an instrument for the application of the Rome Statute of the International Criminal Court, to which they are subordinate in all cases." In all cases, "the Rules of Procedure and Evidence should be read in conjunction with and subject to the provisions of the Statute." Adopted by the Assembly of States Parties, First session, New York, 3-10 September 2002, Official Records ICC-ASP/1/3Rules of Procedure and Evidence.

25 Rome Statute, Art. 21.1.(b).

26 Rome Statute, Art. 21.1.(c).

27 Rome Statute, Art. 21.2.

28 The Rome Statute, Art. 21, s. 3, states that, "The application and interpretation of law pursuant to this article must be consistent with internationally recognized human rights, and be without any adverse distinction founded on grounds such as gender as defined in article 7, paragraph 3, age, race, colour, language, religion or belief, political or other opinion, national, ethnic or social origin, wealth, birth or other status."

29 Rome Statue, Art. 69, s. 3.

The Court may rule on the relevance or admissibility of any evidence,

> "[T]aking into account, *inter alia*, the probative value of the evidence and any prejudice that such evidence may cause to a fair trial or to a fair evaluation of the testimony of a witness, in accordance with the Rules of Procedure and Evidence."[30]

The Court rules on the admissibility or relevance of evidence on the application of a party or on its own motion.[31]

There are limitations on admissibility, including that on evidence obtained in violation of the Rome Statute or internationally recognized human rights. Such evidence is not admissible if the violation casts substantial doubt on the reliability of the evidence or if the admission of the evidence would be antithetical to and would seriously damage the integrity of the proceedings.[32]

The Court also adheres to the rule that "a Chamber shall not impose a Legal requirement that corroboration is required in order to prove any crime within the jurisdiction of the Court, in particular, crimes of sexual violence."[33] Therefore, in appropriate circumstances, EO information alone may suffice.

The standard of proof to which evidence is held is broadly consistent with other jurisdictions. If it is found that there is a *reasonable basis* that a specified crime within the jurisdiction of the Court has been committed, an investigation will be opened.[34]

There is a presumption of innocence. The onus is on the Prosecution to prove guilt, and the defendant will be found guilty if the evidence is found to prove the crime *beyond a reasonable doubt*.[35]

2.6.2 The ICTR

The Rules of Procedure and Evidence for the ICTR[36] are broadly similar to those of the ICC. The basic principle is the establishment of the guilt of the defendant *beyond a reasonable doubt*.

2.6.3 The ICTY

The criminal procedure at the ICTY, as established by the Rules of Procedure and Evidence,[37] is a blend of the adversarial and inquisitorial models. Once again, the standard for bringing an indictment is *reasonable grounds*. For conviction, it is *beyond a reasonable doubt*. [38]

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30 Rome Statute, Article 69, s. 4. The International Court of Justice (ICJ) by comparison has no standard of proof, but approaches each case individually on its merits.

31 Rome Statute, Article 64, s. 9.

32 Rome Statute, Article 69, s. 7 .

33 Rules of Procedure and Evidence, International Criminal Court, ICC-ASP/1/3, Sec.1, Rule 63.4. See also. Al-Khawaja and Tahery, v. the United Kingdom, [2011] ECHR 2127, (Applications nos. 26766/05 and 22228/06), http://www.bailii.org/eu/cases/ECHR/2011/2127.html, accessed 5 January 2012.

34 Rome Statute, Article 15.

35 Rome Statute, Article 66.

36 See http://www.un.org/ictr/rules.html, accessed 19 December 2011.

37 IT/32/Rev.46 20 October 2011, http://www.icty.org/sid/136, accessed 19 December 2011.

38 There is a strict order of presentation of evidence and cross-examination. See p. 576, Patrick L Robinson, *Ensuring Fair and Expeditious Trials at the International Criminal Tribunal for the Former Yugoslavia*, EJIL (2000), Vol. 11 No. 3, 569-589, http://www.ejil.org/issue.php?issue=41, accessed 2 January 2012. In relation to admissibility of evidence, the author states that "Under rule 89(C), the Trial Chamber 'may admit any relevant evidence which it deems to have probative value'. This reflects the relaxed civilian approach to the admission of evidence and allows Chambers to admit hearsay evidence."

3. VALUE OF EO INFORMATION AS EVIDENCE

In terms of investigation and prosecution of serious international crime, EO information has great potential for providing legal evidence. It has been used to monitor conflicts and other events relating to human security, as well as corollary matters such as deforestation and other environmental damage arising from them.[39] It has the potential of being extremely valuable in confirming the commission of criminal acts, their timing and location, and in the identification of perpetrators.

Crimes against humanity, war crimes, crimes of aggression and genocide have occurred throughout history, and it is not always clear why they are not more immediately detected and prosecuted in an age of seemingly universal, highly technical monitoring. However, there are several reasons that might explain both national and international ignorance of the scale of serious crimes.[40] These may be analogous to the difficulties in obtaining evidence in conflict, IDP or refugee zones. They include:

- physical inaccessibility
- climate
- malaria
- danger from fighting or landmines
- intimidation by criminals or warlords
- political isolation
- lack of infrastructure

In addition, some reasons why evidence may not be sought in the first place, and why the problems or their scale might not be recognized,[41] may indicate why EO information can be so valuable. They include:

- inattention from media, or trivialisation or distortion of information
- NGO focus on other areas
- government policy to mislead or hide problems, or to intimidate those that would reveal it or confront it, including neighbouring states
- divided or weak opposition
- failure to understand fundamental government policies
- denial of the scale of the problem

In connection with events in Burma, Zimbabwe, Rwanda, the Democratic Republic of Congo and Sudan, satellite images have been made public in an attempt to identify potential crimes. These concern among others the destruction of dwellings and other structures, killing and the presence of large numbers of bodies or mass graves and the forced displacement of residents.

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39 See, for instance, *Challenges in Treaty Monitoring*, in Seminar Documentation for GMOSS Seminar *Environment and Conflict: Evaluating and strengthening the means of interdisciplinary cooperation*, eds. Lars Wirkus and Ruth Vollmer, 2007.

40 Guy Horton, *Dying Alive: An Investigation And Legal Assessment Of Human Rights Violations Inflicted In Burma, With Particular Reference To The Internally Displaced, Eastern Peoples*, Report Co - Funded By The Netherlands Ministry For Development Co – Operation, April 2005, pp. 72 et. seq.

41 Horton, pp. 72 et. seq.

The specific events described in this Annex have not, with one exception,[42] been the subject of ICC cases,[43] but are nevertheless revealing of the quality of satellite information as well as potential limitations to its value.

The use of EO information in ICC cases has many potential benefits over other forms of evidence. It may offer improved quality and accuracy of information about temporal and spatial relationships.[44] It may have safety and other benefits for those collecting evidence. The area in question may be a conflict or post-conflict zone, and thus it may be dangerous to collect data on the ground, as in the ongoing ICC cases concerning Libya and Darfur. Evidence needed may relate to very large and potentially cross-border areas of land, or land that is difficult to access, such as mountains or deserts. In some cases spatial data may be needed about areas that have yet to be thoroughly or recently mapped.

In addition, there are temporal benefits. ICC cases often relate to situations that are or were rapidly changing. EO information may speedily provide information regarding change in a region. Again, these cases can involve very large areas of land, where it would not be feasible to gather such information from the ground in the time frame demanded. Advances in technology mean that in some cases the turnaround from gathering EO information to having it available to expert interpreters of that information is potentially very rapid; even as little as 30 minutes.[45]

4. OBTAINING EO INFORMATION FOR EVIDENCE

EO information is increasingly familiar, but has not been widely used in legal cases in the areas discussed in this Annex. Some aspects of obtaining EO information for evidence are discussed here.

ICC cases may require complex information as evidence. Availability is a critical issue where vast areas of land, rapidly changing situations, and detailed information about numbers of dwellings or people are concerned. In some cases very high resolution (VHR) images may be needed, whereas in others high resolution (HR) may suffice. In addition, there is a temporal consideration. In rapidly changing situations, images from satellites with small time-gaps in their archives generated by multiple passes, perhaps even daily over the relevant location, may be needed. They are not always available. However as satellite technology improves, with increasing acquisitions, broader coverage and more frequent satellite visits to the same locations, the availability of EO information should increase, and thus its usefulness as evidence.

EO satellites with the potential to provide information relevant to international criminal cases may be state-owned, commercially owned, operated by a non-governmental organisation (NGO) or intergovernmental organisation (IGO), or some combination of these.[46] One such 'hybrid' provider is the Satellite Sentinel Project (SSP).[47]

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42 The ICC Prosecutor v. Germain Katanga and Mathieu Ngudjolo Chui. See Section 6.1: Mapping and Geographical Information.

43 For a discussion of the legal considerations surrounding prosecution of war crimes and crimes against humanity, see Katherine Hughes*, 'Operation Drive out the trash': The case for imposing targeted United Nations sanctions against Zimbabwean officials'*, Fordham Law Review, volume 76, issue 1, 1 January 2007, 326.

44 Annex 6: EO System Capabilities, Section 1.

45 For example, CleanSeaNet data is available to interpreters within 30 minutes of being captured by the relevant satellite. See Annex 1: Workshop Report, Section 3.4.1.

46 Irmgard Niemeyer has stated that, "Among the optical very-high resolution systems, four privately funded systems are in orbit. Three are owned by US companies and the other is owned by an Israeli company. National space agencies, and partly public-private partnerships, are operating or being developed in Canada, France, Germany, Italy, India, Russia and South Korea." See *Challenges in Treaty Monitoring*, in Seminar Documentation for GMOSS Seminar Environment and Conflict: Evaluating and strengthening the means of interdisciplinary cooperation, eds. Lars Wirkus and Ruth Vollmer, 2007, p. 64.

47 According to the SSP website, "SSP was launched as a six-month pilot project on December 29, 2010, as the result of an unprecedented collaboration between Not On Our Watch, the Enough Project, Google, the

Obtaining the EO information may be obtained by the Court or by the parties. Where a case is ongoing, current imagery may also be required. Consideration must be given to the type of satellite, the technology to be used to obtain the information, and "acquisition window" (when and where the information would be captured by the satellite). Medium or high-resolution data will be necessary in most humanitarian situations, including military activities and detection of density and change in refugee camps.

The ICC Prosecutor can request the cooperation of States in the process of gathering evidence. The Prosecutor may ask a State to provide EO information in the possession of that State, for example, information of interest to the case, gathered by a State-owned satellite. Material may also be offered by a State. The UN Operational Satellite Applications Programme (UNOSAT) is a potentially useful resource of EO information and image analysis that could provide evidence in ICC cases,[48] in human security and humanitarian affairs. A recent UNOSAT project focused on Southern Sudan,[49] and the information gathered there could have implications for ongoing ICC trials relating to alleged crimes against humanity committed by individuals in Darfur.

5. RELIABILITY OF EVIDENCE AND THE ROLE OF THE EXPERT WITNESS

As in any evidence in a national, regional, or international jurisdiction, there are issues of reliability with EO information in terms of authenticity, accuracy, chain of custody of the information, and the processes that could render the evidence vulnerable to accusations of alteration. An expert witness may contribute to assessing reliability. The degree to which evidence is considered reliable relates to the weight it is given by the Court.

5.1 RELIABILITY OF EVIDENCE

Reliability of EO information is significantly improved when combined with other corroborative evidence, normally "ground truth" evidence. This ground truth may be aerial or surface observations and samples providing circumstantial evidence, or witness testimony of the relevant event giving direct evidence.[50] EO information and ground observations from site or field visits can be mutually reinforcing and corroborative. They can also assist in gathering more focused and probative evidence. EO information can help those on the ground, often with the guidance of global positioning devices, to focus their search and information gathering efforts and reduce the risk of errors.

Conversely, ground truth evidence can help establish what additional EO information may be required.

United Nations UNITAR Operational Satellite Applications Programme (UNOSAT), DigitalGlobe, the Harvard Humanitarian Initiative, and Trellon, LLC. UNITAR/UNOSAT's role concluded when the pilot phase ended on June 30, 2011." http://satsentinel.org/about, accessed 2 January 2012.

48 http://www.unitar.org/unosat.

49 http://www.unitar.org/unosat/sudan; http://www.unitar.org/unosat/node/22/1228

50 Annex 1: Workshop Report. 2.2.6.

5.2 EXPERT WITNESS TESTIMONY

In line with criminal law in other jurisdictions, the ICC often relies on expert witnesses to interpret satellite information and its analysis.[51] The Court Registrar maintains a list of experts to be called upon for such purposes.[52] The Court may direct the joint instruction of an expert by the participants, or may on its own motion instruct an expert.[53]

The testimony of an expert witness may address potential concerns of reliability. The expert witness is neutral, unbiased and independent, and furnishes the Court with the scientific criteria for testing the accuracy of the evidence.[54]

In the case of EO information, an expert witness may be asked to objectively confirm that the information being considered has not been subjected to incorrect or improper processing or handling. It is also worth noting that most data used by EO information providers come from government sources but some are from commercial sources. The data is supplied with no 'fitness for purpose' warranty, and no guarantee. These liability limitation provisions are typical for most satellite data supplied.[55] The expert witness may testify about the authenticity and appropriateness of the EO information supplied.

Experts may disagree in their interpretation of EO information, as in the 1986 ICJ case, when EO information was used as evidence in a boundary dispute case between Burkina Faso and Mali. Disagreement between the expert witnesses over interpretation of the images led to further confusion in the case, and the ultimate conclusion by the ICJ that maps could not constitute a binding document or territorial title by themselves, whatever their accuracy and technical value, unless the parties concerned expressed their acceptance.[56] However, as technology improves issues such as these should become less likely to occur.

6. AREAS IN WHICH EO EVIDENCE MAY BE OF VALUE

There are a number of specific applications in which EO information may be of value in prosecuting serious crime in the international courts. In addition, a number of technical and legal issues affect the utility of EO evidence in ICC cases. These are outlined below.

To prosecute the commission of a humanitarian crime such as those discussed in this Annex, certain facts need to be established. Broadly, the commission of relevant acts, or the existence of a specific state of affairs, are necessary. These will need to be linked to the accused perpetrator.

EO information can be of value in recording events and facts that provide evidence of the necessary elements for a successful prosecution. Areas in which EO information can be of value in relation to this Annex include:

1. mapping and geographical information;
2. detecting changes to topographical features or infrastructure;
3. exploitation of natural resources;
4. detecting changes in populations of livestock, vegetation or crops, or the presence of illegal crops;
5. movement of civilians, combatants, or the formation of IDP or refugee camps;
6. detecting changes to structures; and
7. detection of human remains or mass graves.

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51 Final Report, Annex 4: Expert Evidence and EO Systems.

52 Regulation 44 § 1.

53 Regulation 44 § 2.

54 See Cresswell J on the duties of expert witnesses, National Justice Compania Naviera SA v Prudential Assurance Co Ltd, The Ikarian Reefer [1993] 2 Lloyd's Rep. 68 per Cresswell J at page 69, cited at http://www.swarb.co.uk/lisc/LitiP19931993.php, accessed 4 January 2012.

55 Annex 1: Workshop Report, Section 3.2.

56 Annex 1: Workshop Report, Section 5.2.3.3.

These applications may produce evidence of murder, genocide, or other serious crimes against humanity or war crimes, including forced displacement of people.

This EO information may provide a link to a specific perpetrator and lead to conviction of a crime by itself, or more commonly in combination with other evidence.

Conviction of a perpetrator at the ICC requires not only proof of the occurrence of events such as genocide, but also identification and linkage of an alleged perpetrator to those events; an issue that is relevant to all criminal cases. EO information may contribute to this process. In many cases, a particular location, such as a palace or camp, can be identified with an alleged criminal defendant through ground truth and witness testimony. While it may be clear that atrocities occurred in a particular area, the linkage of those crimes to the defendant could be corroborated by the indication of movement or build-up of personnel and supplies from the alleged criminal's base location, and by the movement of troops or supplies.[57]

The examples below indicate the types of information that may be relevant in linking perpetrators to crimes by physical evidence.

EO information on some or all of these have been used, or can be used, before Courts to provide evidence of crimes, their location and to link them to their perpetrators. Often such evidence will be corroborative or circumstantial, but nonetheless valuable. The examples given in this Annex are illustrative of the use that can be made of EO information. They include material used by NGOs to support allegations of atrocities which are not subject of Court cases, but which do indicate the utility of EO information as evidence.

6.1 MAPPING AND GEOGRAPHICAL INFORMATION

EO information is beneficial for mapping and geographic orientation in ICC cases due to its widespread availability. It can be particularly useful in cases where land-based survey information may be out of date, may not have existed in the first place, or where it may be dangerous or difficult to obtain information "on the ground." Other conditions may also deter the gathering or maintenance of accurate mapping. The "crime scene" may be a very large area of land, and may be too dangerous to map on the ground.

While individual cases may require specific resolutions and time-archives to indicate change, the large number of satellites gathering such data means that such information should normally be obtainable for evidential purposes. Furthermore, where questions might arise about the origin of the information, or potential errors in its handling or analysis, multiple sources of information over the same area will corroborate the information and establish its reliability.

The following are examples of the utility of EO evidence for these purposes.

6.1.1 DRC: Identification of Crime Scene

In a case before the ICC, EO information was admitted as evidence in the prosecution of two individuals for crimes in the DRC. Satellite imagery was submitted to identify the location of alleged crimes.[58] Satellite imagery provided by the Prosecutor was the subject of testimony by an expert witness,[59] along with photographs taken by the expert to produce a 360-degree image, and photographs taken by a drone.

Satellite images were also used in cases before the ICTY, in order to provide information about the geography of the areas in question.[60]

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57 Annex 1: Workshop Report, Section 3.4 discusses this in relation to oil spills.

58 The ICC Prosecutor v. Germain Katanga and Mathieu Ngudjolo Chui, ICC-01/04-01/07-T-90-ENG ET WT 26-01-2010 38/59 NB T, page 38, http://www.icc-cpi.int/NR/exeres/4CE0B881-1146-4D0D-A728-A13F540273BD.htm, accessed 19 December 2011.

59 ICC-01/04-01/07-T-90-ENG ET WT 26-0102010 24/59 NB T, page 24.

60 In the Prosecutor v. Karadžić (IT-95-5/18-I), satellite images were used during the questioning of a witness on 10 October 2010 (page 7954); In The Prosecutor versus Ramush Haradinaj (IT-04-84-T), a satellite

6.1.2 Kyrgyz Republic (Kyrgyzstan): Scope of Destruction

Satellite images taken of southern Kyrgyzstan have also been used by Human Rights Watch to show the geographic scope of destruction in that country, following violent clashes in the City of Osh.[61]

6.2 TOPOGRAPHICAL CHANGE

EO information can reveal changes in the parameters of land-plots, changes to the surface of that land, and minute changes in the elevation of an area of land. Creation or destruction of transportation routes, bridges or communication networks are among the changes that might be detected. In addition, topographical changes may indicate the presence of human remains or a mass grave.

The crimes that are the subject of this Annex are often accompanied by major changes to topographical landmarks, such as the destruction of roads or buildings by military action, fire or by other cause that can be evidenced by EO information.

EO information is clearly valuable in detecting alterations to man-made structures in connection with detecting the crimes under discussion here. Damage or alteration to a structure can be evidence of a mass grave.[62] Destruction, construction or alteration of the course of a road can indicate planned or actual troop movement, potentially in connection with an attack on civilians. These can also indicate the movement of IDPs or refugees.

Changes to topography and land use can also be indicative of the presence or criminal activity of perpetrators or of atrocities. For example, the cultivation of drug crops could indicate the presence or proximity of a warlord's camp. Detection of the removal of crops may provide evidence of destruction of food supplies. Furthermore, changes in land elevation can be evidence of digging or filling in a mass grave.

In addition, satellites that re-visit the same footprint can detect small changes, as small as centimetres, in the overall elevation of a tract of land. This application has been useful in monitoring the effect of earthquake and land subsidence due to excavation.[63]

6.2.1 Earthquake

Optical remote sensing was very valuable in assessing damage to structures, roads and the land itself following an earthquake. Following the 2010 Haiti earthquake, with timely triggering and the lack of cloud cover, EO information augmented a combination of web-based local systems using open source tools, mobile systems with web cams and GPS optical imagery.[64] It is worth noting that if there had been persistent cloud cover, or if some of the

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image was used during the examination of a witness on 15 October 2007 (page 9366); see also Nicolas Peter, *The Use Of Remote Sensing To Support The Application Of Multilateral Environmental Agreements*, *Space Policy* 20, 2004, 191.

61 Amnesty International, *Satellite Images Reveal Massive Destruction in Kyrgyzstan*, Human Rights Now, 25 June 2010. Such monitoring may also be a deterrent against violence. See, for example, the project *Eyes on Darfur,* 2007, in which the American Association for the Advancement of Science worked with Amnesty International reported the monitoring of 13 villages. As a result of the monitoring, it is claimed that 9 villages remained untouched in 2011. http://shr.aaas.org/geotech/darfur_2/negeha.shtml accessed 12 January 2012. See Section 6.3.2. below.

62 See section 6.3.1. below.

63 See the Rovigo case below, section 6.2.3. See also Mamoru Koarai, Izumi Kamiya, Hiroshi P. Sato, Masashi Matsuoka, Kazuo Amano, Application Of High-Resolution Satellite *Imagery For Detection Of Disaster Damages And Disaster Monitoring*, at ISPRS Hanover Workshop 2007: High-Resolution Earth Imaging for Geospatial Information, http://www.ipi.uni-hannover.de/125.html?&L=1, accessed 7 January 2012.

64 EO information was provided quickly to the UN World Food Program (WFP), which coordinated the information, and very soon thereafter to the wider community. GeoEye-1 collected colour high-resolution imagery over the capital within a few hours, on 13 January 2010 and 16 January. Google made the imagery universally available, without license restriction that might have interfered with the needs of rapid disaster response. Community or participatory mapping systems such as Open Street or Google Map Maker may have scope in some areas to add to the information rapidly, even if it is not the most accurate. See Andrea Ajmar, Piero Boccardo, Fabio Giulio Tonolo and Carlos Veloso, *Earthquake damage assessment using*

conditions had existed that are typical in conflict zones such as Sudan, the EO information would have been the sole tool available.[65]

This level of detail can provide strong evidence in the prosecution of international criminal cases.

6.2.2 Detection of Change in Land Elevation

As noted, small changes in land elevation can be indicative of a mass grave. An illustrative civil case concerning such change was provided in Rovigo, Italy. EO information provided evidence of subsidence causing damage to three churches, all historical monuments. It was instrumental in assisting the court to establish the cause of the settlement, which was found to be the building of an underground car park in the vicinity.[66]

Several points are significant in this case. First, EO information provided the only actual measurements of the land movement in question. The particular technique in this case utilised radar, and would be useful in future where buildings or other reflective (bright point) features are visible. Second, the use of archival ESA EO information combined with two independent PSInSar analyses resulted in excellent cross-validation of the EO data, pinpointing the time, location and severity of the subsidence. Third, EO information was shown to be a valuable alternative to other sources of information, such as geological models, expert reports of the damage to the buildings, and technical information about the excavation.

6.2.3 Evidence of Mass Graves and Human Remains

Under the Rome Statute and other international humanitarian law, the systematic killing of civilians in peace or war by their own government is a crime against humanity. Mass graves are important as evidence of the murder of civilians or prisoners of war, or of genocide. Changes in the elevation of land such as those described in the Rovigo case above can provide evidence of mass graves. Where mass graves are alleged, EO evidence might be used to map an area, to indicate the location of mass graves by changes in the elevation of land, and to validate or corroborate "ground truth," eyewitness testimony or other evidence of the existence of such graves.

EO information is reported to have been used in the investigative phase of cases before the ICTY and ICC. However, there is little in the public record to indicate the nature of its use, or any published ruling specific as to its value. While NATO made repeated use of images of mass graves during the Kosovo conflict of 1999, it is not from the record whether the images were from aerial reconnaissance or EO information.

EO information has been made public alleging the existence of mass graves in Rwanda, the former Yugoslavia, Congo, Darfur, the Ivory Coast and Libya. One such case arose from the massacres in the area of Srebrenica in 1995, during the conflict in the former Yugoslavia.[67] The US provided to the UN and the Tribunal satellite imagery as evidence in the trial of Radislav Krstic, the first man to be prosecuted for genocide. Other evidence included ground truth and photographs of the victims before the massacre. Krstic was convicted in 2001 and sentenced to 46 years imprisonment.

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remote sensing imagery. The Haiti case study, in *Geoinformation for Disaster and Risk Management: Examples and Best Practices*, Eds. Orhan Altan, Robert Backhaus, Piero Boccardo, Sisi Zlatanova, preface by Margareta Wahlström, Special Representative of the Secretary-General for Disaster Risk Reduction, 2010, Joint Board of Geospatial Information Societies (JB GIS) and United Nations Office for Outer Space Affairs (UNOOSA) 2010, pp. 31-37.

65 The authors note that the role of radar remote sensing (not only aimed at identifying the main faults by measuring ground displacements) in the post-earthquake damage assessment should be a research priority.

66 Annex 1: Workshop Report, Section 4.2.

67 Prosecutor v. Radislav Krstic, IT-98-33-T. See also James F Keeley, Robert N Huebert, *Commercial Satellite Imagery and United Nations Peacekeeping: A View from Above*, 2004, p. 186, and David Rohde, *Evidence Indicates Bosnia Massacre*, Christian Science Monitor, 18 August 1995, http://www.csmonitor.com/1995/0818/18012.html accessed 11 January 2012.

6.2.3.1 Sudan

In July 2011 the SSP submitted to both the ICC and the UN Security Council information (including EO information), which they claim is indicative of mass graves in the South Kordofan region of Sudan.[68] They alleged that the Sudan Armed Forces (SAF) and Government of Sudan-aligned (GoS) militias have engaged in a campaign of systematic mass killing of civilians in Kadugli, the main town of the South Kordofan region of Sudan[69]. In July 2011[70] and August 2011,[71] SSP alleged the presence of mass graves. EO images were published to corroborate eyewitness statements that bodies were being dumped or that bodies were being buried in the area.

In the following image, dozens of heavy transport trucks are visible, which appear to be consistent with vehicles of Sudan Armed Forces and militia aligned with them observed elsewhere, and with those described by multiple eyewitnesses as being present in Kadugli town. In addition, on 4 July 2011, a pile of white bundles is clearly visible in Kadugli town, along with vehicles consistent with those used by SAF and GoS-aligned militia are present in that area and tracking consistent with the presence of heavy vehicles.

The image below from the SSP report[72] shows the vehicles in residential areas where killing of civilians had allegedly occurred, and appears to corroborate reports of systematic house searches. The presence of white bundles is consistent with the allegations that bodies have been placed in tarps or bags, and may corroborate claims that civilians were being systematically hunted and killed.

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68 SSP used images provided by DitigalGlobe for their reports included in this Annex. SSP 16, Satellite Sentinel Project, *Crime Scene: Evidence of Mass Graves in Kadugli, Sudan*, http://www.satsentinel.org/report/crime-scene-evidence-mass-graves-kadugli-sudan.

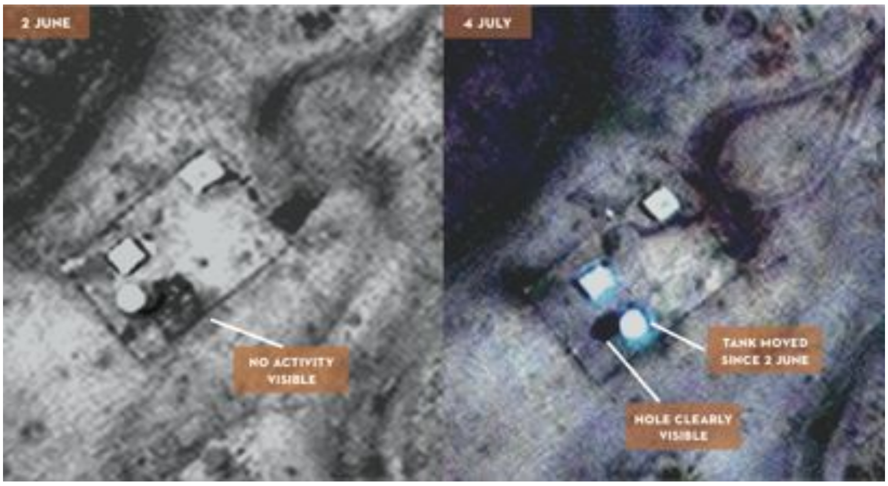
69 South Kordofan, bordering on South Sudan, became independent in July 2011 after a prolonged conflict.

70 SSP 16, *Crime Scene: Evidence of Mass Graves in Kadugli, Sudan*, 13 July 2011, http://www.satsentinel.org/report/crime-scene-evidence-mass-graves-kadugli-sudan.

71 SSP 17, *Cover-Up: New Evidence of Three Mass Graves in South Kordofan*, http://www.satsentinel.org/report/cover-new-evidence-three-mass-graves-south-kordofan, and SSP 18, *Special Report: Evidence of Burial of Human Remains in Kadugli, South Kordofan*, p. 8, http://www.satsentinel.org/report/special-report-evidence-burial-human-remains-kadugli-south-kordofan.

72 SSP 16, *Crime Scene: Evidence of Mass Graves in Kadugli, Sudan*, 13 July 2011, p. 8, http://www.satsentinel.org/report/crime-scene-evidence-mass-graves-kadugli-sudan.

The following images from June through August 2011 show disturbance of terrain, movement of a water tank to conceal a hole, and subsequently moving it back (presumably covering the bodies that witnesses stated were put there).[73]



Other images show large numbers of scattered shapes identified as human remains, perhaps in body bags, along with an excavated hole that is later filled in, presumably containing the bodies.[74]

[73] SSP 18, *Special Report: Evidence of Burial of Human Remains in Kadugli, South Kordofan*, p. 8, http://www.satsentinel.org/report/special-report-evidence-burial-human-remains-kadugli-south-kordofan, accessed 20 December 2011.

[74] SSP 18, *Special Report: Evidence of Burial of Human Remains in Kadugli, South Kordofan*, p. 7, http://www.satsentinel.org/report/special-report-evidence-burial-human-remains-kadugli-south-kordofan, accessed 20 December 2011.

Further proof of the utility of this type of EO information can be seen in the following detail from an image in an SSP report, showing a heavy truck at the water tank site.[75]

6.2.3.2 Rwanda

EO information from Landsat Thematic Mapper (Landsat TM) has been used to search for mass graves in Rwanda as part of investigation of crimes against humanity. An image from 1990 showing Rwanda before the alleged crimes[76] was compared with a mosaic of images dated 1995, which identifies mass graves and resistance sites from the conflict.[77]

6.3 DETECTION OF DESTRUCTION OF DWELLINGS

War crimes include "…the wanton destruction of cities, towns and villages, and any devastation not justified by military, or civilian necessity…"[78] EO information can reveal such destruction. Use of EO information to monitor dwellings for other purposes also indicates the usefulness of such information. EO information was used to analyse the reconstruction of dwellings in Indonesia after the 2004 tsunami. The area of interest was one of the worst hit across all countries affected, with approximately 150,000 houses in the region either damaged or destroyed.[79] Two EO maps, one from the beginning of the audit period and one from the end, were overlaid to determined changes over the time in question.

While this effort focused on the *construction* rather than *destruction* of dwellings, it indicates how EO information can be used to provide time- and geographic-specific information about dwelling structures, with obvious implications for ICC cases. The monitoring of the *construction* also indicates how EO information could be used if, for example, a case of illegal settlement were ever to be brought before the Court. The construction of dwellings is also relevant in providing evidence in relation to refugee or IDP camps.

In several cases under current consideration by the ICC, defendants are accused of the pillaging, burning or razing of villages. These examples occurred in the DRC, Darfur, and Libya.

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75 SSP 17, *Cover-Up: New Evidence of Three Mass Graves in South Kordofan*, p. 7, http://www.satsentinel.org/report/cover-new-evidence-three-mass-graves-south-kordofan.

76 See http://www.yale.edu/gsp/rwanda/rwanda_before_genocide.html.

77 http://www.brown.edu/Courses/HI0135/Documents/rwandamap.htm, accessed 20 December 2011. See also Jo-Ansie Van Wyk, *Space for Peace? The Use of Space Technology to Monitor Conflict Trends and Human Security in Africa*, Conflict Trends Issue 4, 2008, pp. 12-17, http://www.isn.ethz.ch/isn/Digital-Library/Publications/Detail/?ots591=0c54e3b3-1e9c-be1e-2c24-a6a8c7060233&lng=en&id=101729.

78 Gary D. Solish, *The Law of Armed Conflict: International Humanitarian Law in War*, 2010, Cambridge University Press p. 302. See also: UK Ministry of Defence, *The Manual of the Law of Armed Conflict,* 2004, Oxford University Press, para.16.21 at 422.

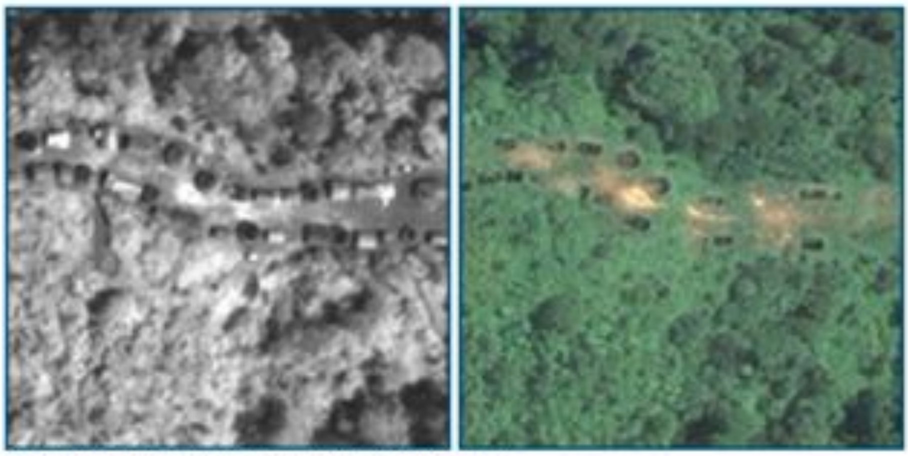
79 Annex 1: Workshop Report, Section 4.4.

6.3.1 DRC

In 2009 the American Association for the Advancement of Science (AAAS) and Human Rights Watch provided satellite images from DigitalGlobe and GeoEye to the ICC relating to the case of the DRC. The images allegedly show villages burned down in North Kivu by the Congolese Army and the Rwandese rebels.[80]

In addition, witnesses indicate that on 9 May 2009, armed men with the Democratic Forces for the Liberation of Rwanda (FDLR) conducted another in a series of attacks on civilians in the area of Busurungi, Walikale, on the southern border of North Kivu. The attack was reported and condemned by the United Nations Organization Mission in the DRC (MONUC), which investigated its aftermath and interviewed survivors. Due to the remoteness of the region and security risks, a full accounting of the devastation is difficult. The American Association for the Advancement of Science (AAAS) was approached by Human Rights Watch, part of the Congo Advocacy Coalition, to acquire and analyze satellite imagery of the area and document the extent of the attack on civilians.

Analysis of pre- and post-attack satellite images 8 months apart identified a large number of destroyed structures and found evidence of continuing violence.[81]



© Copyright 2009 DigitalGlobe Inc. (left) and GeoEye (right)
A close-up of a village in the area of Busurungi, intact on January 22 and evidently burned by September 22, 2009. This village had 103 structures destroyed. Latitude / Longitude: -1.672472°, 28.583403°

6.3.2 Darfur, Sudan

Another example of the documentation of potential criminal events was attributable to the SSP,[82] which published EO and other information about the Abyei region of Southern Sudan.[83]

80 American Association for the Advancement of Science (AAAS), *Evidence of Destruction in the Democratic Republic of Congo: Case Study Report*, October 13, 2009, http://shr.aaas.org/geotech/drcongo/drcongo.shtml, accessed October 18, 2009.

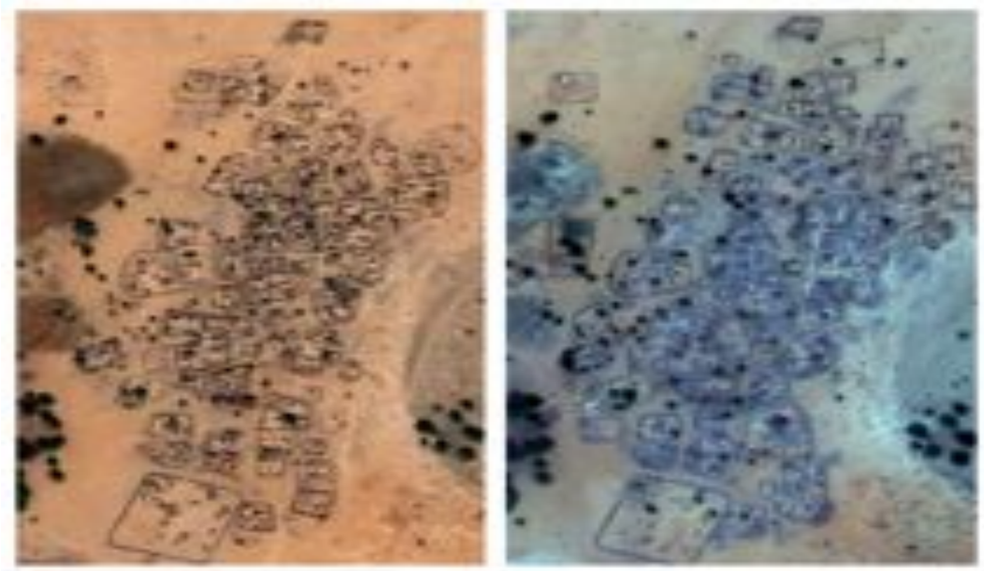
81 American Association for the Advancement of Science, *Evidence of Destruction in the Democratic Republic of Congo: Case Study Repor*t, 13 October 2009, http://shr.aaas.org/geotech/drcongo/drcongo.shtml, accessed 19 December 2011.

82 See http://www.satsentinel.org/, accessed 2 January 2012.

83 See http://www.goss-brussels.com/index.php?option=com_content&view=article&id=3060:satellite-sentinel-project-confirms-deliberate-burning-of-third-village-in-abyei-region&catid=34:news&Itemid=70. See also *Burned to the Ground: Evidence of Potential War Crimes and the Intentional Destruction of Abyei Town by the Government of Sudan*, report by the Satellite Sentinel Project, 28 May 2011, http://www.satsentinel.org/report/burned-ground-evidence-potential-war-crimes-and-intentional-destruction-abyei-town-government-sudan.

The images analysed and published are not sequential, providing "before" and "after" images, but appear to show evidence of the destruction of dwellings and other structures, looting and other crimes. The continuing focus on this area by satellite may be useful if charges are brought against the perpetrators.

The following images are from a 2011 report by the American Association for the Advancement of Science, and concern another area in South Darfur.[84] The image on the left, from December 31, 2005, shows a community of intact structures. By the January 13, 2010 image on the right, 206 structures in the settlement (whitish-grey colour) have been completely destroyed. Additionally, seven structures were found damaged between January and December 2010.



84 (12.898 N, 25.408 E) Left image courtesy of Google Earth. © 2011 DigitalGlobe, Inc. Right image © 2011 DigitalGlobe, Inc., AAAS Scientific Responsibility, Human Rights and Law Program, *Negeha, South Darfur: High-Resolution Satellite Imagery and the Destruction of Housing Structures*, http://shr.aaas.org/geotech/darfur_2/negeha.shtml accessed 12 January 2012.

6.3.3 Zimbabwe

It has been alleged[85] that between May and July 2005 some 700,000 people in Zimbabwe lost their homes, their livelihoods or both as a direct consequence of the government's programme of mass forced eviction and demolition of homes and other structures, carried out across the country.[86]

Satellite images were put forward to show the extent of destruction at four sites: Porta Farm settlement and portions of both Hatcliffe and Chitungwiza, all located around the capital Harare, and Killarney, an informal settlement on the outskirts of Bulawayo in the south of Zimbabwe.[87]

The following DigitalGlobe image shows destruction of structures in the Porta Farm settlement.

It has been alleged that because of the nature and history of the settlements, the lack of warning, the speed and violence of the destruction, the demolition and displacement were

85 *Zimbabwe: satellite images show destruction of community',* Amnesty International, 2 June 2006, http://www.amnesty.org.au/news/comments/526/, full report at http://www.amnesty.org/en/library/info/AFR46/004/2006/en, both accessed 19 December 2011.

86 Harare, Chitungwiza, Bulawayo, Mutare, Kariba and Victoria Falls were targeted in Operation Murambatsvina , which according to Amnesty International's publication means "'drive out rubbish' in Shona". AFR 46/014/2006, Amnesty International 8 September 2006.

87 Amnesty International reported conducting interviews with residents, and visiting sites where there was visible evidence of the demolition of thousands of dwellings.

illegal under international law.[88] The government disputes this. Forced evictions and demolitions without due process, even of structures deemed to be "illegal", are not permitted under international law. The UN Commission on Human Rights considers that "the practice of forced evictions constitutes a gross violation of human rights, in particular the right to adequate housing."[89] In addition, the UN Committee on Economic, Social and Cultural Rights, which monitors compliance with the International Covenant on Economic Social and Cultural Rights, to which Zimbabwe is a state party, has stated that "instances of forced eviction are prima facie incompatible with the requirements of the Covenant and can only be justified in the most exceptional circumstances, and in accordance with the relevant principles of international law."[90]

Satellite images of the locations involved, taken before the events described, were obtained subsequent to the alleged crimes.[91] Images of the locations after the events revealed the destruction of a large number of structures. The resolution of the information, the resulting images and the subsequent analysis could have been useful to a Court in a potential case. Individual structures were identifiable, including many measuring as small as a few metres on a side.[92] Such information will become more valuable with higher resolution EO systems.

The evidentiary value of the images must be weighed against information that might have been captured immediately after the events in question, because the "after" images dated from ten months to more than 30 months after the alleged criminal destruction and forced displacement.[93] As with CCTV footage which is unmonitored or destroyed after a relatively short interval, the lack of a consistent archive of imagery is a handicap to those wishing to prosecute alleged crimes. A readily accessible, searchable archive of EO information would be beneficial, but would be costly and would obviously require large storage capacity.

Those prosecuting serious crimes of this nature will need to be aware of the need to obtain images promptly once a crime is suspected.

6.4 Natural Resources

The use of EO information is well established in agricultural and environmental monitoring and enforcement. Humanitarian crimes may be accompanied by the destruction of food and water supplies, of livestock and other resources such as firewood. The planting of food crops or illegal crops such as narcotics can indicate the existence of the presence in the neighbourhood of a criminal or warlord.

88 Report of the Fact-Finding Mission to Zimbabwe to assess the Scope and Impact of Operation Murambatsvina by the UN Special Envoy on Human Settlement Issues in Zimbabwe, 22 July 2005. See also: Amnesty International, "Zimbabwe: shattered lives – the case of Porta Farm", AI Index AFR 46/004/2006, 31 March 2006;

89 UN Commission on Human Rights, Resolution 1993/77, para 1.

90 CESCR General Comment No. 4 on right to adequate housing (1991), para 18.

91 Images were obtained by Amnesty International, and analysed by the American Association for the Advancement of Science, with funding from the MacArthur Foundation in the United States.

92 Amnesty International 8 September 2006 AI Index: AFR 46/014/2006.

93 QuickBird satellite images obtained for the area of Porta Farm, included a "before" image from 22 June, 2002 and an "after" image from 6 April 2006. The alteration of the Hatcliffe Extension settlement, comprising Hatcliffe Extension Holding Camp and Hatcliffe Extension New Stands, outside Harare, was documented in the Amnesty International report with QuickBird images from 14 May 2004 and an "after" image from 2 September 2005 of the area of Hatcliffe Extension known as Hatcliffe Extension New Stands. Chitungwize was documented by two QuickBird satellite images, showing a portion of St Mary's suburb in Chitungwiza. The "before" image is from 25 August 2004; the "after" image is from 22 June 2005. Killarney, outside Bulawayo, was documented by two QuickBird images covering the area including a "before" image from 22 August 2004 and an "after" image from 7 September 2005.

6.4.1 Land Use

The monitoring EU Common Agricultural Policy (CAP) clearly illustrates how this information may be utilised.[94] Thousands of square kilometres each year are monitored in order to ensure that agricultural subsidies are properly allocated.[95] The CAP uses EO information to confirm that land is being used for farming, to monitor what crops are being grown, and the condition of the crops and the land.[96] Very High Resolution satellites or aerial orthophotos are used to check the size of fields, their cover type and in some case their cover status.[97] EU CAP monitoring of agricultural land and crop growth (stubble, newly cleared, nearly mature, etc) indicates how EO satellites can provide information relating to the destruction of crops or livestock.

EO information can also be used to indicate vegetation clearance and, with coverage over time, the progress of vegetation growth.[98] These may be helpful in prosecuting crimes on a number of levels. The destruction of fields that provide populations with a livelihood or basic means of survival may be relevant in cases of criminal activity before the ICC, including those related to Darfur and the DRC. Further, the destruction by combatants of crops and anything else that might be useful to the enemy, in the advance or retreat across an area has obvious implications for civilians. Civilians may themselves be the targets of the destruction as part of a larger strategy to demoralise a population.

This type of EO information is also capable of showing livestock populations, which, when linked to other information, may indicate destruction of food supply, depriving a local population or seeking to drive them off. Evidence of new cultivation, by contrast, might indicate the establishment of a camp for combatants, criminals, IDPs or refugees.

6.4.2 Mining: Links Between Violence and Mining

Although the war in the DRC ended in 2003, there is small scale (artisanal) mining taking place, especially in the East. There is fighting in these areas, as well as militarised control over mining activities. Abuse of civilians by armed groups is linked directly to natural resources, as they seek control of resource rich areas to access mining operations and tax revenue. It has been noted that conflict levels escalated during a period when mined minerals were at their highest prices.[99]

A 2010 report documents a study aiming to use very highly tailored parameters to identify these mining areas.[100] Very highly targeted and carefully processed EO information was generated, and combined with other data. Research combined EO with socio-economic and ground truth data, and aims to move toward a transferable, robust and fast analysis of exploitation of natural resources, in this case mining.

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94 See: *Remote Sensing,* Research EU, September 2008, http://ec.europa.eu/research/research-eu/earth/article_earth34_en.html, accessed 5 January 2012. See Annex 1: Workshop Report, Section 4.3.

95 In 2010 255 zones, each of approximately 650 square kilometres, were covered with HR images and 316 zones with VHR images.

96 Annex 1: Workshop Report, Section 4.3.

97 Annex 1: Workshop Report, Section 4.3.

98 Annex 1: Workshop Report, Section 6.2.1.

99 Global Witness, 2005, *Under-Mining Peace. Tin: The Explosive Trade in Cassiterite in Eastern DRC*, June 2005, London. See also Nicholas Garrett, *Walikale. Artisanal Cassiterite Mining and Trade in North Kivu Implications for Poverty Reduction and Security,* 2008, report for the Communities and Artisanal & Small-scale Mining Initiative (CASM).

100 E. Schoepfer, O. Kranz, *From Monitoring Natural Resources in Conflict Using an Object-based Multiscale Image Analysis Approach*, 2010 GEOBIA 2010: Geographic Object-Based Image Analysis 29 June - 2 July, 2010, Ghent, Belgium, Editor(s): E.A. Addink and F.M.B. Van Coillie, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVIII-4/C7, http://www.isprs.org/proceedings/XXXVIII/4-C7/, accessed 10 January 2012.

Potential areas of interest are identified using high spatial resolution images, spatial aggregation analysis, and fine-scale spatial pattern analysis. Since most of the mining areas in the North and South Kivu are inaccessible by road, extracted material must be carried on foot to nearby towns. Features selected are therefore within a certain distance of features such as roads, settlements or rivers since this is necessary for the movement of the minerals, and since rivers are frequent sources for the minerals.

In approaching the common problem of quasi-permanent cloud cover, a method was devised to distinguish between clouds and shadows and other features. Classification was then carried out of water bodies, bare ground, settlements and roads, moist and secondary forest, referring to the nomenclature of the Royal Museum for Central Africa (RMCA). Where necessary, these categories were elaborated into sub-sets. Complex data analysis was applied to, among other things, identify bare ground and settlements, which would be closely linked in mining operations, and to eliminate agricultural or other irrelevant areas.

One result of the data analysis highlighted rough ground in a riverbed, with dwellings close by, which could be indicative of a mining site. Recommendations included enhancing the object-based analysis, better knowledge of mining areas and socio-economic data, and linking radar with optical data. Irregular mine structure could be identified by radar, while overall hot spot detection would be done with optical imagery.

This approach could prove useful in linking perpetrators to crimes where vegetation and cloud conditions are challenging, and where there is not a visible network of roads.

6.5 Movement of People, Forced Displacement, IDP and Refugee Camps

One of the crimes prosecuted by the ICC is that of intentionally directing an attack against a civilian population. The upheaval and forced displacement of large numbers of civilians is often indicative of the commission of such a crime. If civilians are forced to flee but remain within their country of origin, they are classed as internally displaced persons (IDPs). Persons forced out of their country of origin, remaining there due to a well-founded fear of persecution or an unwillingness to return for fear of persecution, are refugees. Refugee camps often form across the border of a country in conflict, while IDP camps may spring up in a number of locations.

EO information showing the build-up of troops and military equipment, as in the examples in sections 6.5.3 and 6.5.4 of this Annex, could be useful to a Court or tribunal if it could be linked to an individual. In this connection, the identification of encampments, supply routes and troop movements can be documented by EO information.

Information on population density and its spatial distribution is arguably one of the most crucial requirements for disaster management, and by analogy, detection of serious crime such as genocide. These parameters can successfully be monitored with remote sensing technology and GIS processing.[101]

EO information from high-resolution satellites[102] is capable of providing evidence of the number of people in a crowd[103] and therefore the size of populations, including numbers of IDPs and refugees.[104] Satellite re-visits allow for the build-up of a time-archive by which the direction, movement and alteration of such a population can be determined. A further use of

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101 Altan, O., Backhaus, R., Piero Boccardo, P., Zlatanova, S. (eds.): *Geoinformation for Disaster and Risk Management - Examples and Best Practices. Joint Board of Geospatial Information Societies* (JB GIS), United Nations Office for Outer Space Affairs (UNOOSA), pp. 89 – 94.

102 Annex 6: EO System Capabilities, Section 1.

103 GeoEye-I can resolve objects as small as 41 centimetres in the right conditions.

104 In addition, EO information has been used to monitor the impact of refugee or IDP camps on resources such as firewood, grazing and water. See Olaf Kranz, Stefan Lang and Stephen Clandillon, *Earth Observation in Conflict Mitigation*, GIM International, July 2009, pp. 33-37, http://www.gim-international.com/issues/articles/id1387-Earth_Observation_in_Conflict_Mitigation.html, accessed 8 January 2012.

EO information is the documentation of the establishment, growth and destruction of IDP or refugee camps by virtue of detecting the size of the camp or population density.

6.5.1 Sudan (Darfur) and Chad: Camps and Forced Displacement

The existence of IDPs or refugees has arisen in relation to serious crime. In relation to the situation in Darfur, Sudan, among the charges alleged in a case before the ICC is "forcible transfer" of civilians.[105]

In connection with a number of specific situations, EO information has been used to document camps in Darfur and Chad arising from the conflict in the region[106]. In this conflict, particularly during the worst fighting in 2003-2004 but continuing even today, millions of civilians were forced to leave their homes.[107] Humanitarian and peacekeeping efforts proved ineffective for a number of reasons. EO information emerged as a useful tool in monitoring and investigation of these conflicts and crimes arising from them.[108]

One such use of EO information was the 2008 collaboration between the External Relations Directorate-General of the European Commission (DG RELEX) and European Forces (EUFOR), who obtained EO information[109] and worked with a number of European organisations to process, validate and analyse the material. The aim was to support the delivery of EU aid and assistance to the conflict areas through NGOs and UN agencies in the field, and to plan an EU peacekeeping mission to Chad. [110]

Rapid mapping techniques were applied to analyze the effects of raids on three villages in Darfur, including the displacement of people.[111] Analysis was also carried out on the evolution of two IDP camps in Western Darfur, focussing on the population growth and densities within the camps and surrounding villages. QuickBird imagery was used due to its very high resolution (0.6m), making it capable of detecting small features such as huts and temporary dwellings or tents. The number of these features was indicative of the magnitude of the displacement.

105 The Prosecutor v. Ahmad Muhammad Harun and Ali Muhammad Al Abd-Al-Rahman, ICC-02/05-01/07-2 4/16 CB PT.

106 Kranz et. al. 2009.

107 It is estimated that almost half of Darfur's total population was internally displaced by January 2009. Olaf Kranz, Gunter Zeug, Dirk Tiede, Stephen Clandillon, Denis Bruckert, Thomas Kemper, Stefan Lang, Mathilde Caspard, *Monitoring Refugee/IDP Camps to Support International Relief Action*, 2010, in Altan, O., Backhaus, R., Piero Boccardo, P., Zlatanova, S. (eds.): *Geoinformation for Disaster and Risk Management - Examples and Best Practices. Joint Board of Geospatial Information Societies* (JB GIS), United Nations Office for Outer Space Affairs(UNOOSA), pp. 51-56.

108 EO information is capable of providing timely delivery of maps and further information to humanitarian relief operations as well as investigations into potential serious crimes, where remoteness of conflict areas and unavailability of up-to-date maps can be factors. Monitoring of environmental damage arising from refugee and IDP movement and camps is another use of EO information, as is the management of the camps themselves. Issues include uncontrolled growth, movement of individuals, pollution and environmental degradation, water supply and sanitation issues, and security, all of which can add to or start new conflicts.

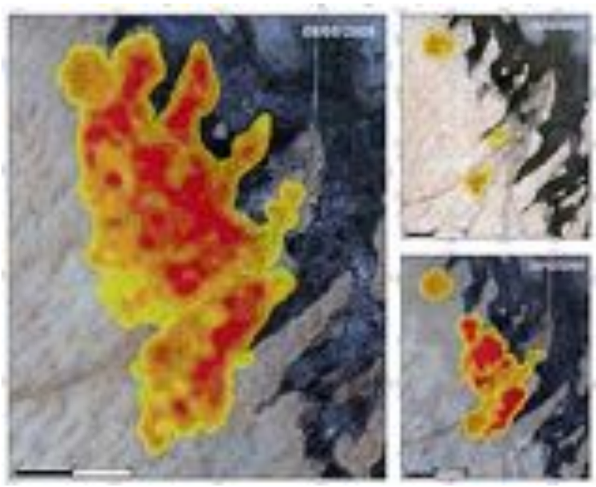
109 Information was requested from the Global Monitoring for Environmental Security (GMES) project), Land and Sea Integrated Monitoring for European Security (LIMES), which aims to define and develop prototype information services to support security management of the EU. Kranz, et. al. 2009.

110 See Kranz, et. al. 2009, p. 33; also Olaf Kranz, Gunter Zeug, Dirk Tiede, Stephen Clandillon, Denis Bruckert, Thomas Kemper, Stefan Lang, Mathilde Caspard, 2010, *Monitoring Refugee/ IDP Camps to Support International Relief Action*, http://elib.dlr.de/68874/, accessed 2 January 2012.

111 The villages were Abu Sorouj, Sirba and Dagrase. Olaf Kranz, Stefan Lang, Dirk Tiede, Gunter Zeug, Thomas Kemper, Mathilde Caspard and Stephen Clandillon, *GMES Services for Conflict Prevention and Mitigation: Supporting the DG Relex in Mission Planning*, 2010, In: Konecny, M., Zlatanova, S. & Bandrova, T. L. (eds.): *Geographic Information and Cartography for Risk and Crisis Management. Towards better solutions*, 2010, Springer, Berlin Heidelberg, pp. 171-188.

The changes to the two IDP camps between 2004 and 2008 were analyzed with object-based image analysis (OBIA)[112], and the resulting information was augmented by statements from Médecins Sans Frontières (MSF) and by available statistics from the Spanish Red Cross (HNP) and the UN Office for the Coordination of Humanitarian Affairs (UN OCHA). There was good agreement between the reported populations and estimates based on the EO information. Information was thus gathered on the density of the camps, including the distinction between temporary dwellings such as tents or tarpaulins and more permanent structures.[113]

The following image shows, clockwise from upper right, the growth of a camp from 2002, through 2004 and 2006.[114]



Additional information in respect of IDP camps in eastern Chad was requested for further detail about IDP camps.[115] Analysis of information from GMES was available within 44 hours of data reception. Satellite mapping, along with population monitoring, helped meet one of the objectives of the EUFOR mission, to monitor the return of IDP camps. While speed of delivery could have been better, the information was considered of very good quality for the purpose. The rapid response provided by carefully planned combination of established capacities should prove useful in serious crime cases in future.

6.5.2 Zimbabwe: Forced Displacement

Section 6.3.3. above outlines the case presented by Amnesty International to show destruction of dwellings. The EO information in their report was also said to corroborate forced displacement of civilians.

6.5.3 Iraq: Changes to Troop and Civilian Transportation Routes

A study carried out following the 1999 Gulf war[116] reveals how accurate EO information can be in detecting changes associated with conflict or large-scale movements. It concerned the

112 OBIA integrates segmentation, class-modelling and knowledge-representation techniques. Kranz et. al. 2009.

113 Traditional dwellings present as dark on the images, while tents and tarpaulins present as bright, or reflective, structures. Kranz et. al 2009, p. 35.

114 Olaf Kranz, Stefan Lang, Stephen Clandillon, *Earth Observation in Conflict Mitigation*. GIM International, Issue 7, Volume 23, July 2009, 33-37.

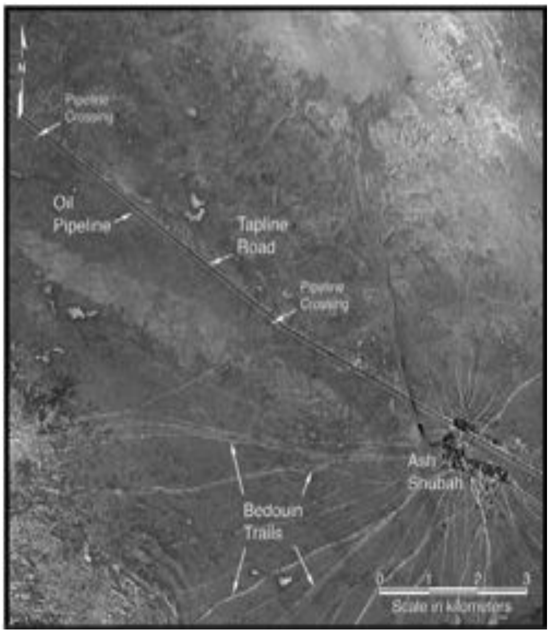
115 The camps were located in Kerfi and Abdi. Kranz et. al. 2009 p. 36.

116 Vipin Gupta and George Harris, *Detecting Massed Troops with French SPOT Satellites*, SAND98-85972, http://www.cmc.sandia.gov/papers-reports.htm, accessed 7 January 2012.

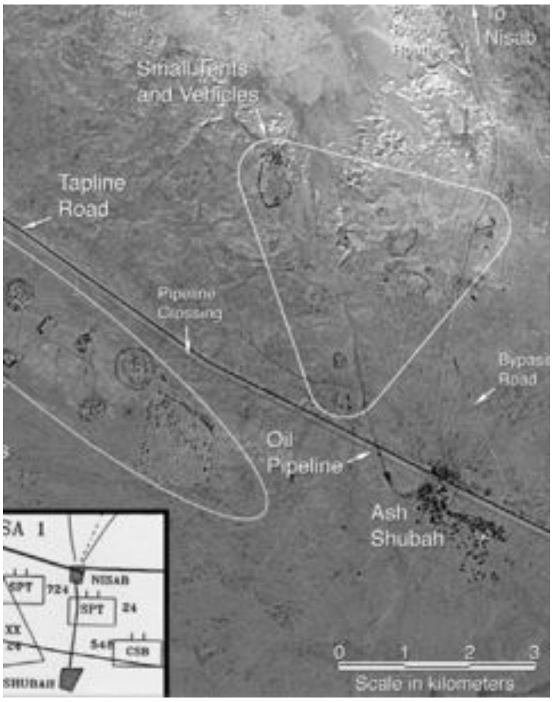
feasibility of evidencing troop (and other) movements using SPOT EO information with 10-metre resolution, by comparing the imagery with a large body of existing non-satellite information.

The “before” image below, of the area around Ash Shubah town, shows the town, the Tapline Road, an oil pipeline and Bedouin trails. Personnel deployed along the Road, and near one of two primary supply routes to the border, played a critical role in supply of the military.

The "after" image shows that the Bedouin trails have been covered with sand, indicating the absence of civilian traffic between the town and desert, as well as a bypass road that has been built in the interim. The cessation of civilian traffic was directly attributable to the military build-up. Other new features are also clear, such as clusters of what are said to be small vehicles and tents.



Before



After

6.5.4 Sudan: Troop Movement And Transportation Routes

A more recent example from the ongoing conflict in Sudan[117] illustrates the benefits of the higher resolution EO information that is now available. SSPs analysis of DigitalGlobe satellite imagery captured on 4 July 2011 reveals a convoy[118] travelling through a town consistent with a regiment-sized unit, which is equal to approximately 1000 troops. The convoy is at least 2 km in length, with 80 vehicles visible, including light vehicles, cargo trucks, a vehicle consistent with a fuel or water tanker, heavy transports and towed artillery.

[117] SSP 15, Convoy: Evidence of Heavy Military Activity in Kadugli, South Kordofan, 5 July 2011, http://www.satsentinel.org/report/convoy-evidence-heavy-military-activity-kadugli-south-kordofan.

[118] SSP 15, Convoy: Evidence of Heavy Military Activity in Kadugli, South Kordofan, 5 July 2011, p. 3, http://www.satsentinel.org/report/convoy-evidence-heavy-military-activity-kadugli-south-kordofan.

In the following image from the report,[119] a known armed forces installation to the west of the town has apparently been recently fortified. Multiple occupied and unoccupied artillery firing positions are visible.

The report also includes an image of aircraft at the Kadugli airstrip, including a heavy transport plane with a mass of people and material gathered nearby, two helicopters consistent with helicopter gun ships and another plane.

119 SSP 15, Convoy: Evidence of Heavy Military Activity in Kadugli, South Kordofan, 5 July 2011, p. 5, http://www.satsentinel.org/report/convoy-evidence-heavy-military-activity-kadugli-south-kordofan.

6.6 POTENTIAL USES: DETECTION OF DRUG TRAFFICKING, CRIMES OF AGGRESSION

6.6.1 Drug Crops

The cultivation of crops for the production of illegal drugs may be associated with funding military activities. It may be possible to detect such crops by EO.[120] However, the proposal to make drug trafficking a crime under the ICC is controversial. The likelihood of this being approved seems low, though rising atrocities in Mexico could have an impact on the international community's response to the problem. In the prosecution of drug traffickers, EO information could be used as evidence, to indicate *inter alia* the growth of crops, and the movement of goods and people.

6.6.2 Crimes of Aggression

As mentioned previously, the crime of aggression is prosecutable at the ICC, but the difficulty in defining "aggression" has delayed its pursuit in any cases.

At its Plenary Meeting in Kampala on 11 June 2010, the Review Conference of the Rome Statute adopted an amendment[121] to the Rome Statute[122] defining the *crime of aggression* and *act of aggression*. The relevant jurisdiction of the ICC does not come into effect until after 1 January 2017, and a decision by the States Parties to activate the jurisdiction.

A *crime of aggression* is defined therein as the planning, preparation, initiation or execution by a person in a leadership position of an *act of aggression*. Importantly, it contains the threshold requirement that the act of aggression must constitute a manifest violation of the Charter of the United Nations. An *act of aggression* is defined as the use of armed force by one State against another State without the justification of self-defence or authorization by the Security Council.[123]

7. POTENTIAL LIMITATIONS ON THE USE OF EO EVIDENCE

The ICC's practice of considering the admissibility of evidence on a case-by-case basis suggests that EO information will continue to be used, and most likely more widely used, as it becomes better understood and precedents are established regarding its use.

There are, however, actual or potential limitations to the use of EO information as evidence in ICC and other international criminal cases. Some of these are discussed below.

7.1 AVAILABILITY

In general, EO information is relatively universal in coverage. Where EO information exists, access will normally be available in most situations. Indeed, the UN has encouraged the use of EO and remote sensing to improve human security "for the benefit and in the interest of all countries".[124] It has been said that "The Principles …. confirmed the unrestricted right to remote sensing without prior consent or notification. In return, the state subject to remote sensing has access to the data on a non-discriminatory basis and at a reasonable price. The Principles do not apply to military reconnaissance."[125]

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120 Steven A Sader, *Remote Sensing of Narcotics: With Special Reference to Techniques for Detection and Monitoring of Poppy Production in Afghanistan*, report PNABT431 for USAID, 1990. The report also comments on detection of marijuana and cocaine crops.

121 Resolution RC/Res 6.

122 Rome Statute, Article 8*bis*

123 The definition of the act of aggression, as well as the actions qualifying as acts of aggression contained in the amendments (for example invasion by armed forces, bombardment and blockade), are influenced by the UN General Assembly Resolution 3314 (XXIX) of 14 December 1974.

124 UN Principles relating to remote sensing of the earth from space (Principles), A/RES/41/65 of 1986, <http://www.un.org/documents/ga/res/41/a41r065.htm>, see also the Treaty on Open Skies, available at <http://www.osce.org/documents/ doclib/1992/03/13764_en.pdf>, which entails similar provisions for airborne images.

125 Irmgard Niemeyer, *Challenges in Treaty Monitoring*, eds. Wirkus and Vollmer, p. 64.

7.1.1 Legal and Regulatory Issues on Availability

The use of satellite images to support claims of human rights violations committed by national governments has triggered a debate about the legal implications of its use.[126] It has been suggested[127] that despite the Outer Space Treaty of 1967 and the UN Principles, that some countries may not accept the legitimacy of being observed from space.[128] This may arise in part because most of the limited number of satellites belong to national governments.[129] This concern may to some extent be resolved by an increase in the number of commercial satellites.

The European satellites of GMES imply dual-use of the data, shared between military and civilian users. Other systems like the Indian Cartosat-2, do not offer image data on a commercial basis yet. However, among the optical very-high resolution systems, four privately funded systems are in orbit. US companies own three and an Israeli company owns the other. In addition, very high-resolution optical and high- resolution SAR satellites are under operation or being developed by national space agencies and, partly as public-private-partnerships, in Canada, France, Germany, Italy, India, Russia, and South Korea.[130]

7.1.2 Restrictions for National Security or Military Purposes

Very rarely, there are blanket restrictions on the acquisition of imagery of a particular type or area. Two examples of restriction are the prohibition of the sale by US firms of optical satellite data of Israeli territory with better than two metres resolution,[131] and the purchase of exclusive rights of Ikonos EO information covering Afghanistan by the US National Geospatial-Intelligence Agency during the 2001 conflict. The Government did not invoke *Shutter Control*,[132] the US policy that grants the U.S. government authority to restrict domestic commercial satellite companies from imaging areas that might in its view compromise U.S. national security interests, but rather bought up all the imagery.[133]

7.2 Areas Where EO Is Not Available, or May Not Be Sufficiently Useful

EO cannot monitor some areas effectively due to particular conditions. Combatants or equipment may be hidden in urban areas, in refugee or IDP camps. Military hardware or supplies may be hidden in bunkers or otherwise, making EO detection difficult.[134] Heavy forest cover or cloud cover may also make it difficult to identify supply paths. However, in terms of the crimes under consideration in this Annex, the following are more significant.

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126 Ruth Vollmer, Summary of Seminar Discussion, in *Challenges in Treaty Monitoring*, in *Monitoring Environment and Security: Integrating concepts and enhancing methodologies*, Bonn International Center for Conversion (BICC), eds. Lars Wirkus and Ruth Vollmer, 2008, (Seminar Documentation of *Environment and Conflict, Evaluating and strengthening the means of interdisciplinary cooperation),* p. 74, http://www.bicc.de/publications/briefs/brief-37.html.

127 Stefan Schneiderbauer, *Monitoring Multilateral Humanitarian Agreements*, in Wirkus & Vollmer, 2008 p. 48, where he cites J K Hettling, *The use of remote sensing satellites for verification in international law*, Space Policy, Vol. 19, No. 1, pp. 33–39.

128 If a country conceals inappropriate activities or weapons, because it is aware of being observed, a satellite image may show nothing. This is not *evidence of absence,* but merely *lack of evidence.*

129 Ruth Vollmer, *Summary of Seminar Discussion*, in Wirkus & Vollmer, 2008, p. 74.

130 Irmgard Niemeyer, *Challenges in Treaty Monitoring,* Wirkus & Vollmer, 2008, p. 64.

131 Stefan Schneiderbauer, *Monitoring Multilateral Humanitarian Agreements*, in Wirkus & Vollmer, p. 48. See also Irmgard Niemeyer, *Challenges in Treaty Monitoring,* Wirkus & Vollmer, 2008, p. 64. See also The Economist, *Eye Spy*, Satellite Technology, 8 November 2001, http://www.economist.com/node/852498 accessed 7 January 2012.

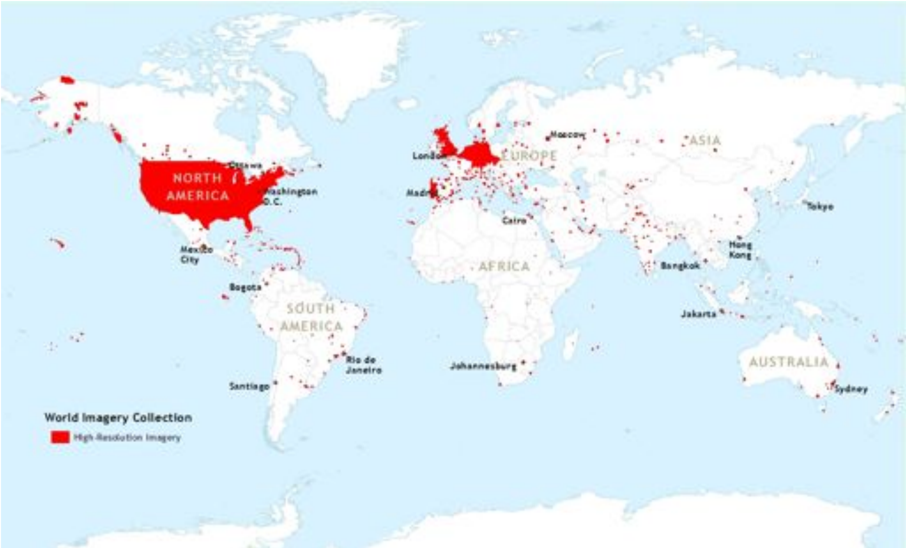
132 Presidential Decision Directive (PDD-23) 1994. See Frank Sietzen Jr., *Advanced Imagery Raises the Ante: High-resolution imagery from a burgeoning commercial remote sensing industry may pose perplexing policy questions,* Aerospace America, The American Institute of Aeronautics and Astronautics, September 2001, http://www.aiaa.org/aerospace/Article.cfm?issuetocid=136&ArchiveIssueID=18 acc. 7 Jan 2012.
See also Raphael Prober, Shutter Control: Confronting Tomorrow's Technology With Yesterday's Regulation, 2003.

133 Duncan Campbell, *US buys up all satellite war images*, 17 October 2001, The Guardian.

134 Ruth Vollmer, *Summary of the Seminar Discussion,* in Wirkus & Vollmer, 2008, p. 73.

7.2.1 Limits to High Resolution Monitoring

As has been stated previously, high-resolution imagery is often essential in the prosecution of crimes that are the subject of this Annex. High-resolution information is not being routinely archived as a matter of course over large parts of the world, including Africa and Asia. [135] Specific commissioning of such information for a target area on short notice will add significantly to cost.



Another factor in the availability of high-resolution EO information is the capability of the satellite covering the area. GeoEye-1, for instance, scans an area of about 6000 square miles in two minutes at a resolution of about 40 cm. This very large image file is compressed and stored in a 1-terabyte drive. Files are downloaded to ground stations 40 times a day. While the resulting imagery is of very high quality, it is not possible for the satellite to record continuously. The following shows the additional information that can be identified in very high-resolution imagery.[136]

[135] The ArcGIS world imagery map page includes a coverage map showing the areas with high-resolution imagery throughout the world, last updated in October 2011, http://www.arcgis.com/home/item.html?id=10df2279f9684e4a9f6a7f08febac2a9, accessed 10 January 2012.

[136] Bjorn Carey , *How It Works: The Best View From Space Yet,* Popular Science, 03.13.2008, http://www.popsci.com/node/19968, accessed 10 January 2012.

Radar satellite data is also restricted by coverage, and is highly dependent on the presence of a time archive. This is relevant in uses such as identification of mass graves or destruction of dwellings.[137]

7.2.2 Weather

It is possible with lower resolution EO information to document the burning of a large area, for instance, but high resolution EO information will be necessary for identification of the cause of the fire, or the perpetrator. However, the majority of high-resolution sensors applicable for monitoring of humanitarian issues receive the visible portion of the electromagnetic spectrum, and deliver undisturbed images only in cloud-free weather conditions.[138]

A recent study addressed the presence of clouds and shadows as part of an analysis of mining in the DRC, achieving some good results in identifying possible mine sites and producing recommendations for further study.[139]

Two additional methods can expand the range of coverage where weather is a problem. Night-time monitoring is indicative man-made lighting, and may provide evidence of destruction of dwellings. Multi-spectral sensors, for instance near infrared, or radar sensors may provide alternative information that is basically independent of daylight and weather conditions. There are some limitations on their use. Time coverage is an issue, as there are few systems in operation. The information is not in the form of an image, and data must be subjected to high levels of processing. In addition, radar is disturbed by natural phenomena not related to weather, such as water turbulence or algal growth. [140] However, technological developments such as very high-resolution radar sensors[141] continue to expand the quality of the data produced.

7.2.3 Temporal resolution

Not all satellite missions have the same scientific and archive base. Time gaps in archives may reduce their usefulness as evidence. With increasing acquisitions, increasing coverage and daily re-visits the position is improving, but this does not resolve the historic problem.[142]

7.3 SCIENTIFIC & TECHNICAL CONSIDERATIONS RELATING TO AVAILABLE MATERIAL

Medium- and high-resolution data is necessary to monitor military activities, IDP and refugee camps, or changes in population density and size. These types of monitoring make use of morphological data processing and automatic change detection, among other steps. Temporal considerations come into play, as well. The frequency of satellite visits will determine whether EO information is of use in the specific situation.

However, even the best EO information can only monitor physical objects. It is possible to count tents but not to detect the number of people in them. It will be necessary to apply an estimate of occupancy to arrive at a population figure. Nor is it presently possible to identify an individual.

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137 Ruth Vollmer, *Summary of Seminar Discussion*, in Lars Wirkus and Vollmer, 2007, p. 75, http://www.bicc.de/publications/briefs/brief-37.html, accessed 19 December 2011. Another issue with radar sensors is disturbance due to natural phenomena such as water turbulence.

138 Stefan Schneiderbauer, *Monitoring Multilateral Humanitarian Agreements*, in Wirkus & Vollmer, 2008, p. 48.

139 E. Schoepfer, O. Kranz, from *Monitoring Natural Resources in Conflict Using an Object-based Multiscale Image Analysis Approach*, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVIII-4/C7, http://www.isprs.org/proceedings/XXXVIII/4-C7/, accessed 10 January 2012. See section 6.4.2. of this Annex.

140 Ruth Vollmer, *Summary of the Seminar Discussion,* in Wirkus & Vollmer, 2008, p. 73.

141 TERRASAR-X provides 1 m. resolution independent of weather and lighting conditions, and COSMO SkyMed, is equipped with Synthetic Aperture Sensors (SAR), and operates in all visibility conditions, in real time, and at high resolutions.

142 Annex 1: Workshop Report, p. 38.

A second point of interest arises from the nature of EO. The indirectness of the acquisition process may seem to indicate that it is objective. However, while EO information is gathered in an 'objective' manner, the final image is a result of analytical steps. As with a visual image, it is a subjective interpretation of reality, and must be shown to be verifiable and technically sound to have value as evidence.

Furthermore, it is a general scientific problem that the underlying assumptions and instruments used to address a question can influence the answers that are produced. The decision to acquire EO information is affected by the availability of funds, and by political, economic, security and other policy considerations. Potentially, all decisions – definition of the target, temporal and spatial resolution, methodology, relevant indicators, specific research aims, etc. – made before obtaining satellite imagery of a location may have some impact on the results.

Political, economic, security and other policy considerations will have preceded these decisions. In addition, factors such as political developments, media coverage or reports from affected areas may influence the areas chosen as targets for high-resolution observation.[143] Until, and unless, there is universal coverage of all at-risk areas, these issues will persist to some degree.

In order to ensure that appropriate choices are made, there should be a very high degree of transparency with regard to the available tools, methodologies, sources, and capacities.[144] The mining study in the Kivu provinces of the DRC is of interest in this connection.[145] The creation of a central database of EO sources will also assist those seeking access to available information.

7.4 RELIABILITY

EO information is obviously a valuable tool in corroboration of other evidence, such as eyewitness statements. There is little reporting on the point of whether, or in what circumstances, EO information could be considered reliable enough to be probative on its own merits, in the absence of other evidence.[146]

Some States may lack the skilled scientific support to properly interpret EO information.[147] In those cases, it is unlikely that there would be the ability to properly commission or to interpret EO information that may be available.

The process of setting standards in this area has begun. Improved standards of certification and verification are likely to lead to EO information being more readily used as evidence. Standards agreed by the legal community as well as those set by the International Standards Organisation (ISO)[148] will go some way to creating benchmarks of reliability. EO information has already been shown to be reliable in many areas.[149] However, it is still necessary that EO information should be used consistently and effectively in a number of ICC cases in order to establish precedents and confidence in its utility.

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143 Ruth Vollmer, *Summary of the Seminar Discussion,* in Wirkus & Vollmer, 2008, p. 73. See also footnote 64 above, in the discussion of the 2010 Haiti earthquake. The speed with which high-resolution imagery was made available, without license restrictions, was remarkable, and might be compared with other situations that did not receive such immediate worldwide focus.

144 Irmgard Niemeyer, *Challenges in Treaty Monitoring,* Wirkus & Vollmer, 2008, p. 64.

145 See section 6.4.2. above.

146 For further discussion of reliability, see Annex 1: Workshop Report.

147 Jo-Ansie van Wyck, *Space for Peace? The Use of Space Technology to Monitor Conflict Trends and Human Security in Africa,* for African Centre for the Constructive Resolution of Disputes (ACCORD), Conflict Trends, Issue 4, 2008, p. 5, where she cites Michael Sheehan, *The International Politics of Space,* 2007, p. 125.

148 See for example ISO 21962:2003, and ISO 19123:2005, at www.iso.org.

149 Olaf Kranz, Stefan Lang, Stephen Clandillon, *Earth Observation in Conflict Mitigation*. GIM International, Issue 7, Volume 23, July 2009, 33-37.

7.5 COST

EO information can be costly, especially in the case of very high-resolution imagery (such as is necessary for population verification) or where high levels of analysis and modelling are necessary. 2011 price lists show costs in the low thousands of Euros for single acquisitions. Archival imagery (more than 90 days old is typical) are the cheapest, and those commissioned for specific targets within a short time frame can be much more expensive.

However, alternative methods of evidential collection, including “ground truth” or collection of eyewitness testimony, may be equally or even more costly.

In many cases, government sources of EO information will be available. In some cases the required information has been donated, as in the audit of aid following the 2004 Indian Ocean tsunami.[150] The Korean Aerospace Research Institute (KARI) donated images of the Indonesian province of Aceh to the International Organisation of Supreme Auditing Institutions (INTOSAI) for its audit of humanitarian aid to rebuild communities after the natural disaster.[151] EO information may also be made available by NGOs or INGOs, such as UNOSAT, or hybrid organisations such as the SSP. Investigators and prosecutors, as well as defending lawyers, will need to be aware of the sources of information, and the evidence that it can provide.

7.6 VIOLATION OF HUMAN RIGHTS

As has been stated, the use of remote sensing of the earth from space has been encouraged for human security. However, the use of satellite observation has been debated in the context of human rights.[152] Issues of concern include whether a search warrant may be required to obtain EO information as evidence, and whether the gathering of EO information may violate a person’s right to privacy.[153]

Clearly, the collection and use of such information must adhere to applicable law, and the clarification of those laws in relation to an international tribunal, for instance in the holding of information about an individual, would go some way to alleviating concerns regarding privacy.

7.7 OTHER LIMITATIONS

There are limits to the ability of some countries to obtain, process and interpret EO information, due to budgetary or other constraints. Regional differences exist in data availability and capacities to use them, including interpretation of the information. For instance, movements of tribes, clans or ethnic groups may be difficult to distinguish from forced displacements. Accurate interpretation and corroboration will be necessary. International cooperation could be improved.[154]

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150 INTOSAI is the International Organisation of Supreme Audit Institutions (SAIs). See Wietske Bijker, Egbert Jongsma, Richard A Kidd , *Audit of Indian Ocean Tsunami Aid in Aceh with Geo-information*, in Geoinformation for Disaster and Risk Management: Examples and Best Practices, pp. 83 – 87, http://isprs.org, accessed 2 January 2012.

151 Annex 1: Workshop Report, pp. 16-19.

152 Sánchez Aranzamendi M., Sandau R., Schrogl K.-U., *Current Legal Issues for Satellite Earth Observation. Treaty Verification and Law Enforcement Through Satellite Observation, Privacy Conflicts from High Resolution Imaging*, ESPI Report 25, August 2010, 34.

153 See for example ISPRS/ESPI/IAA/IISL Conference, *Current legal issues for satellite Earth observation*, Vienna, 2010, http://www.espi.or.at/index.php?option=com_content&task=view&id=479&Itemid=37, accessed 7 January 2012. See also Annex 8, Section 8.6: US Report, s. 3.3.

154 Jo-Ansie van Wyk, *Space for Peace? The Use of Space Technology to Monitor Conflict Trends and Human Security in Africa*, Conflict Trends, Issue 4 (2008).

8. CONCLUSION

In order to investigate and prosecute the "most serious crimes of concern to the international community as a whole",[155] the ICC and other international criminal Courts use a vast range of information as evidence. EO information can contribute to such cases, as it can in the prosecution of warlords and their followers, either by corroborating or verifying other evidence, or by providing unique material.

It provides “a comparable, mostly verifiable, unbiased, and continuous data source for monitoring and change detection…of the Earth’s surface.”[156] It is singularly valuable, and may be the only viable option in cases where it is necessary to observe vast and sometimes dangerous areas of land, in rapidly changing situations and repeatedly over time.

Witness testimony even in ordinary criminal cases tend to be uncertain as to time and detail. In the types of case being considered here witnesses are under much greater pressure. EO information can corroborate such evidence by fixing the temporal sequence of events. It can also provide information that supports, for example, the direction in which personnel and vehicles travel, sequence in which villages are attacked or burned, leading to the identity of perpetrators.

On occasion circumstantial evidence obtained by EO can strengthen the case against perpetrators. For example, crop cultivation, be it to generate revenue, such as poppies, or to provide supplies, can point to the existence of camps and persons.

Precedents for the use of EO information as evidence exist in domestic, regional, and international legal cases as well as in tribunals and enforcement of treaties and agreements. It has been widely used for human rights monitoring or auditing purposes. All of these provide analogies of how such data may be used as evidence. There is every indication that its use in prosecution in the international criminal courts will increase. However, in order to do so, issues including reliability, availability, cost and potential violation of human rights must be addressed.

Where concerns persist, for instance on the question of processing and human intervention in the process, it may be necessary to increase non-technical persons’ knowledge of these matters. Improved standardisation regarding the quality of both the information and the experts that interpret it, perhaps through an organisation such as the ISO, should increase the credibility and acceptance of satellite-derived EO evidence.

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155 Statute of Rome, Article 5.1.

156 Ruth Vollmer, in Ruth Vollmer, *Summary of the Seminar Discussion,* in Wirkus & Vollmer, 2008, p. 51.

APPENDIX 1: ACRONYMS

DRC	Democratic Republic of Congo
EO	Earth Observation
ESA	European Space Agency
CAP	Common Agricultural Policy
GIS	Geographic Information System
HR	High Resolution
ICC	International Criminal Court
ICJ	International Court of Justice
ICTY	International Criminal Tribunal for Yugoslavia
ICTR	International Criminal Tribunal of Rwanda
IDP	Internally Displaced Person
IGO	Intergovernmental Organization
INTOSAI	International Organisation of Supreme Audit Institutions
NGO	Non-Governmental Organization
SSP	Satellite Sentinel Project
UNOSAT	United Nations Operational Satellite Applications Programme
VHR	Very High Resolution
WMD	Weapons of Mass Destruction

ANNEX 3

THE USE OF EARTH OBSERVATION SATELLITE-DERIVED INFORMATION AS EVIDENCE IN WATER DISPUTES

CONTENTS

APPENDICES

1. INTRODUCTION

Water is a fundamental part of life on earth, an essential part of the natural world and integral to agriculture, industry and energy production.[1] It is also a finite and mobile natural resource, the supply of which varies by year, by season and by location. There is increasing pressure on supplies due to demand, climate change, declining water availability and the imposition of stricter environmental standards. These pressures have an impact on existing water allocation regimes, and may also trigger water disputes.[2]

This Report will focus on the use of satellite-derived Earth observation (EO) information as evidence in the resolution of water disputes, which are generally civil actions. There will be some reference to administrative and international cases. As most jurisdictions deal with water through water rights, they are described here.

This Report will focus on disputes arising out of legal rights to surface water and groundwater. Disputes over rivers or bodies of water that form territorial boundaries will not be discussed, nor disputes over maritime exclusion zones

2. WATER RIGHTS

A *water right* is a formally established or legal authority to take water from a water body and to retain the benefits of its use. Water rights may relate to a lake, stream, river, or to surface water or ground water. Canals and artificial watercourses are often treated differently in law.

Water rights holders do not generally own the water resource itself, but rather the right to abstract and use the water.[3] In most jurisdictions, water rights are conferred administratively or by statute, on application to take water or by recognising a prior appropriation. Rights are granted by the owner of the water, which is usually a state or government, and are referred to as rights, licences, concessions, permits, access entitlements or allocations.[4] In some jurisdictions irrigation water is supplied by a state agency on the basis of a detailed formal contract. In California, for example, water user associations may hold 25 to 30 year contracts with the Federal Bureau of Reclamation (FBR) or the State Water Department for the supply of water. Similar contractual arrangements are being introduced in the former socialist states, such as Azerbaijan and Romania, as part of irrigation sector reforms.

Water rights specify more than just the entitlement to a *quantity* of water. The rights are conditional on factors such as the location of the water extraction and where it will be used, the nature of the use[5] and the timing or rate of extraction.[6] They are granted to specific users

1 See HM Government, UK Department for Environment, Food and Rural Affairs (Defra), *Water for Life*, White Paper, December 2011.

2 See Anglian Water, Frontier Economics Ltd, *A right to water? Meeting the challenge of sustainable water allocation*, Report, February 2011, p.13; Bruns, Bryan Randolph, Ringler, Claudia, Meinzen-Dick, Ruth Suseela (eds.), *Water Rights Reform: Lessons For Institutional Design*, International Food Policy Research Institute, 2005 p.19.

3 Productivity Commission 2003, *Water Rights Arrangements in Australia and Overseas*, Commission Research Paper, Melbourne, p.93, http://www.pc.gov.au/research/commission/waterrights. Hereafter: Productivity Commission 2003, *Water Rights*.

4 For a glossary of terms related to water use, regulation, monitoring and enforcement, see Productivity Commission 2003, *Water Rights*, pp. 311-320.

5 The Bureau of Land Management of the US lists recognized uses for water in the various Western states, including Agriculture, Aquatic Life, Commercial, De-watering, Domestic, Erosion Control, Fire Protection, Fish, Geothermal, Groundwater Recharge, Industrial, In-stream Flow, Irrigation, Mining, Municipal, Navigation, Pollution Abatement, Power, Recreation Uses, Sediment Control, Stock water, Storage, Water Leased, Waterfowl and Wildlife.

for a specified time, for specific uses.[7] Those who might hold a water right include municipalities, irrigators, manufacturers, water companies, and those who use the water to some extent, returning less to the source than they take. Some water rights are non-consumptive, such as those held by fish farmers and energy producers, who use water in-stream or divert water from its natural course but return most or all of it after use.

In some instances, water rights can be transferred between an original and new holder, or the water may be transferred to a new specified use, such as from municipal to irrigation. These transfers are regulated and authorised by the state or its agent. These are quite distinct from the selling of groundwater by a landowner to other parties, such as occurs in India. Water users may also obtain water from those holding a water right, under contracts such as those between an urban water authority and a homeowner.

Once a legal water right has been created, the right holder can expect to be able to assert that right throughout its duration against other parties and the state. Loss of, or damage to a water right will be a matter for the relevant court to resolve. The corollary is that a person who undertakes an activity that requires a water right without holding such a right may be subject to legal action, by the holder of the water right, the state or the body responsible for water rights administration. Water rights will be subject to government authority in specific ways, for instance powers to regulate navigable waters, agricultural and commercial use of water. Governments may *reserve* water rights for some purposes, for example in relation to tribal or government lands.

Modern water rights systems have wider aims than historical systems, including protection of water resources, sustainability and water resource management. Recently drafted legislation in this area has included a number of defined water uses: abstraction; storage; waste disposal which has an impact on water resources; removal, discharge or disposal of underground water; changes to watercourses; stream flow reduction; and recreational use.[8] Most uses of water will require a water right. Possession of a water right will usually be necessary, for example, to divert water, restrict it, or alter the flow of water within a water course, to discharge wastes or pollutants into a water course, to undertake fishing, or to navigate on the water course.

Finally, a connection has been asserted between *the right to water* and other *human rights,*[9] either as a right in itself or as an ancillary aspect of the right to an adequate standard of living and health, notably by UN resolutions,[10] other international instruments,[11] or deriving from

6 It is common for users of small amounts for private use or livestock to be generally exempted from licensing.

7 Tom Le Quesne et al, *Allocating Scarce Water, A Primer On Water Allocation Water Rights And Water Markets*, p.11 (WWF Water Security Series, April 2007), http://assets.wwf.org.uk/downloads/scarce_water.pdf.

8 South African National Water Act, 1998, s. 21.

9 See for instance the UN Human Rights Council Resolution A/HRC/15/L.14 of 24 September 2010, http://www2.ohchr.org/english/bodies/hrcouncil/15session/resolutions.htm, accessed 27 January 2012; UNGA Res 64/292 of 28 July 2010, http://www.un.org/en/ga/64/resolutions.shtml, accessed 27 January 2012.

10 See Articles 11 and 12 of the International Covenant on Economic, Social and Cultural Rights; See also UN Committee on Economic, Social, and Cultural Rights, E/C 12/2002/11, Substantive Issues Arising in the Implementation of the International Covenant on Economic, Social and Cultural Rights, General Comment No. 15 (2002); http://www.unhchr.ch/tbs/doc.nsf/0/a5458d1d1bbd713fc1256cc400389e94

11 See *The Rights to Water and Sanitation in International Law*, http://www.righttowater.info/progress-so-far/timeline/, accessed 25 January 2012; see also Thorsten Kiefer, et al, *Legal Resources for the Right to Water and Sanitation*, International and National Standards, Centre on Housing Rights and Evictions (COHRE), 2nd edition 2008, available at: http://www.worldwatercouncil.org/fileadmin/wwc/Programs/Right_to_Water/Pdf_doct/RWP-Legal_Res_1st_Draft_web.pdf.

provisions contained in certain national constitutions,[12] such as the "right of access to water" in South Africa. While there have been a number of cases throughout the world in which the right to water as a human right has been recognised and legally enforced at national and local levels,[13] few display the potential for use of EO information as evidence in the context of civil disputes.[14] This aspect of water entitlement is therefore not the subject of this Report.

2.1 LEGAL SYSTEMS GOVERNING WATER RIGHTS

Historically there have been a number of approaches to water ownership and use, from absolute ownership and complete control of water by the government,[15] to the principle of "share and share alike"[16] applied in Eastern US states. There are differing legal traditions within which water law exists, notably civil[17] and common[18] law. Some jurisdictions are influenced by both traditions, or by others, such as collectivism.[19] Water law has also been modified to incorporate many modern developments.

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12 See also the relevant provisions of the constitutions of a large number of countries, in *The Rights to Sanitation and Water in National Law*, http://www.righttowater.info/progress-so-far/national-legislation-on-the-right-to-water/.

13 In Indonesia, for instance, while the Constitution does not explicitly mention a right to water as a human right, it can be inferred from its human rights provisions. See Constitution of the Republic of Indonesia, 1945 and its Amendments, Arts. 28 B (2), 28 C (1), 28 H (1), 28 H (3) and 28 I (3), cited in Mohamad Mova Al'Afghani, *Constitutional Court's Review and the Future of Water Law in Indonesia*, 2/1 Law, Environment and Development Journal (2006), pp. 4-5, available at http://www.lead-journal.org/content/06001.pdf. See also: *Legal Approach*, http://www.righttowater.info/ways-to-influence/legal-approaches/, accessed 27 January 2012.

14 The Phiri case of South Africa is frequently cited. While it was an important water dispute case, it concerned amounts and metering of domestic water supplied to residents, and therefore was not amenable to resolution with EO information. The case before the Indian Kerala High Court in Attakoya Thangal v. Union was a more likely candidate for the use of EO information as evidence. The case involved pumping of groundwater from small islands, with salination occurring as a result. The court ordered a programme of monitoring to help in devising a new water plan. It might have resulted in EO monitoring of aquifer depletion and replenishment, if the location in question had been different, or the events more recent EO could also have helped to identify the numerous wells on the islands in question. See Judgement, *Kerala High Court, Attakoya Thangal vs Union Of India (Uoi)* on 1 January, 1990, http://www.indiankanoon.org/doc/1980528/. Interestingly, the islands have been mapped with high detail as part of a wetland survey of India, using GIS. See moef.nic.in/downloads/public.../NWIA_Lakshadweep_Atlas.pdf.

15 This doctrine prevailed under Dutch rule in South Africa. See DD Tewari, A detailed analysis of evolution of water rights in South Africa: An account of three and a half centuries from 1652 AD to present, Water SA (Online), Vol. 35, No. 5, Oct. 2009, http://www.scielo.org.za/scielo.php?pid=S1816-79502009000500019&script=sci_arttext, accessed 28 January 2012. See also James Hanson, Arthur Woldorf, Leonard Black, *Water Withdrawal Rights: An Overview of Ohio Water Withdrawal Law*, 1991, 2nd Edition, http://www.dnr.state.oh.us/water_rights/tabid/4065/Default.aspx, accessed 29 January 2012, for a discussion of Ohio water rights. Until 1984, the rule in Ohio had been that of Frazier v. Brown, 12 OS 294 (1861), which held that one had no right to ground water. One did have a right to use one's land, including the pumping of water from it, no matter how it affected another's water supply. In the Cline v. American Aggregates case, the Ohio Supreme Court substituted a rule of "reasonable use."

16 California Environmental Protection Agency, State Water Resources Control Board, *Water Rights*, http://www.swrcb.ca.gov/waterrights/board_info/faqs.shtml, accessed 27 January 2012.

17 The civil law tradition is found in most European countries (including the former socialist countries of Eastern and Central Europe), nearly all countries in Latin America, large parts of Africa, Indonesia and Japan as well the countries of the Former Soviet Union.

18 The common law tradition emerged from the law of England and Wales. Countries in which the common law tradition applies include Australia, Canada, India, New Zealand, Pakistan, Singapore, and the United States, and the remaining African countries that are not in the civil law tradition, as well as other Commonwealth countries and a number of countries in the Middle East.

19 In Indonesia, water is regulated under a collectivist system intended to alter the colonial legal tradition. A large number of water-related activities are regulated. A 'water usage right', which may be analogous to a water right in Western legal systems, comprises daily subsistence and commercial uses. The first does not require a permit, and previously existing irrigation schemes were exempted. 'Customary' water rights of

Civil law tradition distinguished between *public* waters, such as perennial streams and rivers, and *private* waters, those located below, along or upon privately owned land.[20] The right to use *public* waters was open to anyone with access to them, subject to government regulation. *Private* waters could be utilized by the landowner, subject to certain statutory limitations such as rights of way. The private versus public water distinction in civil law has been blurred in adapting to modern circumstances.

Likewise, common law tradition has evolved. In the early years of industrial development, water rights were based on *first occupancy*, generally defined as the first water-dependent capital investment. Established users of streams had priority over newcomers, who had to bargain for water rights.[21] A water right was conditional on a beneficial use by the right holder. With increased economic development, water law has been re-evaluated.[22]

Water quality became an issue, as each user's activity could affect other users. With growing numbers of users and increasingly complex uses for water, monitoring and enforcement become more difficult. Courts and legislators modified the legal regime, giving all riparian or water rights owners a correlative, common right to the stream for *reasonable uses*, along with an obligation to those downstream.[23] This *reasonable use* doctrine has become very significant for water rights in many jurisdictions.[24]

Common law tradition did not distinguish between public waters and private waters, but did maintain the principle that flowing waters are subject to a public right. From this principle, two approaches to water law and water rights developed, namely, riparian and prior appropriation. *Riparian* water rights have a long history. *Prior appropriation* rights are more recent. There are also some less common types of water right.

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communities are recognised if they still exist and have been affirmed by local regional regulations. However, significantly large uses, smallholder crops outside the existing irrigation system and uses which change the natural condition of the water source all require permits from the central or regional government. In addition, a water exploitation right "may flow water above another person's land based on approval of the holder of rights over the relevant land", which may take the form of indemnity or compensation, agreed between the parties. See Constitution of the Republic of Indonesia, 1945 and its Amendments, Arts. 28 B (2), 28 C (1), 28 H (1), 28 H (3) and 28 I (3), cited in Mohamad Mova Al'Afghani, *Constitutional Court's Review and the Future of Water Law in Indonesia*, 2/1 Law, Environment and Development Journal (2006), pp. 4-7, available at http://www.lead-journal.org/content/06001.pdf

20 The French Civil Code, which influenced many jurisdictions, retains this distinction between the public or national domain.

21 Water rights in common law derived from English law, and were adopted by the US east of the Mississippi. Japan developed similar rights. See J Mark Ramseyer, *Water Law in Imperial Japan: Public Goods, Private Claims and Legal Convergence*, 18 J. Legal Stud. 51, 1989, cited in Bruce Yandle and Andrew P Morriss, *The Technologies of Property Rights: Choice Among Alternative Solutions to Tragedies of the Commons*, Ecology Law Quarterly, Vol. 28:123, p. 150, www.colby.edu/economics/faculty/thtieten/ec476/Yandle.pdf.

22 For example in England, some 4,500 Private and Local Acts of Parliament were adopted between 1800 and 1947 giving rights to use water, as well as a comparable numbers concerned with land drainage, river improvement and inland navigation. See Stephen Hodgson, *Modern Water Rights: Theory and Practice*, Study 92 for the Food and Agriculture Organisations of the UN Legal Office, p. 22, ftp://ftp.fao.org/docrep/fao/010/a0864e/a0864e00.pdf.

23 Yandle and Morriss, p. 151.

24 In determining whether water use is reasonable, considerations will include the interests of the person making the use, of any person harmed by the use, and of society as a whole. For a discussion of factors to be considered, see Section 858 of the Restatement of Torts, a scholarly legal work which attempts to describe the accepted law in the United States. That section in turn refers to Section 850A, which describes reasonableness of use.

2.1.1 Riparian Water Doctrine: Water Rights Connected to the Water Source[25]

Riparian water rights derive from ownership of land that physically touches a river, stream, pond, or lake.[26] They relate to watercourses with a definite natural channel and a bed with banks, and not to *diffuse* surface water spread over the surface, such as storm or flood drainage. Riparian water rights are indefinite, and cannot be lost through a limited period of non-use.[27] They are generally considered part and parcel to the land, and are conveyed with the property when sold.[28] Owners of riparian land have an equal right to the use of water from that source.[29] However, it is only a usufructuary right,[30] and not a property right in the water. The water may be used as it passes through the property of the landowner,[31] but cannot be unreasonably detained or diverted, and it must be returned to the stream from which it was obtained.[32] Nor can it be used on non-riparian land.[33] In times of shortage, rights holders share any necessary reduction.

Due to the unpredictability of riparian rights,[34] they have frequently been modified or exchanged for an alternative system, where water is scarce.

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25 This section, and the next, are excerpted from the National Science and Technology Center, Bureau of Land Management, Western States Water Laws: Water Appropriation Systems, http://www.blm.gov/nstc/WaterLaws/appsystems.html, accessed 16 January 2012.

26 However, in City of Canton v. Shock, 66 OS 19 (1902), The Ohio Supreme Court broadened the concept of riparianism beyond all common-law precedent by declaring that a municipality was a riparian proprietor in its corporate capacity if a stream flowed through its corporate limits. It did not have to own land along the stream. This holding gives Ohio cities the same advantages in water control held by traditional riparian proprietors. It permits a riparian municipality, like any riparian owner, to use all the water it needs for its own "proper purposes," returning to the stream all that is not consumed, without liability to a downstream riparian owner. See Hanson, et al, *Water Withdrawal Rights*.

27 They can be lost through prescription, a process of involuntary transfer from one party to another, when a party making open use of water for the proper time period (usually 20 years) gains title to the water right superior to that of the original holder It is similar to a “squatter’s right” to land, and is difficult to obtain - it can only be granted by a court. Frequently the only way to acquire a new water right is to apply for and receive a water right.

28 When riparian lands are subdivided, parcels which are severed from the adjacent water source lose their riparian rights unless the rights are reserved.

29 he doctrine of riparian rights in the United States has its basis in case law which first involved Tyler v. Wilkinson in 1827, concerning a dispute between mill owners over the right to use the flow of a river for mill power. The judgment stated that all riparians had equal rights to water in the river, although an upper proprietor could not diminish the quantity that would naturally flow to the lower proprietor. However, the court recognized that such an absolute right would not be practical, and held that an upper proprietor could make "reasonable use" of the water, including consumptive withdrawals.

30 Usufruct is the right to enjoy the use and advantages of another’s property short of the destruction or waste of its substance. Such property may be commonly owned.

31 Unless adjudicated, the right is not quantified, rather it extends to the amount of water which can be reasonably and beneficially used on the riparian parcel. During times of water shortage, the riparian proprietors share the shortage. The riparian right does not extend to seasonal storage of water.

32 Water may be used only upon that portion of the riparian parcel which is within the watershed of the water source.

33 The common rule forbidding transfer of water for use on non-riparian land has been amended in some instances to allow non-riparians to use the water, so long as the use is "reasonable" with regards to other riparians.

34 Hanson, et al, *Water Withdrawal Rights*.

2.1.2 Prior Appropriation Doctrine: First in Time, First in Right[35]

Unlike a riparian right, an appropriative right is not reliant on a physical relationship between land and water, but is generally based on control and beneficial use of the water. The prior appropriation doctrine developed in the western United States in response to the scarcity of water in the region.[36] These rights are entitlements to a specific amount of water, for a specified use, at a specific location, with a definite date of priority. The *priority date* of the right to water is generally the time of first diverting the water and putting it to *beneficial use*. Those with the earliest priority dates have a superior right to the use of that amount of water, over others with later priority dates. Unlike riparian rights, appropriative rights depend on continued use of the water and may be lost through non-use or abandonment. In addition, unlike riparian rights, these rights can generally be sold or transferred, and long-term storage is not only permissible but also common. Changes to any component of a water right are closely regulated, and cannot cause harm to another water user, regardless of priority.

There are four elements to acquisition of water under this system.[37]

1. There must be a demonstration of *intent* to appropriate water, divert it, and apply it to beneficial use. Historically, intent was indicated by on-the-ground acts such as site surveys, land clearing, preparation of diversion points, and posting of notice. Today, it is generally indicated by the application for a permit.

2. A physical *diversion* of water is essential in consumptive rights. This requirement has diminished in states with in-stream flow programs.[38]

3. *Beneficial use* is necessary for a water right to be recognized and protected by law against later appropriations.[39] The aim is to reduce waste of water, and each state defines what it considers to be beneficial uses.

4. *Priority* of a water right is specified, under which the first appropriator of a water source has the right to use all the water in the system necessary to fulfil his water right. A junior appropriator cannot use water to satisfy his water right if it will injure the senior appropriator.[40]

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35 This section, and the previous section, are excepted from the National Science and Technology Center, Bureau of Land Management, Western States Water Laws: Water Appropriation Systems, http://www.blm.gov/nstc/WaterLaws/appsystems.html, accessed 16 January 2012.

36 The doctrine evolved during the California gold rush when miners wished to divert water from the stream to other locations to process ore. Customs and principles relating to water diversion developed in the mining camps, and disputes were resolved by simple priority rule.

37 The US prior appropriation doctrine is used for this example.

38 In-stream uses of water are those that take place within a stream channel, such as hydroelectric power generation, navigation, fish propagation and fishing, and recreational activities.

39 The justification for beneficial use is to prevent waste. Since water is a scarce resource in the west, states must determine what uses of water are acceptable. Beneficial uses of water have been the subject of great debate, and each western state has an evolving system for evaluating what uses of water are considered "beneficial." Elsewhere, certain countries allow withdrawal of water rights if a project with a more beneficial use to society is presented. This is the case in the Philippines. See Jeremy Bird, Wouter Lincklaen Arriens, Dennis Von Custodio, *Water Rights And Water Allocation: Issues And Challenges For Asia*, Asian Development Bank, 2009.

40 A senior appropriator may "place a call" on the river. A call requires that the institution which manages the water source shut down a junior diverter in order to satisfy the senior right.

2.1.3 Hybrid Doctrines and Exceptional Circumstances

Hybrid systems include elements of riparian and appropriative water rights, and may include other types of rights, such as *pueblo rights* in California.[41] Tribal water rights are important in many parts of the world, and have been the subject of much adjudication.[42] The water systems of South Asia and China include some irrigation systems based on the collection of monsoon rain in reservoirs or tanks from which water is distributed through canals to irrigate crops during the dry season.[43] With no direct physical link to regulated water resources, these waters may fall outside the scope of water law.

2.2 DISTINCTION BETWEEN TYPES OF WATER

Water rights can be characterized by the legal tradition to which they belong, whether common law, civil law, or hybrid. To some degree, the various legal systems also make a distinction between types of water: groundwater, surface water, and water in man-made watercourses.[44] Historically most of the focus of water law and water rights has been on surface water resources. It is only relatively recently that specific legal responses have been formulated in water legislation to the issue of groundwater management.

2.2.1 Surface Water

Under common law and civil law traditions, the right to use surface water related to the use or ownership of land or structures built on it, apart from in-stream uses.

The civil law distinction between public and private waters meant that administrative permission was necessary for the use of public waters, and led to innumerable disputes and legislative reforms. This system was influential on the legal systems of many countries, including Spain and countries in Asia, Latin America and parts of Africa. In the Democratic Republic of Congo, for example, lake beds and all navigable water courses are public domain, and belong to the state. The right to use such water is open to everyone, subject to legal and administrative measures regulating use or to concessions, which can be seen as the precursor of modern water rights.[45]

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41 These rights are derived from Spanish law under which Spanish or Mexican pueblos could claim water rights. Pueblo rights are paramount to the beneficial use of all needed, naturally occurring surface and subsurface water from the entire watershed of the stream flowing through the original pueblo. Water use must occur within the modern city limits, and excess water may not be sold outside the city. The quantity of water available for use increases with population and with extensions of city limits, and in general, are limited to use for ordinary municipal purposes.

42 Indian water rights in the US are defined and governed by federal law recognising unique property and sovereignty rights of tribes in the water on their reservations. There are three types of Indian water rights in the US. Aboriginal rights relate to water rights accorded a priority date from “time immemorial”. Pueblo rights date from Spanish land grants and from a US treaty with Mexico.42 Winters rights are based on Winters v. US, 207 US 564 (1908), under which tribes agreed to substantial land cession in return for guarantees of permanent reservation for Indian use and occupation, including a right to sufficient water. The rights date from the time of the establishment of the reservation, and make up the largest body of federal Indian water rights. It has been found that rights relate to both surface and groundwater. The US Supreme Court recognised that Indian water rights had to be quantified. This has been done in general by the practically irrigable acreage (PIA) method, which identifies the amount of water needed to irrigate arable land. See Susan M. Williams, *Overview of Indian Water Rights*, Water Resources Update, Universities Council on Water Resources, Issue 107: Native Indian Water Rights, Spring 1997, http://www.ucowr.org/updates/107/index.html, accessed 2 February 2012.

43 Hodgson, *Modern Water Rights*.

44 H. Thompson, *Water Law: A Practical Approach to Resource Management and the Provision of Services*, 2006, p. 38, cited in Tewari, 2009. This distinction is not universal, however. Ohio law uses the reasonable use standard for both ground water use and stream water rights. See Hanson et al, *Water Withdrawal Rights*.

45 Hodgson, *Modern Water Rights*, p. 15.

2.2.2 Groundwater

Only relatively recently have legal responses been formulated in water legislation to address groundwater use. Both civil law and common law traditionally conferred specific benefits on adjacent landowners in the use of groundwater. Within the civil law tradition, groundwater was the property of the owner of the land above it.[46] Common law jurisdictions in western US states apply the prior appropriation doctrine toward all or some of the groundwater, providing individuals with relatively secure rights to the use of specified amounts of this resource. Other states allow beneficial use by overlying landowners, to pump unspecified amounts of groundwater as long as they do not engage in wasteful uses or interfere with the rights of other overlying owners. Further distinctions arise when considering different categories of groundwater, such as wetlands and estuaries, some of which are regulated, and others not.

With the development of modern well drilling techniques and pumps, weaknesses in both legal traditions became apparent with regard to effective regulation of groundwater. The failure of common law rules to deal with excessive groundwater extraction have led to the introduction of statutory controls over groundwater abstractions in the western United States.[47] Similar difficulties arose within the traditional approach of the civil law jurisdictions, because the distinction of private waters from public waters makes no sense from a hydrological perspective. The need to deal with pollution, a large number of water uses and users, and the difficulty of reconciling the water use of neighbouring landowners over separate yet connected "private waters" led the weakening of the concept of private water, and the introduction of formal and explicit water rights.[48]

Under the California hybrid system overlying landowners have rights to reasonable use of groundwater on their land, rights which are correlative to those of other holders. Overlying owners have a superior right to the water for reasonable use over appropriators, who are those who pump water but do not own the overlying land. Appropriators have a right to the surplus, if any, but also share proportionately in water supply reductions in the event of shortages, based on a system of seniority, with reductions imposed first on junior rights holders.

2.2.3 Man-made Watercourses

Canals and man-made watercourses are generally distinguished from natural watercourses. Under traditional common law and civil law traditions, landowners are not in a beneficial position with regard to water in adjacent artificial watercourses, in the absence of some form or grant or arrangement. The operator of the canal or scheme abstracting water from a natural source will usually be required to obtain a water right. For anyone else to take water from

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46 This approach is reflected in article 552 of the French Civil Code which states that "Ownership of the ground involves ownership of what is above and below it. An owner may make above all the plantings and constructions which he deems proper, unless otherwise provided for in the Title Of Servitudes or Land Services. He may make below all constructions and excavations which he deems proper and draw from these excavations all the products which they can give, subject to the limitations resulting from statutes and regulations relating to mines and from police statutes and regulations."

47 In Arizona, where until 1980 a landowner could pump as much groundwater as could reasonably be used. This led to severe over-depletion of groundwater and the enactment of the Arizona Groundwater Management Act, which regulates it separately from surface water. See http://www.blm.gov/nstc/WaterLaws/arizona.html. However, further changes are needed. In Texas groundwater provides about 60 percent of the water use, particularly for irrigated agriculture and urban water supply. While the courts have made some modest modifications to limit limiting pumping these minor changes in the law are not sufficient to prevent over-abstraction of groundwater. See Hodgson, *Modern Water Rights*, p. 23.

48 Hodgson, *Modern Water Rights*, p. 23

such a canal would probably amount to theft, because once water is abstracted or appropriated, the existence of a property right is capable of being the subject of theft.[49]

3. CAUSES OF WATER DISPUTES

The nature of legal water rights may vary greatly in different jurisdictions. Despite this variability, a number of basic attributes of a water right can be identified, which together describe the extent of the use and control of the water that is conferred on the holder.

The following are some attributes of a legal water right, any of which may be the source of a dispute.[50]

Attribute	Specification
Quantity	The amount of water the holder of the right may abstract, and the amount, if any, that must be returned to the water source.[51]
Quality	The quality of the water to be abstracted or disposed of.
Source	The specific resource and location from which the right is awarded.
Timing	Restrictions on the time that the right applies, such as the time of year at which a volume may be abstracted.
Conditionality and assurance of supply	Whether rights are absolute, i.e. guarantee a certain quantity and quality, or variable, depending on the available resource. May be based on principles of priority or proportionality.
Use	The specific use for which the water is abstracted (e.g. irrigation, mining, etc.)[52]
Duration and ownership	The duration for which the holder is entitled to the rights conferred. Some rights are permanent while other rights are authorised for a specified period of time.
Price	Specification of fees to water authorities, for purposes including management costs, water level or environmental monitoring, compliance with conditions, or to control demand.
Transfer	Whether the right can be sold, traded, transferred to another person or location, or inherited.
Security & enforcement	Details of the administrative body that has the legal mandate to award the right, including the extent of that mandate.

Disputes over water rights may be triggered by a variety of factors, including one or more of the attributes of the water right. The quantity or flow of water available may be the cause of a dispute, due to water scarcity[53], diversions of water that reduce the available flow or the need to maintain water quantity for the protection of the natural ecosystem. Water rights disputes

49 Hodgson, *Modern Water Rights*, p. 18.

50 Le Quesne et al, *Allocating Scarce Water*, p.11.

51 For monitoring of water for environmental purposes, the allocation may be based on flow requirements rather than as a fixed volume or share of available water. See Productivity Commission 2003, *Water Rights*, p. 278.

52 Water rights can be described in terms of diversion or depletion. Consumptive use is depletion - what is taken from the river or ground and never returned because it is consumed. The difference between diversion and depletion is the water that returns to the system.

53 Water scarcity is a lack of adequate water available to fully satisfy the demands of all users. This may be due to drought or other weather conditions, or human activities.

may also arise over water quality if pollutants are introduced, or changes made by a water user that render it unfit for the use of others, such as introduction of sediment, alteration of temperature or turbidity.[54] The timing or duration of a right may be disputed, as well as the source or disposal of water. Water diversion or interference with water flow may also create a dispute.

These factors and others can be the subject of monitoring and enforcement, which may be disputed. Systems in place may be founded on long historical practice, but may no longer be functioning to the satisfaction of some parties. Tribal or local considerations may add an element of complication.[55] Alteration of the water supply by a non-water user, for instance by pollution or interference with flow, might be at the root of a legal dispute.

4. VALUE OF EO INFORMATION IN RESOLVING WATER DISPUTES

The rules applicable to the use of EO information as evidence are covered in other Study reports. Those considerations apply equally here and will not be repeated. The admissibility of EO information as evidence, and the weight given to any EO evidence by a court or tribunal, will be determined under the rules articulated elsewhere in this Study.[56]

EO information has demonstrated its value in water monitoring and enforcement, as a regulatory tool in issues from drought assessment[57] to verification of water rights. It has many applications that are relevant to resolving water disputes.[58] While EO information is approaching the status of a universal tool in many areas, it is important to recognise that without easy access to data, which may be spread over a large number of companies, agencies, governments and international bodies, the information is unhelpful. Universal, rapid access to this data would be beneficial not only in resolution of water disputes, but for many other purposes.[59]

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54 Suspended material may be objectionable in water for several reasons; it is aesthetically displeasing and provides adsorption sites for chemical and biological agents. Biologically active suspended solids may include disease-causing organisms as well as organisms such as toxin-producing strains of algae. S. S. Zaghloul, Hussein Elwan, *Water Quality Deterioration Of Middle Nile Delta Due To Urbanizations Expansion*, Egypt, pp. 10-11, Fifteenth International Water Technology Conference, IWTC-15 2011, Alexandria, Egypt, http://iwtc.info/?page_id=714, accessed 23 January 2012.

55 See Michael J Pearce, *Analytic Geography in Western Water Management*, Natural Resources and Environment, Spring 1999, pp. 537-541.

56 See Annex 1: Workshop Report, Section 5.2.1.

57 See for example, P S Thenkabail, M S D N Gamage, V U Smakhtin, *The Use of Remote-Sensing Data for Drought Assessment and Monitoring in Southwest Asia*.

58 A number of projects carried out by WaterWatch, a company based in the Netherlands, provide an overview of the information available. The systems used would be applicable to the resolution of water disputes in a number of areas. including monitoring the use of water by farmers in Idaho. See http://www.waterwatch.nl/projects/world-overview.html, accessed 22 January 2012. WaterWatch has merged with eLeaf, http://www.eLeaf.com.

59 The Remote Sensing and Geographic Information System Unit (RS GIS Unit) of the International Water Management Institute (IWMI) is a centralized facility for spatial data-related activities of IWMI. “Large volumes of multi-temporal data from multiple satellite sensors are used in several IWMI research projects. Comprehensive river basin datasets are available for a number of benchmark basins spread across the World. Most innovative datasets are in the data archive named: (a) AVHRR 0.1 degree monthly data as a single mega file of 956 bands over 20 years (red, near-infrared, 2 thermal infrared bends), (b) MODIS continuous streams of data from 2000 to present every 8-days for several benchmark river basins mentioned above, (c) SRTM 90-m DEM data for Asia, (d) rainfall data available monthly for last 40-years at 0.5 degree resolution for the entire globe, and (e) Satellite sensor data from sensors such as SPOT vegetation, Landsat ETM+, TM, MSS, and a few IKONOS images for various spots in the World.” http://free-gis-data.blogspot.com/2009/01/free-gis-and-remote-sensing-data-on.html, accessed 28 January 2012.

4.1 EO SYSTEM CAPABILITIES

EO information is not always a replacement for ground-based evidence. However, there are disputes where there are clear temporal issues, in which EO information will provide the most reliable, and in some cases the only, evidence. For example, water allocation within a basin is a large-scale undertaking. It is a matter of considering all the water users in a basin, such as agriculture, industry, urban, and environmental. EO techniques are very useful as they can produce data over large areas for the different land covers in a basin over the recent past. By contrast, field measurements are limited to smaller areas and are not realistic at basin level. It is important to note that in many applications, EO information will not be used by itself. For instance, in planning for future water distribution, such as predicting water use for a growing city or estimating the effects of climate change, hydrological modelling will be necessary as part of the process.[60]

The analysis and processing of EO information is also a significant part of the procedure. GIS facilitates the integration of spatial and other EO data that is otherwise difficult or impossible. Spatial water-related data may be stored, queried, displayed, integrated and analysed. Designation of specific items with one of a wide range of colours is a useful way to make data visually accessible. It is possible to overlay a map of land use, for instance, with a soil type map and to generate a unique map of hydrologic response units (HRU),[61] or to generate hydrographic maps from topographic maps to document stream networks in a given basin as well as factors critical to the computation of runoff and soil erosion. Issues of water allocation might be addressed by water productivity mapping. Sites of pollution may be identified in order to resolve disputes with downstream users.[62] Gaps in existing data may be filled by EO information where traditional means are constrained, for instance in areas with security problems.

Parameters obtained from EO imagery include panchromatic and multi-spectral data, surface temperature, albedo,[63] and vegetation index. The use of modelling in conjunction with the data is frequently crucial to obtaining a useful result. Complex algorithms have been developed to obtain information from EO data to calculate, for instance, evapotranspiration and biomass production, crop water productivity, regional distribution of measured meteorological variables and ground water conditions, giving information about watersheds where other types of data are scarce or unobtainable.

There are certain caveats that should be considered. It is critical that as EO technology evolves it is calibrated against data collected on the ground. Current technology is also limited as to detecting water conditions below a certain depth. Finally, these technologies must be supported by good hydrology datasets.[64] There are many hydrological models

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60 Geoff Kite, Peter Droogers, *Comparing Estimates of Actual Evapotranspiration From Satellites, Hydrological Models, and Field Data: A Case Study from Western Turkey*, Research Report 42, International Water Management Institute, 2000, pp. 28-30.

61 The HRU is the smallest unit of water balance computation in some hydrological models. Christopher J. Perry and Julia Bucknall, *Water Resource Assessment in the Arab World: New Analytical Tools for New Challenges*, in Water in the Arab World: Management Perspectives and Innovations, Eds. N. Vijay Jagannathan, Ahmed Shawky Mohamed, Alexander Kremer, 2009, The International Bank of Reconstruction and Development / The World Bank, Middle East and North Africa (MNA) Region, p. 82. (Hereafter Perry and Bucknall, 2009.)

62 New York City's Department of Environmental Protection used models to identify problem areas upstream, and agreed management principles with farmers. Water quality was improved for the City, and farmers benefited from City funding for watershed protection. See Perry and Bucknall, *Water Resource Assessment*, p. 91.

63 Albedo is the fraction of solar energy (shortwave radiation) reflected from the Earth back into space. It is a measure of the reflectivity of the earth's surface.

64 Perry and Bucknall, *Water Resource Assessment*, p. 86.

available with a range of spatial scales and physical detail, suitable for a variety of uses. Selection of appropriate models is critical to obtaining accurate results.

4.2 Selection of Appropriate EO Technology

Current EO technology captures characteristics of physiographic and natural resources like surface and groundwater, vegetation, soils and topography, as well as climate variables such as temperature, precipitation and solar radiation. It is possible to measure the amount of precipitable moisture in the atmosphere, air temperature, evaporation and transpiration, soil moisture content and aquifer storage of soil, without a sensor close to the measured objects.

Some variables can be assumed stable over a period, such as topography, geology and soil texture, while others, such as vegetation growth, weather conditions and soil moisture, change frequently. Some vary over a given area, such as air temperature, while soil properties, precipitation and elevation do not. It is therefore important to select the most appropriate EO technique and data to address a given water issue. A satellite providing weekly observations may not be appropriate to study water issues on a daily basis. Similarly, an EO technique giving observations at 100-km resolution would not be appropriate to analyze water resources at plot-scale level of 10-km by 10-km.

The table below gives a partial list of variables that can be measured or estimated by EO, as well as the spatial scope of satellite missions and links to water-resource-related datasets.

No.	Data type	Spatial scale	Satellite name/mission name
1	Rainfall	3 to 25 km	TRMM (25km); GOES; NEXRAD; METEOSAT; IRS; ESA
2	Skin soil moisture	25 km	AMSR-E
3	Root zone soil moisture	30 m to 1 km	Nimbus SSM/I (25km);
4	Air temperature	1 km	AVHRR
5	Solar radiation	1 km	AVHRR
6	Leaf Area Index	30 m to 1 km	MODIS; LANDSAT
7	Biomass production	30 m to 1 km	LANDSAT; MODIS
8	Snow cover and snow accumulation	30 m to 1 km	GOES
9	Land use/land cover	30 m to 1 km	MODIS; LANDSAT
10	Crop types, surface albedo, vegetation fraction	30 m	MODIS; SPOT-4
11	Crop yield	30 m	MODIS; LANDSAT
Secondary spatial data			
12	Air humidity	1 km	NASA's UARS
13	Wind speed and direction	1 km	LIDAR
14	Water depletion by land cover	1 km	MODIS
15	Water productivity	30 m	MODIS
16	Stream flow and water quality	1 km	LANDSAT; MODIS
17	Groundwater recharge/abstraction; terrestrial water storage	30 m to 1 km	GRACE
18	Irrigation water demand, irrigation intensity, and irrigation efficiency	30 m to 1 km	MODIS; LANDSAT
19	Carbon sequestration	30 m to 1 km	MODIS
20	Topography, geology	30 m to 250 km	ASTER; RADARSAT
21	ET (based on, e.g., SEBAL and METRIC approaches)	30 m to 1 km	MODIS (30 m to 1 km); LANDSAT

Source: Christopher J. Perry, Julia Bucknall, *Water Resource Assessment in the Arab World: New Analytical Tools for New Challenges*, in *Water in the Arab World: Management Perspectives and Innovations*, Eds. N. Vijay Jagannathan, Ahmed Shawky Mohamed, Alexander Kremer, 2009, The International Bank of Reconstruction and Development/The World Bank, Middle East and North Africa (MNA) Region.

4.3 EO Information Products

Satellite sensors and systems provide a range of data which is converted to information to be offered as evidence. The relevant tribunal is focused on the type of information available rather then the underlying nature of the technology.

In relation to water disputes being considered in this Study, there are many legal issues that must be resolved, but as far as EO information is concerned, there is a limited range that will assist a tribunal to reach a determination. Examples of some of the relevant information products are outlined here.

For example, to determine if water has been diverted from a given source, the court may need to have information about any new channels constructed along the watercourse. Optical sensors will provide images of the watercourse at different dates as evidence of the time and places where any diversion has occurred. Optical images of the area over the relevant period will need to be date stamped and located on a map, using the GPS system.

The volume of water diverted may also be determined by measurement of the size of the new channels, possibly using PSInSAR or other radar based techniques. This will establish the width and depth of the channel.[65] The inclination of the channel may also be assessed to provide an estimate of the rate of water-flow.[66] The information will be presented in the form of images in which colour variations identify different topographic levels. An expert witness will explain the measurements and calculations.

In relation to quantity of water use, more sophisticated techniques, often using multi-spectral sensors, can provide information by showing vegetation coverage and rate of evaporation. The information product will be in the form of a visual image showing the area covered by vegetation, soil moisture and temperature, leaf area and moisture,[67] and temperature. Microwave sensor readings may provide information about temperature. Passive microwave provides water level readings.[68] To compute the volume of water used, an expert will need to have these measurements, which will then be applied to a model to determine the required information.

Water quality disputes range from changes to the temperature of the water to bacterial and algal pollution of the supply. Therefore, the EO information product sought is equally varied. The techniques used will provide the relevant data from which the needed information can be generated.

The main information relevant to water quality and obtainable by satellite systems relates to water clarity, concentration of chlorophyll, concentration of total suspended sediments, and

[65] The US NASA research project Sea-viewing Wide Field-of-view Sensor (SeaWiFS), was designed to detect ocean characteristics, including turbidity, algal blooms and pH. These techniques may be adaptable to smaller scale detection. See generally Kenneth J Markowitz, *Legal Challenges and Market Rewards to the Use and Acceptance of Remote Sensing and Digital Information as Evidence*, 12 Duke Environmental Law & Policy Forum 219-264 (Spring 2002).

[66] Advanced Very High Resolution Radiometers (AVHRR) available on NOAA satellites can provide information about many features of land and water, including temperature. See Markowitz, footnote 65 above.

[67] Leaf Area Index is measured from data provided by visible and near-infrared sensors, Landsat TM and AVHRR satellites, depending on size of the area and sensor resolution; see J Qi, Y H Kerr et al, *Leaf Area Index Estimates Using Remotely Sensed Data and BRDF Models in a Semiarid Region*, Remote Sensing of Environment 73, 18 (2000).

[68] Sensors operating in the blue-green band can detect water depth; see for example Landsat 7 ETM+ which can provide such information at a resolution of about 15 metres.

turbidity. Optical and multi-spectral sensors can provide information about these, and the extent and potential source of pollution, in the form of optical images.

Although it would be useful information in many instances, the chemical composition of pollutants is not yet detected by available satellite sensors. It should also be noted that EO information is not invariably provided by sensors observing characteristics on Earth. An example of such a system that provides information about water resources is the Gravity Recovery and Climate Experiment (GRACE) satellite mission.[69]

The EO information is often presented in combination with other information, such as maps. Maps are generated by integrating the EO information and GPS coordinates into a Geographic Information System (GIS).[70]

Using the example of water diversion above, the sensor will detect the coordinates of a new channel that is then displayed on a scale map of the location. In addition, colour is used to denote different characteristics detected, or the variations of those characteristics. For example, if two types of crops are present, each will be represented by a different colour. Similarly, a range of temperatures can be denoted by variations in the intensity of a chosen colour.

Other important qualities of EO information for water dispute applications are information about the spatial, spectral and temporal resolutions of the product. The clarity of any image is important, as well as the time at which it was obtained and period covered, and the spectrum at which the sensor operates. For example, a radar sensor provides different information from one detecting infra-red. The information will often need to be time-stamped and its geographic position ascertained to ensure that it is of the relevant location.[71]

Clearly, although such representations make the information more readily understood by the tribunal, the expert engaged to interpret the information will also rely on the underlying technical information provided by the sensor.

4.4 APPLICATIONS

There is an increasing range of information available from EO for water management, monitoring and dispute resolution. The following are some types of EO information useful to different applications.

4.4.1 Water Use, Change of Use and the Documentation of Water Rights

In the verification of the existence of a water right, a proposal to change water use, or documentation of water quantity, it may be necessary to identify the number or size of fields irrigated by identifying evidence of water use such as diversion channels or canals. EO information with high spatial and temporal resolution will be useful in these applications, and in cases of water theft.

Documentation of crop cover can also provide circumstantial or corroborative evidence in cases where water rights or quantity documentation is required. Visible, near infrared and thermal infrared data reveal the presence and condition of vegetation, including irrigated crops. Measurement of evapotranspiration with EO information, hydrological models and

69 For a fuller discussion of GRACE see Annex 6: EO System Capabilities, Section 5.

70 See generally Environmental Systems Research Institute (ESRI), *What is GIS?*, at http://www.gis.com/content/what-gis.

71 For a discussion of relevant resolutions, see Annex 6: EO System Capabilities, Section 1.

field measurements can document the presence and scale of crop growth, and differentiate between different types of cover. All methods for computing evapotranspiration (ET) have their advantages and disadvantages, and each method can be assessed for its usefulness in relation to a specific application. A number of parameters can be incorporated, and some are systems capable of estimating evaporation and transpiration for a full spatial and temporal range. The best can be used even on cloudy days.[72]

In the evaluation of ET for irrigation assessment of basins and other large areas, especially those with varied conditions or crops, collection and analysis of field data are too labour-intensive. EO techniques are useful for a real distribution of ET at very high resolution, and for verification of hydrological models on cloud-free days, but cannot provide some data, such as return flows, drainage, percolation, and capillary rise.

4.4.2 Environmental Problems or Water Quality

Monitoring and detecting vegetation in large watersheds is difficult and expensive. Field readings are time consuming, and experimental data are hampered by variability in physical, environmental and farm management parameters. The combination of EO information, field sampling, and access to farm program documents has proved to be a successful and powerful tool in estimating crop cover and nutrient uptake at the watershed scale.[73]

In addition, EO has considerable potential for the resolution of water-related agricultural and environmental disputes on a smaller scale. For instance, the use of winter cover crops can reduce agricultural non-point pollution, and cover crops can be detected with EO techniques.[74]

Periodic monitoring of aquatic pollution is possible with high-resolution multi-temporal data sets. Water clarity is an issue related to algae growth that lowers transparency. EO information is an improvement of the standard method of on-site measurements by an individual lowering a disk into the water until it disappears from sight. The US Geological Survey (USGS) is using Landsat imagery to augmented these measurements. Although accuracy is slightly less than that provided by disk measurement, the advantage of EO is that there are over 11,000 lakes to be monitored for water quality.[75] Other issues of water quality may be addressed with EO information to assess algal bloom, turbidity or pollution by data including optical, infrared or fluorescence interferometry.

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72 For a discussion of a particular case study with reference to comparing methods for analysing this parameter, see Kite and Droogers, *Comparing Estimates of Actual Evapotranspiration*, pp. 28-30.

73 A commonly used measure is the Normalized Difference Vegetation Index (NDVI), calculated as a ratio of red and near-infrared (NIR) reflectance, which correlates closely to plant leaf area. It has been used successfully to calculate biomass, yield, N status, chlorophyll content, and photosynthetic capacity of wheat crops.

74 Cover Crops reduce the potential for leaching of residual agricultural nitrogen to groundwater following the summer growing season. Accordingly, cover crops play a central role in efforts to reduce agricultural nonpoint source pollution inputs to watercourses. Cover crops also provide additional cropping-system benefits such as erosion prevention, carbon sequestration, bioenergy production, and nutrient cycling (N and organic matter contribution to the following crop). In a study concerning a Maryland watershed, false-colour infrared SPOT imagery was collected and combined with state cover-crop cost-share data and other information. See W.D. Hively, M. Lang, G.W. McCarty, J. Keppler, A. Sadeghi, and L.L. McConnell, *Using Satellite Remote Sensing To Estimate Winter Cover Crop Nutrient Uptake Efficiency*, Journal of Soil and Water Conservation, Conservation Society www.swcs.org 64(5) 303-313.

75 Shaheen Kanthawala, *Satellite Watch: Measuring from Space Quality of Lakes in Great Lakes Region*, 18 May 2011, Great Lakes Echo, http://greatlakesecho.org/2011/05/18/measuring-great-lakes-water-quality-from-space/, accessed 20 January 2012.

4.4.3 Identification of a Water Source

The source of a water abstraction can be clarified by EO information, for instance the presence of a groundwater extraction well, or diversions or channels from a river. Optical sensors will be useful, at a resolution best suited to the scale of the area.

4.4.4 Aquifer Depletion

Good monitoring networks exist for precipitation and rivers in most regions, but this is not the case with subsurface waters that include aquifers and soil moisture, and account for about 30% of global fresh water.[76] Depletion and absorption of an aquifer may be measured through topographic movement, using InSAR,[77] or interferometric analysis of imagery from synthetic aperture radar (SAR), which is essentially high-resolution radar. A further refinement of the technology, PSInSAR, has proved useful in detecting topographic movement.[78] Arizona uses these techniques to monitor aquifer storage and land subsidence.[79]

In addition, the Gravity Recovery and Climate Experiment (GRACE) mission satellite, has the potential to detect regional water storage changes approximately monthly, on the basis of measurements of the Earth's global gravity field.[80]

4.4.5 Compliance with Water Right Conditions and Pollution Regulations

Compliance with water right conditions of timing and duration of water abstraction may be verified and documented by visible EO information, ideally with high temporal resolution. This is especially helpful in cases concerning large or remote locations. Crop documentation will also be useful in assessing compliance with pollution regulations.

4.4.6 Alteration of Waterstream

There have been cases in which upstream users alter water flow, adversely affecting downstream users. Evaluation of timing and extent of damage could be documented by EO information. This can provide evidence of the occurrence of change in flow, the location where it took place and its duration.

4.4.7 Disposal of Surface Waters

Disputes arise from damming or from drainage of excess surface water from rain, springs, and melting snow. Common law permits surface water removal without liability for flooding that may result. Civil law imposes a liability for damage caused by a landowner who interrupts or alters the natural flow of water. A *reasonable use* standard would permit reasonable alterations to land for drainage purposes as long as the alteration does not unduly interfere

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76 By contrast, rivers represent about 0.006% of global fresh water. Gil Strassberg, Bridget R. Scanlon, and Don Chambers, *Evaluation Of Groundwater Storage Monitoring With The GRACE Satellite: Case Study Of The High Plains Aquifer, Central United States*, Water Resources Research, Vol. 45, W05410, doi:10.1029/2008WR006892, 2009.

77 InSAR produces an image, called an interferogram, showing differences in land features between two SAR images taken at different times. *Satellites measure bulging earth to map water resources*, U.S. Water News Online, July 2001, http://www.uswaternews.com/archives/arcsupply/1satmea7.html.

78 For information on PSInSAR and related technologies, see Annex 6: EO System Capabilities, Section 3; and J. W. Bell, F. Amelung, A. Ferretti, M. Bianchi, and F. Novali, *Permanent Scatterer Insar Reveals Seasonal And Long-Term Aquifer-System Response To Groundwater Pumping And Artificial Recharge*, 5 February 2008, Water Resources Research, 44, W02407, doi:10.1029/2007WR006152.

79 See www.azwater.gov/azdwr/Hydrology/Geophysics/InSar.htm.

80 Strassberg et al, *Evaluation of Groundwater Storage Monitoring.*

with another's rights. EO information can help establish the relevant facts for the resolution of disputes arising in relation to these rights.

5. WATER QUANTITY DISPUTES

Civil actions are typically between a water right holder and another water right holder. Parties may be individuals, corporations, state entities or unlicensed water users, any of whose water usage adversely affects the other party's rights. In order to resolve these disputes, the court will consider the existence and attributes of the parties' water rights and the actual water usage.

5.1 OVER-EXPLOITATION OF WATER SOURCES

Due to scarcity of surface water resources and closure of basins, over-extraction of groundwater is becoming a worldwide problem. Most aquifers are exploited at unsustainable rates. Good groundwater management plans based on balancing recharge and extractions are fundamental for making the use of this resource sustainable and avoiding future disputes. EO information is an invaluable part of the data used to devise these plans, and to resolve disputes in cases such as those that follow.

5.1.1 Mexico[81]

Mexico is the fifth largest national user of ground water, and a very large user of irrigation for agriculture. In order for the Mexican government to develop ground water management plans as specified by law, it is necessary to specify allowable extractions from aquifers, both artificial extractions through pumps and natural extractions through deep rooting natural vegetation. One of the first steps for such program is the description of the extractions. The purpose of the assessments discussed below was to provide information for water management plans. The techniques used are also useful in cases of dispute.

In Sonora State, the system employed combined EO to assess groundwater use without the need for metering or interviewing individual farmers. Crops that are highly irrigated with pressure drip and micro-sprinkler systems were found to be high users of pumped groundwater. This data was compared with power consumption data. Net ground water use (NGU) was monitored and a distinction drawn between natural vegetation and irrigated crops. The parameters examined included evapotranspiration, precipitation, interception and runoff, canal discharges and field losses. It was possible to establish the annual depletion of the ground water table, and the system may be extended to other Northern Mexican aquifers.

Another part of Mexico with critical water management problems, such as the over-exploitation of surface and ground water resources, utilised EO to analyse conditions. Stream-flow in the Rio Bravo has been severely reduced by unsustainable irrigation practices. A diagnosis of the Rio Bravo and Northern Central Aquifers has been made to demonstrate management options. EO images were used to generate a land cover map of the entire basin, and analysis was applied to produce maps of actual ET, biomass production and soil moisture. Detailed ET and related parameters were derived from the analysis, in conjunction with Landsat imagery. According to the researchers:[82]

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[81] WaterWatch, *Mapping Ground Water in Sonora State,* Mexico 2004 – 2005, http://www.waterwatch.nl/projects/north-america.html, accessed 21 January 2012. WaterWatch has merged with eLeaf, eLeaf.com.

[82] WaterWatch, *Remote Sensing and Hydrological Modelling of the Rio Bravo, Mexico,* http://www.waterwatch.nl/projects/north-america.html, accessed 22 January 2012. WaterWatch has merged with eLeaf, http://www.eLeaf.com.

This study demonstrates that a fleet of satellites is available to describe the water resources conditions in a spatially distributed manner. Landsat appears suitable for crop identification, crop ET, soil moisture, crop production and crop water productivity. Moderate Resolution Imaging Spectroradiometer (MODIS) is found useful for acquiring the basin-wide picture of water depletion, soil moisture and biomass production of all agro-ecosystems including biomass water productivity. Tropical Rainfall Measuring Mission (TRMM) adds key information on the spatial distribution of rainfall. Although the Soil and Water Assessment Tool (SWAT) model and land cover and crop maps are all preliminary versions, it rolls out a new methodology that assist water policy makers in making firm decisions on water use, water diversion and water abstraction and where land cover changes could be considered.

The parameters, characteristics and measurements derived from EO in these situations illustrate the capabilities of EO systems to provide similar information in disputes where these factors are relevant.

5.1.2 Africa

Water scarcity and over-allocation are significant problems in Africa. The subject of the following case study is the Incomati river basin, shared between South Africa, Swaziland and Mozambique. Population growth, economic development, socio-economic reforms including the issue of land to emerging farmers and global climate change add pressure on the already scarce land and water resources. Many watersheds with similar conditions raise disputes that can continue for long periods of time.

Promotion of bio-fuel production in the Incomati Basin also adds to the strain on water resources, raising the price of food for poor urbanized consumers. Claims on water become increasingly complex to manage because globalising forces shift the balance of power increasingly to an international level. International trade policies may have a bigger impact on cropping patterns and consequently water use than local water management policies. There is therefore a clear need to identify more harmonized policies as well as options of local communities to improve their livelihood while sustaining Incomati water. To be able to do so, insight is required into the implications of international as well as national policies on water use and water productivity at the various levels.

A project was carried out[83] to support inter-sector and inter-state policy development and the sustainable use of the Incomati basin water through building capacity with respect to water valuation and innovative water monitoring. Water valuation is a tool to enhance the ability of decision makers to evaluate trade-offs between different water policies and courses of social actions that alter the use of water and the multiple services it provides. The project employed the interactive WIBIS tool, an open-source web application used to evaluate the implications of land use. It generates continuously updated on-line maps with land and water indicators, and is based on satellite images. Actual evapotranspiration and biomass production are calculated on a monthly basis with Surface Energy Balance Algorithm on Land (SEBAL algorithms) applied to MODIS[84] images, with a spatial resolution of 250x250 m. Rainfall is retrieved from the Tropical Rainfall Measurement Mission (TRMM), which carries a precipitation radar. The results enable comparison of the value of various land and water indicators in a wet, dry and average year. For 15 land use types, the regional differences in

83 *Coping with competing claims on Water in the Incomati Basin through Interactive Science (WIBIS)*, Lead Institution: Agricultural Economics Research Institute (LEI), Social Sciences group, Wageningen UR, Project leader: Dr. Petra Hellegers, LEI, http://www.dgis.wur.nl/UK/Competing+Claims/Projects/Coping+with+competing+claims/.

84 MODIS (or Moderate Resolution Imaging Spectroradiometer) is a key instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites. It functions in the visible and infrared regions. http://modis.gsfc.nasa.gov/about/, accessed 22 January 2012.

water consumption, biomass production and water productivity can also be presented. For 24 regions the rainfall, reference ET, rainfall surplus and existing monitoring data can also be displayed.

The parameters, characteristics and measurements derived from EO in these situations illustrate the capabilities of EO systems to provide similar information in disputes where these factors are relevant.

5.2 VERIFICATION OF WATER RIGHTS

Disputes over water rights may result in legal action such as lawsuits or adjudication. Some of these have been very complex due to the historical systems in place, changing conditions, and anticipation of future needs. Courts in the US, including the Supreme Court, and in other countries have dealt with disputes.

5.2.1 Western States of the US

For a variety of reasons, many rivers in the western states of the US are over-appropriated, that is, the total volume of water to be extracted by entitled rights holders at a given time exceeds the environmentally sustainable level of extraction for that water resource system. For these and other reasons, a majority of the western states are currently involved in stream adjudications.[85] Western states are conducting general stream adjudications, including validation of use. In addition, the underlying information is used in the development of improved water management, and to create centralized, current records of water use.

These are among the largest civil proceedings ever to be litigated in state and federal courts. According to judicial statistics, 27,000 persons have filed more than 77,000 claims to water rights in the Arizona general stream adjudication. In Idaho, more than 110,000 persons have filed 150,000 claims for water rights in the Snake River system. In Montana, approximately 80,000 persons have filed more than 200,000 water rights claims in adjudication.[86]

It is not clear to what extent satellite EO data is being used as evidence in current water rights adjudications. However, the Snake River adjudications in Idaho show that EO information can play a helpful role in resolving these disputes.

5.2.1.1 Snake River Adjudications

The Snake River Plain, which supports most of Idaho's irrigated agriculture, covers approximately 18,000 square miles.[87] The river and its tributaries account for 87% of the water in the state.[88] By 1989, Snake River water was being pumped or diverted onto about 6,250 square miles, providing farmers with three quarters of their irrigation supply.[89] The

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85 Various state water adjudications have been ongoing since the late 19th century. Arizona, California, Idaho, Montana, Wyoming, and Washington are undertaking comprehensive, basin-wide adjudications of water rights. Utah, Colorado, New Mexico, Oregon, and Oklahoma are presently dealing with water rights on a more piecemeal basis, either because they have finished general adjudications, or because general adjudications are not necessary at this time. North Dakota has not attempted an adjudication, Texas has completed one, and South Dakota and Alaska abandoned their attempts. http://www.judges.org/dividingthewaters/about.html, accessed 18 January 2012.

86 For overview of current adjudications, see: http://www.judges.org/dividingthewaters/adjudications.html.

87 Idaho Department of Water Resources, http://www.idwr.idaho.gov/GeographicInfo/Publications/adjudica.htm.

88 US Department of Justice, *Federal Reserved Water Rights and State Law Claims*, http://www.justice.gov/enrd/3245.htm, accessed 10 January 1012.

89 4 million acres, or about 1,619,000 hectares.

Idaho Power Company also depended on Snake River water for about 57% of its electrical generating capacity. Its right, dating from the early 1900s, related to a dam at the downstream end of the Snake River Plain. These competing needs led to a dispute, and in 1982, the case of *Idaho Power Co. v. State of Idaho* reached the Idaho Supreme Court.[90] The Court upheld the Power Company's contention that its water right[91] was not necessarily subordinate to the water rights of upstream irrigators. The court's ruling severely over-appropriated the Snake River basin, as existing water rights claims and pending claims exceeded the available water.

The power company then filed suit against 7,500 holders of upstream permits and water-right applications for which beneficial use had not yet been proven.

After two unsuccessful attempts by the State Legislature to resolve the conflict, a settlement was negotiated between the state and the power company, under which all water rights in the Snake River Plain must be adjudicated. The Idaho Department of Water Resources (IDWR) would provide the presiding Court with the technical information necessary for the Court to decide each water right. The process began in 1987, and most of the state of Idaho was involved.[92]

Figure 1. The crosshatched area shows the part of Idaho subject to adjudication.

Map from Morse, et. al., 1990.

The IDWR used aerial photography, but found that the resolution of aerial photographs was inappropriate for very small areas.[93] EO information was considered suitable for the purpose.[94] The IDWR[95] developed a system of EO and Geographic Information System

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[90] *Idaho Power Co. v. State of Idaho*, Idaho S.Ct.18 (1982). See also D Costello and P J Kole, Commentary on Swan Falls Resolution, Western Natural Resource Litigation Digest (Summer 1985), 1118.

[91] 8,400 cubic feet per second (CFS) at the Swan Falls Dam, at the western (downstream) end of the Snake River Plain, dating from the early 1900s.

[92] Idaho estimates more than 150,000, with 133,000 already determined. See http://www.idwr.idaho.gov/WaterManagement/AdjudicationBureau/, accessed 16 January 2012. See also Anthony Morse, Thomas J Zarriello and William J Kramber, *Using Remote Sensing and GOS Technology to Help Adjudicate Idaho Water Rights*, Photogrammetric Engineering and Remote Sensing, Vol. 56, NO. 3, March 1990, p. 365 – 370, and Clay J Landry, *The Role of Geographic Information Systems in Water Rights Management*, in *The Technology of Property Rights*, eds. Terry Lee Anderson, Peter Jensen Hill, 2001, p. 28.

[93] Many water rights concerned very small areas. Rights are keyed to sections of 40 acres, each of which may contain 4 further sections of 10 acres each. See note 93 below.

[94] Terry L Anderson and Peter J Hill (eds.), *The Technology of Property Rights*, (Rowan & Littlefield, Oxford, 2001), p. 29. See also Ron Beck, *Idaho-Developed Mapping Method Garners Prestigious Award*, USGS, http://landsat.gsfc.nasa.gov/news/news-archive/news_0231.html, accessed 18 January 2012.

[95] The work was carried out by the Idaho Image Analysis Facility (IIAF), a remote sensing and GIS section within the IDWR.

(GIS) technology to estimate the irrigated acreage associated with each water right, to be completed within a ten year timeframe.[96] Landsat multispectral scanner (MSS) information was used to produce land-cover maps in a number of classes, including irrigated land.[97] Land parcels were identified and the EO information combined with it. In order to do this, section corners were digitised from the US Public Land Survey System (PLSS) of 1:100,000 scale, with sections sub-divided into various 'quarter-quarter sections', because Idaho water rights are keyed to these sections.[98]

The Landsat information was digitally overlaid with the PLSS data, and the irrigated acreage computed for each quarter section. Analysis and processing was carried out on satellite data, U-2 photography, 35-mm aerial slides, 1:100,000 scale mylar maps, cadastral surveys, and 1:24,000 scale orthophotos. The image processing aspect of the project is based on digital analysis of Landsat MSS data using in-house software, clustering and classifying software, and other image processing software. The analysis included four steps: (1) geometric control,[99] (2) principal component analysis,[100] (3) unsupervised classification,[101] and (4) post-classification sorting to reduce error.[102] Further controls for accuracy were introduced. The results were land-cover overlays at 1:24,000 scale, and a database of land cover, facilitating this large-scale adjudication of water rights. This information enabled the adjudicators to estimate actual water use. That estimate is compared to the existing water rights and to claims submitted as part of the adjudication, to assess the accuracy of the claims.

The IDWR is not required under the terms of the adjudication rules to utilise EO information, but does so routinely in satisfying the need to provide the best possible information. The IDWR uses IR images. The Adjudication Court admits such evidence as a matter of course. However, the claimant is required under Rule 37.03.01 to produce a map and aerial images in support of his claim.[103]

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96 Morse, et al, *Using Remote Sensing*.

97 Fifteen Landsat MSS scenes are required to cover the Snake River Basin. IDWR purchased the scenes from EOSAT based on minimum cloud cover and dates that corresponded to peak agricultural crop maturity. The dates of 14 of the scenes ranged from 3 July 1986 to 23 August 1986. One scene dated 16 July 1984 was acquired because no acceptable 1986 or 1985 scene was available. EOSAT radiometrically and geometrically corrected all scenes, re-sampling pixels to 57 by 57 meters.. See Morse, et al, *Using Remote Sensing*.

98 A 'section' is one square mile (640 acres); a quarter section is ¼ of a square mile, or 160 acres. A quarter-quarter section is 1/16 of a square mile, or 40 acres. A quarter-quarter-quarter section would therefore be 1/64 of a square mile, or 10 acres.
http://www.idwr.idaho.gov/WaterManagement/WaterRights/WaterRightTerms.htm#Q.

99 Images purchased from EOSAT were radiometrically and geometrically corrected. See Morse, et al, *Using Remote Sensing*.

100 Each scene was transformed to its principal components as the second step in image processing. Principal component analysis was used to reduce the dimensionality of the data, which in turn reduced both the volume of data to be processed and the CPU time needed to process them. Software clustered and classified county sub-scenes using histograms and look-up tables for extremely fast processing of ERDAS-format images. See Morse, et al, *Using Remote Sensing*.

101 Selecting the number of spectral classes to generate in unsupervised classifications is often difficult and subjective depending on the algorithm used. IIAF analysts adopted the practical and consistent solution of generating the maximum number (255) possible for each classification. Five land-cover types were identified: irrigated agriculture, dryland agriculture, non-agricultural land, riparian vegetation, water, and one class of clouds and/or cloud shadows. An image interpreter delineated irrigated agriculture, dryland agriculture, and riparian vegetation. Areas outside of these boundaries were non-agricultural land. When the Landsat data were inconclusive, the interpreter analyzed U-2 colour-infrared photographs to assist in drawing these boundaries. See Morse, et al, *Using Remote Sensing*.

102 For example, in many parts of Idaho, harvested fields of irrigated small-grains are spectrally similar to native rangeland. Post-classification sorting allows each spectral class to be labelled to more than one information class, increasing classification accuracy. See Morse, et al, *Using Remote Sensing*.

103 Personal communication, Carter Fritschle, Section Manager, Adjudication Office, IDWR, 30 May 2012.

5.2.2 Spain[104]

There is a significant water demand in Mediterranean countries for irrigation, raising water quantity and quality problems. Irrigated agriculture in Mediterranean countries is essential, compared to marginal use in central and northern European agriculture. There are conflicting interests from a number of regions, economic sectors and political and environmental groups. Large-scale water extraction for irrigation puts pressure on water resources and ecosystems in Portugal and Greece, and even more in Spain, Italy and Turkey, due to sustained public investment in storage, transport and distribution of water for irrigation, has resulted in a combined water demand of 80,000 hm^3 for the acreage under cultivation.[105] Italy and Spain have also developed groundwater extraction systems in the second half of the 20th century. By contrast to the surface water regulation, private groundwater extractions are not subject to much control by the water administration.[106]

Local and regional policy measures being considered to solve water scarcity include banning aquifer overdraft, water pricing,[107] introducing water markets, subsidies to upgrade irrigation systems, and augmenting supply with water from inter-basin transfers or from seawater desalination. These should be seen in the context of current legislation in Spain.

EO information has been the subject of extensive court proceedings concerning registration of existing water rights under the 1985 Spanish Water Act, and one of the few examples where conflict between EO information and the evidence of an individual was directly at issue.[108] The Act changed the legal framework of water resources in Spain. Previously, groundwater resources were considered a private good, belonging to the owner of the field in which they were found and piped. Under this legislation,[109] any private use of inland waters and renewable underground water resources requires a specific and express administrative title called “concession,” which enables the user to use the specific public good in a private or

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104 Albiac, J., Martinez, Y., Tapia, J., 2005. *Water Quantity And Quality Issues In Mediterranean Agriculture*, in OECD Workshop on Agriculture and Water: Sustainability, Markets and Policies, Adelaide, Australia, 14–18 November 2005. <http://www.oecd.org/agr/env>

105 A cubic hectometre (hm^3) is equal to 1 million cubic metres.

106 In Italy, pervasive aquifer overdraft and water quality problems are located in the Po basin, Romagna and Puglia, and in the coastal plains of Campania, Calabria, Sicily and Sardinia. In Spain, the most severe scarcity and quality problems occur in the Júcar, Segura and South basins, located in the south-eastern Iberian peninsula. There is a dual situation for water resources linked to irrigation in Spain. The irrigation districts of inland Spain are based on collective surface irrigation systems and low profit crops, and water resources degradation is moderate, as basin authorities regulate water extractions, and there is some degree of fluvial ecosystem protection by the enforcement of minimum ecological flows. Highly profitable Mediterranean crops such as fruits and vegetables concentrate in the coastal areas of Spain, which are based on individual pumping from aquifers. There is a lack of effective control on aquifer extractions, both on the number of legal and illegal wells and on the volume of water extracted.

107 See for instance the 2000 *European Union Water Framework Directive*, Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy. The Directive’s aims are the protection of continental, subsurface and coastal waters, including the improvement of water quality and ecosystems conditions, the promotion of sustainable use of water, and the reduction of emissions and discharges to water media, along with emission limits and water quality standards. The Directive, which is reliant on water pricing, is supported by the findings of the European Environmental Agency, which point to agricultural nonpoint pollution as the primary cause of water quality deterioration in many European watersheds. See European Environmental Agency. 1999. *Nutrients in European Ecosystems*, Environmental Assessment Report No 4. EEA. Copenhagen.

108 Richard Macrory, *Regulation, Enforcement and Governance in Environmental Law*, 2008, p. 406.

109 Art. 1.2 of the Water Act (L.A.), declares that inland waters, and renewable underground waters, constitute a unitary resource, subordinated to the public (general) interest, and are included in the State public domain.

exclusive way. Those who could show pre-existing rights might continue use for a period of 50 years, after which rights might be renewed under certain circumstances.[110]

This legislation made it necessary to recognise and register rights of those who, before the Water Act came into force, had any property or exploitation water right. This entailed identifying the kind of rights under the new framework, their time duration, and the quantitative limits of the waters that can be privately used by them. The "Disposiciones Transitorias" (Transitory Provisions) were intended to enable those who under the previous legal structure had a right over private waters from wells or galleries to establish their rights before the River Basin Water Authority.

The Water Basin Authority can also declare an aquifer over-exploited if the total amount of water extraction could endanger water use in the long term.[111] In these cases, the Water Basin Authority can approve a Water Extraction Plan, which may set a maximum volume of water extraction, as well as the distribution of the water volume for each user.

EO information has been a useful tool in identifying and quantifying water extraction and exploitation in these situations. The methodology developed for Spanish water rights registration and water extraction monitoring was based on multi-temporal data sets of multispectral EO images from Landsat 5 TM, combined with digital cadastral data and an alphanumeric database with data on the water users. Images from the LISS III[112] multispectral sensor of the IRS 1C satellite have been used when Landsat TM images were unavailable due to cloud cover.[113]

It is possible for farmers as water users to challenge the water authorities' administrative findings.[114] If this occurs, EO information may provide the evidence to resolve the dispute.[115]

5.3 MONITORING AND ENFORCEMENT

Monitoring and enforcement of water rights is not the subject of this Report. However, as will be noted, the facts that have to be observed and monitored and the techniques employed are relevant to civil disputes. It is for that reason that they are considered here.

5.3.1 Monitoring

There is generally no direct monitoring and enforcement of water related to stock and domestic rights, unless administratively granted through a licence or permit, or of indigenous

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110 Concession applications are made public, and are open to competition. Preference is on the basis of the most rational use and the highest level of environmental protection. Concessions are limited to 75 years. Rights may be challenged where water is over-exploited. All water use, except those under 7,000 cubic metres per year of groundwater, requires a concession. See also Ingrid Kissling-Näf, Stevan Kuks, *The Evolution of National Water Regimes in Europe: Transitions in Water Rights and Water Policies*, 2004, p. 349, and European Commission, *APERTURE Final Report* (European Commission, DG XII Space, Ispra, Report ENV4-CT97-437, October 2000), p.79-95, http://www.ucl.ac.uk/laws/environment/satellites/docs/ accessed 15 January 2012.

111 Art. 54 of the Water Act, Art 171.2 of the RD 489/1986 on the Hydraulic Public Domain. For example, in 1987, the Confederación Hidrográfica del Guadiana (CHG), which is the Guadiana river basin Water Authority, declared provisionally that the Mancha Occidental aquifer was over-exploited, Aperture Final Report, p. 81 – 82.

112 Linear Imaging Self-Scanning of the Indian Remote Sensing Satellites (IRS).

113 Aperture Final Report, p. 83, in relation to the Guadiana River Basin, La Mancha Occidental Acquifer.

114 Aperture Final Report, p. 80.

115 Tribunal Superior de Justicia de Castilla-La Mancha (Sala de lo Contencioso-Administrativo, Seccion 1a), Sentencia Num. 376/1998 de.

rights.[116] For uses that are monitored, such as irrigation, agencies may rely on self-monitoring, reporting by right-holders,[117] and metering, which may be compared with power use data from electrical suppliers. Field monitoring may also be carried out,[118] and regular or random audits,[119] to determine compliance with the terms of rights.

Where water use is not metered, aerial surveys may be employed to determine areas of land under irrigation, or volumes of water used. EO information may also be employed where it is of use, for instance in remote areas. Satellite telemetry may also be utilized to relay monitoring information.[120]

5.3.2 Enforcement

Most enforcement agencies are government owned and accountable to a single authority.[121] They are generally responsible for consultation, monitoring, investigation, and enforcement, which may include prosecution. Monitoring and enforcement arrangements are employed to maintain the integrity of water rights and environmental allocations, among other things, and to ensure that both those with and without rights comply with relevant water legislation and licence or permit conditions.

With few exceptions, enforcement agencies do not also have a water distribution role, which might create conflicts of interest. Chile and South Africa have both roles,[122] as well as the Australian state of Victoria.[123]

116 Indigenous cultures may place a value on water not directly related to criteria otherwise considered. For a discussion of water rights issues related to indigenous populations, see WaterCulture.org, http://www.waterculture.org/Irrigation_Management.html, accessed 10 January 2012.

117 For instance, in California all groundwater users who have an adjudicated right are required to report their extractions each month to the court appointed Watermaster. Similarly, all persons or designated agencies holding a surface water right in California are required to file a statement of diversion and use each year with the SWRCB. See Productivity Commission 2003, *Water Rights*, p. 246 and 277.

118 The Office of the State Engineer (OSE) in Colorado undertakes field monitoring of surface water diversions. Productivity Commission 2003, *Water Rights*, p. 277.

119 Productivity Commission 2003, *Water Rights*, p. 276.

120 In Colorado, the CWCB holds over 1,300 environmental in-stream flow (ISF) rights for the benefit of all of the people in the State of Colorado. These are monitored in a number of ways, including the use of hundreds of gauges throughout the state by the OSE and the United States Geological Survey (USGS), which make it possible for the Colorado Water Conservation Board (CWCB) to monitor whether or not its ISF rights are being met. Many of the gauges have satellite telemetry and, as a result, the flow volumes are available on a day-to-day basis via the USGS and the OSE Internet sites, and therefore, to the public.

121 Productivity Commission 2003, *Water Rights*, p. 270. In the US, there are some notable differences. In California, the monitoring and enforcement of surface water rights (including in-stream rights), groundwater rights and the provision of water for specific environmental programs is undertaken by a number of independent agencies. In Colorado, the monitoring of surface and groundwater rights is undertaken by the OSE, whereas the monitoring of in-stream flow water rights is undertaken by the CWCB (both are separate divisions within the Department of Natural Resources).

122 It is proposed that the Department of Water Affairs and Forestry in South Africa will progressively withdraw from direct involvement in water distribution (Thompson et al. 2001).

123 The Victoria rural water authorities (RWAs) monitor and enforce rights held by individuals and have the power to impose sanctions. They are also responsible for delivering water to individual right-holders such as private diverters and irrigators. In addition, Victorian water authorities (including RWAs) are granted a bulk water entitlement that is enforceable at law. However, in most of the 26 relevant river basins, there is no independent agency monitoring the authorities' compliance with their obligations under that entitlement. As noted by the Parliament of Victoria's Environment and Natural Resources Committee Inquiry into the Allocation of Water Resources for Agricultural and Environmental Purposes: "Water authorities are required to report on the extent to which they have met obligations specified on bulk entitlement orders and these can reveal shortfalls in meeting these obligations. Shortfalls do occur, but no prosecutions had resulted by July 2001 (ENRC 2001, s. 6.58). Productivity Commission 2003, *Water Rights*, p. 270.

States are under increasing pressure from water users and environmentalists to improve water rights enforcement, especially where there is water scarcity or a concern that some users divert more water than allowed under their water rights.[124] The techniques used for enforcement are often the same as those applicable to the resolution of disputes between private parties. Most jurisdictions have an appeals procedure, in which EO information can also be used.

It has been suggested that the use of satellite imagery and GIS to enforce water rights might constitute a violation of the right to privacy.[125] There is, however, precedent permitting monitoring by aerial surveillance and photography.[126] In addition, it is unlikely that a privacy argument would succeed in a water right case, given that water rights are in public view, not located in a private home. In addition, there would be an expectation that the water right would be monitored.

There is very little in the public record concerning water monitoring and enforcement.[127] It is therefore difficult to identify cases in which EO information has served as evidence. There is, however, a wealth of information on the EO techniques which may be used in monitoring and enforcement of water rights and the resolution of water disputes.

5.3.2.1 Australia

EO information is widely used in Australia to monitor compliance with environmental laws.[128] Satellite imagery can show changes in vegetation cover, which can be indicative of irrigation, and can detect those changes that reveal water use by those that do not have a water abstraction or irrigation licence, or have taken more water than a licence allows. EO information is one of the tools used in the detection of water theft, along with audits of licenses, site and equipment inspections, metering and water usage records.

Illegal water extraction and use is an old problem in Australia.[129] Until very recently there were generous allowances, but allocations are being reduced, old entitlements reviewed and new entitlements put on hold, while construction of works for extraction and diversion are more vigorously monitored. Its elevation to an environmental crime of consequence has

124 See Anderson and Hill, *Technology of Property Rights*.

125 Landry, *GIS in Water Rights Management,* p. 32. See also Kelly, Krysten C, *Warrantless Satellite Surveillance: Will Our 4th Amendment Privacy Rights be Lost in Space?,* 1995, John Marshall Journal of Computer and Information Law, p. 734. See also Karen Geer, *The Constitutionality of Remote Sensing Satellite Surveillance in Warrantless Environmental Inspection*, Fordham Environmental Law Review, 2011 Vol. 3, Issue 1, pp. 43 et. seq., http://ir.lawnet.fordham.edu/elr/vol3/iss1/3, accessed 16 January 2012. See also *Pretty v UK*, ECHR 2002 (Application No. 3246/02, Judgment 29 April 2002.

126 *Dow Chemical Co. v United States*, 476 U.S. 227 (1986). In 1998 the US Supreme Court held that photography of a chemical plant from the air required no warrant. However, the Court reasoned that because the public did not have access to the satellite technology, the expectation of privacy from satellite observation was greater than that of aerial observation. This distinction has been blurred by national laws making EO information more universally available, and by the advent of resources such as Google Earth, with images produced by satellites such as LANDSAT and SPOT freely available. Furthermore, even if satellite monitoring in general was found to be intrusive , open field monitoring would likely be permitted. See Geer, p. 92.

127 Productivity Commission 2003, *Water Rights*, p. 273.

128 Annex1: Workshop Report, Section 6: ESRC UCL Study.

129 Samantha Bricknell, *Environmental Crime in Australia*, AIC Reports Research and Public Policy Series, Australian Institute of Criminology, 2010, http://www.aic.gov.au/publications/current%20series/rpp/100-120/rpp109.aspx, accessed 18 January 2012.

largely been in response to more recent concerns about Australia's water supply, aggravated by drought and newly-legislated attempts to reign in past practices of over-supply and overuse.[130]

During the 1980s and particularly the 1990s, states handed out many new water licences with generous extraction allocations, often to irrigators and other large consumers of water. Concerns about mismanagement led to the Intergovernmental Agreement on a National Water Initiative (NWI) of 2004,[131] along with further improvements suggested in 2008,[132] aimed to improve water management and monitoring or assessment of compliance, to connect management of surface and groundwater resources, and to increase focus on environmental outcomes.

However, many are clearly motivated to take more water than had been allocated, to take it from unlicensed sources, to use water for unauthorised purposes, or to tamper with metering equipment to conceal actual usage rates. These are unlawful, as is the theft of water stored from private water tanks and dams.[133] Another type of water theft is quasi-permissible drainage of environmentally sustaining waters, such as occurred in the Macquarie floodplain, where over a period of years, intensifying in the 1980s and 1990s, levees, channels and river storage were constructed.[134] While most of this construction may have been technically legal under the regulations applicable at the time, the continued over-harvesting of 'environmental waters' by diversion of flows from rivers and direct capture from the floodplain is not.[135]

Quantifying water theft is as difficult as tracking illegal native vegetation clearance, with a large body of licensed holders and limited surveillance capability. Furthermore, there is no consistent national water accounting method.[136] It is also difficult to estimate the volume of water taken, as not all water allocations are metered. Metering is increasing, but the level of use is still relatively low, especially metering of groundwater sources and unregulated rivers. There is little published data of theft, or estimates of theft or evidence of non-compliance. Frequently, complaints result in administrative reprimands rather than prosecutions.[137]

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130 The scale of the crime is probably a lot larger than officially reported and comprises a significant proportion of intentional non-compliance. There is little published data on sanctions applied, and little or no information on penalties following prosecution. Warning letters, negotiation and 'statutory notices' are common results, with few prosecutions reported. Bricknell, 2010, p. 112.

131 Tasmania and Western Australia joined in 2005 and 2006 respectively. Bricknell, 2010, p. 109.

132 Report to COAG of 26 March 2008, the Working Group on Climate Change and Water (COAG Working Group on Climate Change and Water 2008), cited in Bricknell, 2010, p. 110.

133 In a five month period in 2007, there were 5 reported cases of water drained from tanks and dams in rural New South Wales, involving more than 100,000 litres of water stolen from tanks, and many more of 10,000 litres or less. Williams, 2007, cited in Bricknell, 2010, p. 110.

134 The Macquarie Marshes is an important breeding site for over 40 species of waterbird. It is one of the largest semi-permanent wetland systems in Australia, surrounded by floodplains which, when flooded, can extend up to 250,000 hectares in area. It is 88% privately owned, and used for agricultural purposes, primarily grazing but also dryland farming and irrigation. A four-fold increase in the construction of levees, channels and river storage facilities took place in the southern regions of the Macquarie floodplain between 1949 and 2005, with much of this development in the 1980s and 1990s, and despite the implementation of the Murray-Darling Basin Cap in 1995. Bricknell, 2010, p. 111. See also Steinfeld & Kingsford, 2008.

135 Steinfeld & Kingsford, 2008, cited in Bricknell, 2010, p. 111.

136 To this end, the National Water Initiative, overseen by the National Water Commission, is developing national standards for the measurement and metering of water. NWC 2007, cited in Bricknell, 2010, p. 110.

137 For example, the majority of bore licence holders in the Leeton area of New South Wales complied with licence conditions while a third in the Murray Irrigation Area had not. In the same time period, the South Australia Department of Land, Water and Biodiversity Conservation investigated 70 complaints about improper water usage in the River Murray (SA DLWBC 2008a). All violations in both states and territories received administrative reprimands. See Bricknell, 2010, p. 110.

Prosecuted cases in Victoria and South Australia include irrigators taking unauthorized water or interfering with meters. In Queensland, 24 cases were prosecuted in 2006–07, three were for unauthorised taking or interfering with water, two for contravening conditions of licence, and two for tampering with a water meter.[138]

Three forms of monitoring are used to establish incidents of water theft. Compliance audits of water licences involve site visits, works and equipment inspection and testing, along with reviews of metering and water usage records. Depending on the jurisdiction, audits may be supplemented by surveillance with aerial, ground or river surveys, aerial photography or satellite images. Alleged breaches may be reported by the public, local councils, state utilities or other government departments.[139] High-risk areas have also been identified for intensive compliance monitoring of surface water licence holders, bore (groundwater) licence holders, irrigators, bore drillers, measurement of water extraction, and use of town water while under a directed water restrictions order.[140]

Excessive or illegal extraction of water may in turn give rise to civil disputes between the extracting party and other legitimate users. Clearly, EO information described above can provide evidence in such claims and disputes.

5.3.2.2 USA

Satellite imagery is an established tool in the US for many purposes, including mapping and analysis of watercourses. Enforcement uses are difficult to identify for specific states, although the capability exists there perhaps more than for any other country (other than the EU states), on both a state and federal level.

In the early 1980s, falling water levels prompted the Arizona Department of Water Resources (ADWR) to close several groundwater basins to new appropriations.[141] While surface water violations would have been relatively easy to detect within a stream system, illegal pumping which could have been taking place anywhere in the basin made detection difficult. To enforce the closures the State developed a combination of GIS and low-resolution infrared satellite imagery capable of identifying high vegetation growth to identify potential irrigation outside licensed areas. Field research was also carried out. This targeted approach allowed the ADWR to spend less time on random field investigations, thus maximising available resources.

State law enforcement agencies have found satellite imagery to be an effective tool to investigate violations of zoning and environmental regulations. For example, the Arizona Department of Water Resources has used satellite imagery to find violations of irrigation permits. In 1998, a farmer was fined for illegal irrigation. The Arizona Department of Water Resources employed EO information with GIS water rights maps.[142]

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138 Qld DNRW 2008b, cited in Bricknell, 2010, p. 111.

139 Bricknell, 2010, p. 112.

140 In their latest annual report, the NSW Department of Water and Energy listed eight regions and groups of licence holders subject to such scrutiny, as the increased pressure of the ongoing drought in the state ‘increased the benefit from and potential motivation for water theft.’ NSW DWE 2008a: 27, cited in Bricknell, 2010, p. 111.

141 Clay J Landry, *GIS in Water Rights Management*, p.32-36.

142 Ross Kerber, *Privacy: When Is a Satellite Photo An Unreasonable Search?,* Wall Street Journal, Jan. 27, 1998, cited in Patrick, Korody, Satellite Surveillance Within US Borders, Ohio State Law Journal, Vol 65, 1627, p. 1629.

While the use of GIS and satellite imagery may not become universal in water rights enforcement, it is being used in a number of States. The U.S. Supreme Court approved a settlement[143] aimed at the protection of existing water rights while providing certainty about the extent of Wyoming's water use and future water development and management. The settlement calls for an increase in monitoring, measurement, accounting, and reporting of water use, among other steps. One identified compliance measure was the measurement of irrigated land from EO satellite imagery.[144] Along with further research to develop water monitoring tools incorporating GIS, the State is assessing how best to utilize the assortment of high quality imagery available for consumptive use purposes.[145]

It is reported that the Wyoming Engineer's Office considered using GIS and satellite imagery for water rights enforcement, but that the technology was never employed primarily because water rights holders and state policy makers raised objections over privacy.[146] However, Wyoming has carried out GIS mapping that included the use of EO information, covering the Snake/Salt River basin.[147]

5.3.2.3 South Africa

In South Africa, policy makers use EO information to monitor irrigation practices.[148]

5.3.2.4. Spain

Analysis of water use relative to water rights has been carried out in Spain through a combination of EO estimates of vegetation cover combined with geographical data on water rights. Software has been developed to combine relevant data including spectral vegetation indices for the recognition of the irrigated areas. It uses a technique that measures the difference in evaporation rate of crops compared with uncultivated soil through near-infrared and visible multi-spectral satellite EO data, providing the means of assessing water used by crops. These have been combined with official cadastral ownership and water rights information to assess water use in the Guadiana River Basin of Castilla-La Mancha, Spain.[149]

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143 Final Settlement Stipulation and entered the Modified North Platte Decree in Nebraska v. Wyoming on November 13, 2001. See State of Wyoming 2010 Annual Report of the State Engineer, http://seo.state.wy.us/docs.aspx, accessed 22 January 2012, p. 58.

144 The Consumptive Use Subcommittee, under contract with Riverside Technology, Inc.

145 The primary sources of imagery comes from the National Agriculture Imagery Program (NAIP; 2001, 2005, 2009 and proposed for 2011) and Landsat satellites. In 2010, Wyoming purchased ERDAS Imagine 2010 software as a tool for imagery assessment. See Wyoming Annual Report, 2010, p. 75.

146 See Landry, *GIS in Water Rights Management,* p. 33.

147 The system combined aerial visible and infrared aerial photography, infrared EO information dating from 1997 to 1999 provided by Space Imaging, and digital raster graphics (DRGs) of the USGS topographic maps. Robert E King, *Snake/Salt River Basin Plan, Irrigated Lands Mapping and Permit GIS Data*, 2003, Wyoming State Water Plan, http://waterplan.state.wy.us/plan/snake/techmemos/irrpermit.html, accessed 18 January 2012.

148 Personal Communication from Maurits Vogt, WaterWatch, 31 August 2011. The satellite data could be used as evidence in disputes, but policy makers prefer to create awareness of the usefulness of such information before using it in court, Personal Communication. Earth observation empowers African scientists to improve water management, 21 December 2011. See ESA's TIGER initiative, in which South African scientists exploited satellite data to map soil moisture conditions, or Soil Saturation Index (SSI) and annual differentiation. SSI mapping can be useful in the agricultural sector and for flood risk assessments. http://www.esa.int/esaEO/SEMFZ4BX9WG_index_1.html, accessed 22 January 2012.

149 Gabriel N Parodi, AHVRR Hydrological Analysis System, WRES-ITC 2002, pp. 7 – 8, http://www.itc.nl/?cx=015731982058527422289%3A-gycaegv6oa&cof=FORID%3A11&id=SEARCH&q=, accessed 18 January 2012. See also Wim G M Bastiaansen, David J Molden, Ian W Makin, *Remote Sensing for Irrigated Agriculture: examples from research and possible applications*, 2000, 46 Agricultural Water Management 137 (142).

5.4 ALLOCATION AND RE-ALLOCATION OF WATER RIGHTS

A water administration authority generally has a legal duty to protect the rights of existing users and the environment when allocating water rights. Parties adversely affected by an administrative decision to re-allocate or cancel a water right may challenge that decision by judicial review.[150] Evidence to support such challenges can include EO information.

5.4.1 Protecting the Environment when Allocating Water

Environmental factors play an important role in administrative decisions on the allocation and management of water resources. The types of information used in these decisions can also be useful in water disputes. In determining whether to grant a licence, the water authorities are often required to take account of the potential effect on river flow or groundwater levels. This involves assessing the status of the resource as to quantity and quality, to determine whether water resources remain available.

It is possible to estimate reductions in flow or the depletion of the water table by EO information combined with hydrological models. Once models are calibrated, they are economically more feasible than ground monitoring. In addition, they can also help guide future decisions.[151]

In a case involving groundwater elimination,[152] the court noted that Texas had used satellite imagery to get precise estimates of the extent of drainage to the water table. Oklahoma had not taken such steps. Therefore, Oklahoma's approval of an oil company's groundwater withdrawal for an oil recovery process was reversed.

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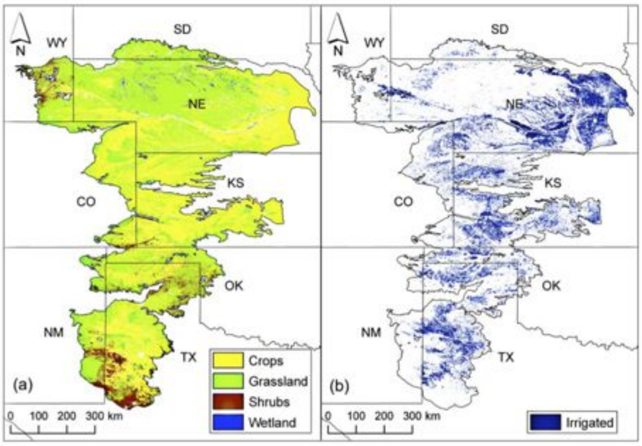
150 See Alexander Horne, Gavin Berman, *Judicial Review: a short guide to claims in the Administrative Court*, House of Commons Library, Research Paper 06/44, 28 September 2006, p.21, http://www.parliament.uk/briefing-papers/RP06-44, accessed 15 January 2012. See also Chris Hilson, Ian Cram, Judicial Review and Environmental Law – is there a coherent view of standing?,16 Legal Studies (1996) 1.

151 Bekele Debele Negewo, Julia Bucknall, Ahmed Shawky Mohamed, *Applications of Latest Technologies and Hydrological Models*, in Water Resources Management and Planning in MNA Region, in N. Vijay Jagannathan, Ahmed Shawky Mohamed, Alexander Kremer, eds., *Water in the Arab World, Management and Perspectives, MNA Region*, The World Bank 2009, p.80-93, http://search.worldbank.org/all?qterm=water%20in%20the%20arab%20world, accessed 18 January 2012.

152 *Oklahoma Water Resources Board v. Texas County Irrigation and Water Resources Association*, 711 P.2d 38 (OK 1984), case nos. 70608. 70609, Joanne Irene Gabrynowicz, (ed.), Remote Sensing Case Law, (2007) 33(3) J.Space L 102 (113), http://www.spacelaw.olemiss.edu/resources/pdfs/biblio.pdf.

EO technology and other water resource management tools have advanced considerably since this case, as can be seen in the National Land Cover Database (NLCD) mapping of the High Plains Aquifer, which includes the Oklahoma county in this case. The data were generated from a standardized set of data layers mosaiced by mapping zone. Typical zonal layers included multi-season Landsat 5 and Landsat 7 imagery centred on a nominal collection year of 2001, and Digital Elevation Model based derivatives. These mosaiced zonal layer stacks often consisted of 18 or more layers. The maps below show the High Plains aquifer with, on the left, major land cover types, and on the right, irrigated areas across the 8 states of the aquifer.[153]



5.4.2 Market Transfers: Protecting Existing Users' Rights

In the western states of the United States, water rights are real property rights that may be bought, sold and transferred to new uses in new locations, subject to the provision that such a change in use will not injure other existing water rights. Colorado is a prior appropriation state with both conditional [154] and absolute water rights, which can only put to the uses for which that water right is granted. Most of the oldest water rights are for irrigation. There is significant pressure to convert those senior irrigation rights to use for municipal purposes via market transfers.[155]

It is necessary to identify existing owners, and to prevent injury to them resulting from the transfer. There must also be an accurate quantification of historic consumptive use in relation to the holder of the original rights, to ensure that other appropriators are not harmed. Water rights are specified in terms of water that may be extracted or diverted, not the amount that may be consumed. When water rights are transferred, the new holder of the right does not receive the entire divertible flow decreed to the original water right, only the consumptively

[153] Collin Homer, Jon Dewitz, Joyce Fry, Michael Coan, Nazmul Hossain, Charles Larson, Nate Herold, Alexa McKerrow, J. Nick VanDriel, and James Wickham, *Completion of the 2001 National Land Cover Database for the Conterminous United States*, Photogramm. Eng. Remote Sens., 73(4), 337 – 341.

[154] If users do not put their water rights to beneficial use, i.e. convert conditional rights to absolute rights, or if they use their rights for a time but then stop using them, e.g. old mining rights where the mining has ceased, they can be abandoned. It typically requires a minimum of 10 years of continuous non-use for the State Engineer to put any water rights on the abandonment list, and then the owner of the right can seek to have it taken off if he can show that he plans to put that right to beneficial use in the future. If a right is abandoned, the water is free for others to appropriate, but it would be a new right with a junior priority.

[155] See Philipps, Dave, *Watered Down*, in: The Gazette (Colorado Springs), Aug 7, 2005, http://www.highbeam.com/doc/1P2-2770783.html.

used portion of that right. Therefore, in order to change the use of the water, the historic depletion to the water source from the consumptive use of the water must be proved.[156]
EO information can be used to establish these facts, and may be relevant in a claim for interference with water rights by competing users.

The monitoring of evapotranspiration from crops[157] is one of the ways being studied[158] to establish quantities of water used for irrigation. The aim is to quantify water historically used by crops, to provide sufficient evidence to permit conversion of irrigation rights to municipal rights and to enjoy the senior status of the right. Information from ground sources is often based on design data rather than actual water use, and EO data can quantify the actual use of water more accurately.[159]

EO information tailored to crops has been used to identify irrigators using more than their allotted share of water. Corroborative field investigations are still necessary, but the use of satellite data allows authorities to target these field investigations more efficiently than random checks.

ET could potentially be used to quantify the "beneficial use" element of a water right under the prior appropriation doctrine, thus minimising disputes over water rights trading. Field studies testing the reliability of the method are currently underway, but the ET data is not yet widely available and has not yet been used in court. In any case, corroborative evidence is likely to be necessary if satellite-derived ET measurements are used in court.

Infrared EO information can help estimate the loss of moisture from crops by the variation in colour on infrared images. The estimated ET is related to the volume of irrigation water being applied to the crop. Taking into account the quantity of water being used to irrigate a crop, data about soil moisture and effective precipitation, it may be possible to determine the volume of water actually used from the water source, and therefore the amount that may be transferred to other uses. Because of the need for calibration and accuracy, the EO data are being corroborated with extensive field-studies on research farms.

5.5 DISPUTES BETWEEN WATER USERS AND GOVERNMENT

Most water is generally owned and controlled by government at some level. Disputes have arisen between governments and water rights holders or users. The following cases are exemplary of this sort of dispute. It is not apparent that EO information was introduced, but there are ways in which it would be helpful in similar circumstances, by documenting the extent of irrigation and water use, as well as the amount of reduction and its timing.

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156 Robert B Naesser, Mark G Smith, *Enforcing Property Rights in Western Water: Is it Better to Be Upstream with a Shovel or Downstream with a Model?*, pp. 39-56, in Terry L Anderson, and Peter J Hill, Peter J (eds.), *The Technology of Property Rights*, 2001, p. 40-41.

157 See http://ga.water.usgs.gov/edu/watercycleevapotranspiration.html, accessed 28 December 2011. EO information can also be used to measure water productivity through crop type and seasonal evapotranspiration. See also Wim G M Bastiaanssen, David J Molden, Ian W Makin, *Remote Sensing for Irrigated Agriculture: examples from research and possible applications,* (2000), 46 Agricultural Water Management 137(142).

158 Colorado State University and Lytle Water Solutions, project using satellite data to estimate water use by crops. Personal communication from Bruce A. Lytle, 28 November 2011. Lytle has served as an expert witness in a number of civil water disputes in Colorado, but has not used satellite data in any of those cases.

159 See Bastiaanssen, p.141.

5.5.1 California: Orff et. al.

In *Francis A Orff v United States*,[160] the petitioning California farmers purchased water from the Westlands Water District. The farmers contended that the US Bureau of Reclamation breached a 1963 contract with the Water District when it reduced the water supply to it in 1993, adversely affecting them. The petitioners were not parties to the contract, but claimed that they were entitled to enforce it as the intended third-party beneficiaries. The court rejected this claim, in contrast to the following case.

5.5.2 California: Tulare Lake

The claimants in the 2001 *Tulare Lake* case[161] had formal water supply contracts for irrigation purposes with the California Department of Water Resources (DWR). Following restrictions on the operation of the California State Water Project, mandated by the federal Endangered Species Act (ESAct), water deliveries were reduced, and the water users claimed damages the US government.

The court accepted that the claimants' rights were derivative of the DWR's, and that water rights in California are limited by *public trust* and *reasonable use* doctrines.[162] The first imposes an obligation on state agencies and courts to consider the effect of diversions on interests protected by the public trust, such as fishing, recreation, or ecological use. The second states that water use must be both reasonable and for a beneficial purpose, such as preservation of fish and wildlife.

However, the court decided that the claimants had an identifiable usufructuary interest in a stipulated volume of water, and that the restrictions mandated by the ESAct affected a *taking* of the claimants' right. Although the contracts with the DWR state that California could not be held liable for any damage arising from shortages in the amount of water for any cause beyond its control, the court ruled that this provided a defence only to California, and could not be used as a defence against the *taking* claim by the national government. Furthermore, the court found that the restrictions mandated by the ESAct went beyond the conditions mandated by California's water allocation Order D-1485, and were therefore inconsistent with California law. The US government settled the claim with the water users by a large payment, without accepting liability.

5.6 Inter-jurisdictional Water Disputes

Inter-jurisdictional arrangements are common in water rights.[163] Complications might arise when the number of parties and jurisdictions are enlarged, and when inter-jurisdictional agreements or treaties come into play.[164] EO information may be useful in these kinds of

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[160] See e.g. *Francis A Orff et al, Petitioners v United States et al*, 545 U.S. 596 (2005) 358 F.3d 1137, affirmed, available at: http://www.law.cornell.edu/supct/html/03-1566.ZO.html.

[161] *Tulare Lake Basin Water Storage Dist. v. United States*, 49 Fed.Cl. 313 (2001).

[162] John D. Echeverria, *Why Tulare Lake Was Incorrectly Decided*, Georgetown Environmental Law & Policy Institute, Georgetown University Law Center, August 2005, www.law.georgetown.edu/gelpi/current_research/documents/rt_pubs_law_tularelakeincorrect.pdf

[163] The Murray-Darling Basin Agreement of 1992 involved New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory. The Colorado River Basin covers 7 states and parts of Mexico, and is governed by a body of law referred to as the Law of the River, under which rights are allocated. Productivity Commission 2003, *Water Rights*, p. 282.

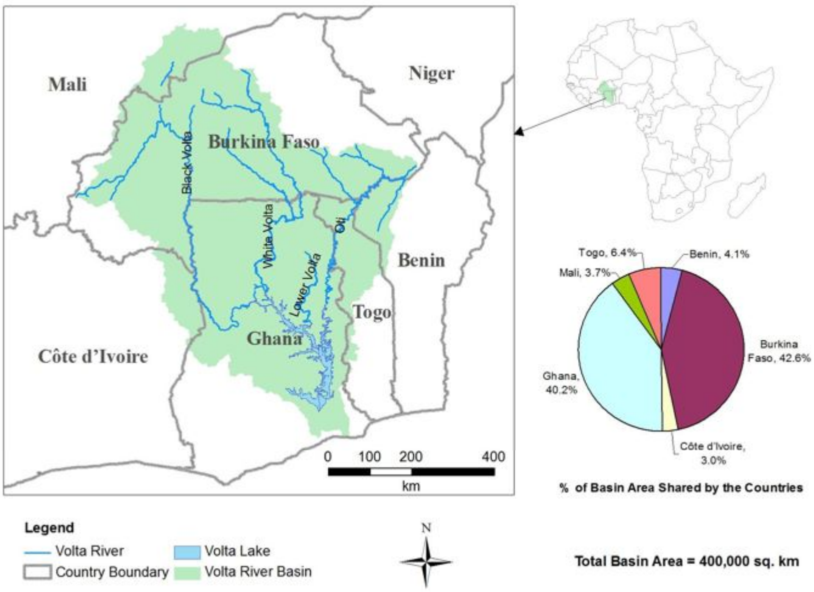
[164] For instance, New Mexico shares river systems with other states and Mexico. Historic disputes over upstream use led to negotiation of eight compacts that prescribe how much water we can take and how much we must deliver downstream. Each compact, approved by Congress, has the force of federal law. The US also has obligations to Mexico the Convention of 1906 on the Rio Grande above Ft. Quitman, Texas, and a 1944 treaty on the Colorado River and Lower Rio Grande. See also the New Mexico Aamodt water

disputes in supporting the assertion of a claim to water, including proof of irrigation and crop growth; assessment of damages when a water supply is withdrawn; and determination of the time-frame and duration of harm to a water user.

5.6.1 Disputes between States: Volta Water Basin

Traditionally, international law has focused on the problem of transboundary surface waters, referring to transboundary groundwater only marginally or not at all, or limiting the reference to those groundwaters that “flow into a common terminus.” In recent years, however, groundwater and transboundary aquifers have received greater attention in the international community, which has begun to call “for the holistic management of freshwater as a finite and vulnerable resource.”[165] Watersheds are shared between states and countries in many areas, and disputes have arisen over the allocation of water. In addition, diversion or alteration of the watercourse can lead to conflict. EO systems using optical and SAR sensors can record these facts.

The Volta River Basin of West Africa covers an area of 400,000 km^2. It is shared by six countries: Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali and Togo.



In August 2007, there was a 50-year flood in Ghana, aggravated by the opening of the floodgates of the upstream Bagre Dam in Burkina Faso. Ghana was not notified at the time of the opening, and was not prepared for the sudden increase of water, which resulted in much damage.[166] If a formal dispute had arisen between the countries,[167] EO information with

adjudication case, begun by a lawsuit in 1966 and only resolved in 2011. Eric Mack, *Pueblo water battle nears its end*, High Country News, http://www.hcn.org/issues/333/16659/print_view accessed 16 January 2012.

165 For a discussion on international law relating to transboundary waters, see Antonio Herman Benjamín, Cláudia Lima Marques, Catherine Tinker, *The Water Giant Awakes: An Overview of Water Law in Brazil*, in Texas Law Review, Vol. 83, pp. 2185 et. seq., available at www.estig.ipbeja.pt/~ac_direito/WaterG.pdf.

166 Yongxuan Gao, Amy Margolies, March 2009, *Transboundary Water Governance in the Volta River Basin*, https://wikis.uit.tufts.edu/confluence/display/aquapedia/Transboundary+Water+Governance+in+the+Volta+River+Basin. accessed 20 January 2012.

167 A transboundary watershed management organization called the Volta Basin Authority (VBA) was created in 2006. However, the VBA has yet to take on a role in attending to the problems of water management, coordinating water projects or resolving water conflicts in the Basin.

appropriate temporal and spatial resolution would have been useful in resolving a dispute by documenting damage to houses and other structures, agricultural areas and transport routes.

It is alleged that repeated release of water from the Bagre Dam has caused flooding in parts of northern Ghana, with consequent deaths and property destruction.[168] In 2008, The Ghana Embassy in Burkina Faso informed the Volta River Authority (VRA) that given the rate of the rise of water in the Bagre Dam, operators of the facility would open its flood gates if the current trend continued.[169] Authorities said the spilling of the water was likely to cause flooding in some communities in Ghana's Northern, Upper East and Upper West regions. As part of its contingency plan towards the expected disaster, the National Co-ordinator of the National Disaster Management Organisation and others were undertaking public education and risk assessment in the flood-prone areas in the three regions that were likely to be affected by the floods.
EO information could clearly be used to assess high-risk areas and to aid in the resolution of any disputes that might arise for loss of life or harm to watercourses or property as a result of the opening of the dam's floodgates.

6. WATER QUALITY

To succeed in a civil action regarding the adverse quality of a water body, the claimant must prove that there has been damage, and that it was caused by the defendant. A number of water quality parameters may be relevant. Single or non-point[170] cases of pollution of surface and groundwater may include oxygen depleting elements, biological or microbiological material, suspended matter, sediment,[171] waste materials such as plastic, nutrients, and chemical pollutants, including nuclear waste. The chemistry of the water may also be altered, for instance in its salinity,[172] acidity, temperature or pH. Causes will include agricultural runoff such as fertilizer or oil, or pollution from residential areas.

Temperature is relevant to some uses of water, for example, at a fish farm. Microwave and infrared satellite sensors have long been used to measure water temperature for meteorological purposes. The techniques used include thermal infrared and passive microwave radiometry.[173] These techniques will be applicable to the measurement of temperature in small bodies of water in the same way as they are used to measure ocean temperature.

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[168] Steve Y. Acheampong, *Opening of Bagre Dam Spillway – For How Long Should This Annual Killing Ritual and Property Destruction Continue?,* Modern Ghana, 11 September 2010, http://www.modernghana.com/news/295591/1/opening-of-bagre-dam-spillway-for-how-long-should-.html, accessed 2 February 2012. See also: *Fear of Bagre Dam Spillage Grips Northern Farmers*, Thursday 21 July 2011, http://www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID=214316, accessed 2 February 2012.

[169] Flood Alert: Burkina Faso to Open Bagre Dam, http://edition.myjoyonline.com/pages/news/200808/19188.php, accessed 2 February 2012.

[170] Non-point pollution does not originate from a single point.

[171] Introduction of sediment into water sources can be harmful for aquatic life including commercially important fish, and there are many other reasons to monitor its presence. For a discussion on the subject, including ways sediment is introduced to watercourses, see Janine Castro, Frank Reckendorf , Effects of Sediment on the Aquatic Environment: Potential NRCS Actions to Improve Aquatic Habitat - Working Paper No. 6, August 1995, http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/rca/?&cid=nrcs143_014201, accessed 30 January 2012.

[172] Andrey G. Kostianoy, Sergey A. Lebedev, Dmytro M. Solovyov, *Satellite Monitoring Of Water Resources In Turkmenistan*, International Water Technology Journal, IWTJ. Vol. I - Issue 1, June 2011.

[173] John Maurer, *Infrared and Microwave Remote Sensing of Sea Surface Temperature*, http://www2.hawaii.edu/~jmaurer/sst/.

The following are some uses of EO information to ascertain water quality.

6.1 EGYPT

In Egypt, the National Centre for Water Research is implementing a project using remote sensing technologies to monitor and assess the quality of water in the Nile River, focussing on the Rosetta Tributary because surrounding residential areas make it susceptible to high levels of pollution. The project also focuses on monitoring agricultural wastewater courses that carry polluted water, which is dumped in the Tributary. It uses multi-layered satellite images and remote sensing to identify levels of saltiness, organic substances, chemical substances and chlorophyll in the water. When the project is completed in 2012, data derived from the images will be fed to the Data Bank of the Water Resources Centre at the Ministry of Irrigation and Water Resources. This will assist in compiling an image of the quality of Nile water for the ministries of irrigation and housing, and could be used for the resolution of water quality disputes.[174] In addition, the Ministry will use EO information to identify encroachments in the course of the Nile, and to monitor Nile floods.

6.2 AUSTRALIA

In Australia, there are a number of projects to evaluate the accuracy, cost and timeliness of image-based EO systems for assessing compliance with water quality standards. These systems would be helpful in verification of water quality, particularly in coastal embayments next to large cities or ports and the Great Barrier Reef.[175]

Satellite derived EO data has been used as evidence in national and international court cases to prove the existence of algal blooms, taconite tailings and oil in the water.[176]

6.3 US

The Environmental Protection Agency (EPA) has developed a GIS system to analyse EO information for monitoring and enforcement of environmental laws,[177] including the Clean Water Act.

In *United States v Reserve Mining Company*,[178] which led to a conviction for violation of the Clean Water Act, the plaintiffs used satellite photographs to show widespread dispersion of tailings and up-welling phenomena in Lake Superior.[179]

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174 *Italy Helps Egypt Use Satellite Imaging to Monitor Water Quality,* OOSKA Newsletter, Weekly Water Report Middle East & Africa, 8 Aug 2011, Vol. 6, Iss. 28, p.9, downloadable at http://washinitiative.org/wp-content/uploads/2011/05/OOSKA-News.pdf. Subscribers may register to access other water articles on this site: http://www.ooskanews.com/middle-east-africa/italy-helps-egypt-use-satellite-imaging-monitor-water-quality.

175 See Ray Purdy, *Satellite Monitoring of Environmental Laws: Lessons to be learnt from Australia* (UCL 2010), p.139 Fn.687

176 See, for example, *Pulp Mills on the River Uruguay (Argentina v. Uruguay),* Judgment of 20 September 2010, available at: http://www.icj-cij.org/docket/index.php?p1=3&p2=2&case=135; European Commission v UK, ECJ 2009, Case C-390/07. For a list of overlapping or closely related claims before other courts and tribunals, see André Nollkaemper, *Cluster Litigation In Case Of Transboundary Environmental Harm*, in: Michael Faure, *China And International Liability: Legal Remedies For Transboundary Pollution* (Edward Elgar Publishing, 2008), p.11 (12).

177 See http://www.epa.gov/compliance/neic/field/gis.html.

178 *United States v. Reserve Mining Co*, 380 F.Supp. 11 (D. Minn.1974). See Kenneth J Markowitz, *Legal Challenges and Market Rewards to the Use and Acceptance of Remote Sensing and Digital Information as Evidence*, (2002) 12 Duke Environmental Law & Policy Forum 219 (256), http://www.epa.gov/esd/gqc/articles.htm, accessed 23 January 2012.

179 Ibid, p. 39.

In the Illinois case of *State ex rel. Scott v Inland Steel Co*[180] the court found liability when it was presented with evidence in the form of satellite photographs, infrared imagery, aerial surveys and other testimony. The case concerned trail of a plume from the canal reaching into Illinois waters that was visually, thermically, and chemically detected.

Two cases in which EO information was introduced concerned algal blooms. In these cases, the courts admitted EO evidence put forward by the respective claimants to prove the existence of algal blooms, and in each case, parties challenged the reliability of specific evidence. Issues raised included reliability, temporal relevance and probative value.

6.4 ARGENTINA V. URUGUAY[181]

In a case concerning the water quality between Uruguay and Argentina, both parties introduced EO information[182] relating to the existence of an algal bloom, which was admitted into evidence by the Court along with reports by experts. According to Argentina the alleged cause of those blooms was a Uruguayan pulp mill creating conditions in the water favourable to algal growth, including high levels of nutrients. Uruguay did not challenge the reliability of EO information *per se*, but raised the issue of temporal relevance when it disputed the evidence as being merely a "snapshot". Uruguay submitted its own satellite evidence to support its claim that the bloom had originated elsewhere. In attacking this evidence as unreliable, Argentina challenged the colour enhancement, calibration and interpretation of the satellite data, and the lack of ground truth collaboration.[183]

The use of expert witnesses was a feature of this case. The majority decision of the court contains several paragraphs relating to the presentation of scientific and technical evidence, including that by experts and consultants put forward by both parties and by the International Finance Corporation (IFC) in its quality as lender to the project. The Court had reservations about some experts who testified as counsel for the parties, and could therefore not be cross-examined.[184]

The Court ruled 13-4 that it was not proven that the mill in Uruguay had caused this bloom, and thus had not breached its water quality, pollution, or woodland and soil management obligations. Judge ad hoc Vinuesa dissented[185]:

> 79. It is reasonable to consider the likelihood of a link existing between the algal bloom and the Orion (Botnia) mill given that the operation of the plant represents a new circumstance. As with other data, the Court would have benefited greatly from a more detailed and expert evaluation of the scientific facts.
>
> 80. I also have difficulty understanding the Court's conclusion that the algal bloom episode of 4 February 2009 may not be linked, in light of the evidence in the record, to nutrient discharges from the Orion (Botnia) mill. During the

180 72-CH-259, 67-CH-5682 (Cir.Ct. Cook County, Ill, 8 September 1975). *Environmental Law-Water Pollution*, (1975-1976) 9 Ind.L.Rev.702.

181 *Pulp Mills on the River Uruguay (Argentina v. Uruguay),* Judgment 20 April 2010, http://www.icj-cij.org/docket/index.php?p1=3&p2=3&case=135.

182 It also submitted a physical sample of the water, which Uruguay disputed.

183 CR2009/20, paras 10-14 and CR2009/21, para 39.

184 See Judgement 20 April 2010, paras 165 – 168. See also paras 119, 236 and 237.

185 Dissenting Opinion of Judge ad hoc Vinuesa, at para 79-80, available at: http://www.icj-cij.org/docket/files/135/15893.pdf. Judge Ad Hoc Vinuesa has made references to satellite evidence in several Dissenting Opinions which may of interest on this subject.

> proceedings, Argentina presented extensive data regarding this phenomenon which pointed to the Orion (Botnia) mill as a significant contributor. The evidence included satellite images showing the vast extent of the bloom, a river flow modelling based on actual data that matched precisely the distribution of the bloom, data indicating the presence in the scum, in addition to algae, of several effluent products coming directly from the Orion (Botnia) mill such as wood fibres, bacteria typically associated with wood pulp, namely, klebsiella, nonylphenol contaminants, and higher levels of sodium and AOX. The presence of those contaminants found in the scum provides clear evidence that the mill effluents contributed to the 4 February 2009 bloom.

Judges Al-Kwasaneh and Simma noted in another dissenting opinion that a court of justice cannot assess, without the assistance of experts, complex and competing scientific claims as to ... "the possible chain of causation that can lead to an algal bloom".[186] In their view, the ICJ's evaluation of the evidence presented to it by the parties was therefore methodologically flawed. As a result they were not in a position to agree that Uruguay had not breached its obligations.[187]

6.5 EUROPEAN COMMISSION V UNITED KINGDOM

In the European Court of Justice case *European Commission v. United Kingdom*,[188] the UK challenged the reliability of EO information. The ECJ addressed the issue of temporal relevance, holding:

> 87. Contrary to what the United Kingdom asserts, that capture of images by remote sensing cannot, as such, be regarded as unreliable, the United Kingdom itself having recourse to such images to support certain of its arguments concerning other areas at issue, and it therefore constitutes a means capable of revealing the existence of accelerated growth of algae and higher forms of plant life.[189]
>
> 88. However, the Commission relies, here, on a single capture of images carried out nearly three years after the date on which the United Kingdom was to identify sensitive areas with respect to eutrophication[190] as referred to in Directive 91/271, namely 31 December 1993.
>
> 89. An isolated capture of images of that kind cannot alone reveal the existence of accelerated growth of algae and higher forms of plant life in the Humber Estuary such as to demonstrate, even *a posteriori*, that that estuary could have become eutrophic in the near future after that date.

The judgment in the ECJ case also stresses the evidentiary weight of ground truth submitted as part of an official report.

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186 Joint Dissenting Opinion, para. 4, available at: www.icj-cij.org/docket/files/135/15879.pdf.

187 The relevant obligations relate to Arts. 35, 36 and 41 of the 1975 Statute. Joint Dissenting Opinion, para. 2.

188 European Commission v UK, ECJ 2009, Case C-390/07, http://curia.europa.eu/juris/liste.jsf?language=en&num=c-390/07, accessed 1 January 2012.

189 European Commission v UK, ECJ 2009, Case C-390/07, Para. 87 of the Judgment.

190 The term 'eutrophic' means well-nourished; thus, 'eutrophication' refers to natural or artificial addition of nutrients to bodies of water and to the effects of the added nutrients….When the effects are undesirable, eutrophication may be considered a form of pollution. National Academy of Sciences, 1969.

> 90. That is all the more the case because the MV[191] report, adduced by the Commission in support of its action, itself draws the conclusion that 'the UK authorities are probably correct to consider that green algae do not occur extensively throughout the Humber Estuary.
>
> 91. It should, moreover, be noted that the Commission did not contest, either in its reply or at the hearing, the explanations provided in the United Kingdom report on the Humber Estuary, which is mentioned in paragraph 80 of the present judgment, to the effect that it follows from a survey carried out in 1996, confirmed by subsequent surveys, that the algae allegedly identified by the images recorded during the remote sensing carried out on 19 August 1996 by the Environment Agency in the form of CASI imaging are, in actual fact, benthic diatoms whose presence on the surface of the mudflats constitutes a natural element of the estuarine ecosystem, which feeds its large bird population.

The ECJ concluded that the satellite image produced by the Commission was not sufficient to show that algae occurred extensively in the Humber Estuary during the relevant time period. However, it clearly admitted and considered the EO information as evidence.

7. CONCLUSION

Disputes over water rights are likely to increase in frequency with growing pressures on water resources. Water scarcity and environmental concerns have led to re-evaluation of water allocation and to increasing regulation. These and the competing needs of water users have the potential to lead to increasing disputes over water. EO is able to provide wide-scale, cost-effective information that might not otherwise be available about a number of issues, including water quantity and quality.

Certain facts must be established in a dispute over water rights, and the varied capabilities of EO systems may provide evidence in such disputes. While no single system will meet all requirements, because of the variety of the facts that need to be determined, there are many systems available, which provide EO information that combined with existing datasets, models and other information can be used as evidence. When used together with GIS and cadastral information, it is ideally suited to large-scale adjudications of existing water rights.

EO information can provide corroborative or circumstantial evidence, and is commonly used in combination with other information, including agricultural, watercourse and socio-economic datasets, estimates of ET, and hydrological modelling, to produce robust tools for a number of applications. In some cases it may be the only practical source of evidence. Where the dispute incorporates a temporal dimension, because EO information has the capacity to accumulate land change data over a period of time, it can provide invaluable evidence.

Where, for instance, new requirements are imposed for obtaining water extraction licences that do not apply to those who have abstracted water for a specified number of years prior to the new legislation, archive information from EO may prove critical in resolving disputes. EO information can also be definitive in circumstances where there is alleged unauthorised taking of water by diversion of a watercourse, and is especially useful in large, remote or dangerous areas, reducing the need for costly and time-consuming field investigations.

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191 Modus Vivendi report (Review of UK Implementation of UWWTD [the Urban Waste Water Treatment Directive] for Six Estuarine or Coastal Sites, Final Report, undated; 'the MV report'), which has been adduced by the Commission and which contains inter alia an examination of the data submitted by the United Kingdom in response to the reasoned opinion of 19 April 2001. It is indicated in that report that the level of chlorophyll in the Humber Estuary 'is generally low'. See para. 82 of Judgment.

Reliability and other evidential standards seem likely to be met in most jurisdictions, with appropriate presentation, which might include expert testimony on such issues as interpretation of the information, modelling, calibration, timing, and data processing.

APPENDIX A: LAW RELATING TO WATER

A.1 INTRODUCTION

Water disputes arise in a number of ways. Many terms are used to describe problems or differences over shared freshwater resources, including *controversy*, *conflict*, *standoff*, *quarrel*, and even *war over water*.[192] For the purposes of this Report, the following definition may be useful:[193]

'Disputes' begin as grievances... A dispute exists when a claim based on a grievance is rejected either in whole or in part. It becomes a civil legal dispute when it involves rights or resources that could be granted or denied by a court.

This Report is concerned with how such disputes are addressed through laws relating to water. Disputes may be resolved within these systems of law with the aid of EO information, or may be prevented from occurring in the first place by management plans that incorporate EO information as a tool.

Water laws exist in a variety of forms, derive from several legal traditions, and function at local, regional or international levels. They have evolved over time, vary within regions or nations, and include elements of a number of legal doctrines. When addressing a water dispute, it is necessary to understand the concepts that govern the specific case. The following is a brief summary of some of these concepts.

A.2 THE NATURE OF WATER RIGHTS

As outlined in Section 2 of this Report, a *water right* is a formally established or legal authority to take water from a water body and to retain the benefits of its use. Water rights may relate to a lake, stream, river, or to surface water or ground water. Canals and artificial watercourses are often treated differently in law.

Water rights holders do not generally own the water resource itself, but rather the right to abstract and use the water. Each society defines its own conception of water rights, and as a consequence, a number of differing approaches to the access to and use of water may be identified. Water law and water rights reflect economic, social and cultural perceptions of water, which are in turn shaped by a range of factors including geography, climate and the variability in the availability of water resources, as well as the uses to which the water is put. In arid climates, where irrigation is necessary, problems of water scarcity and levels of rainfall are significant matters of concern for agricultural and other uses. In more temperate climates, primary uses may also include navigation, hydropower and recreation.

Historically, land and water rights have been closely interlinked. In some particularly arid regions, rights to land use actually depended on the application of water.[194] More commonly, most water rights depended on the use or ownership of land, or structures built on it.

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192 McCaffrey, Stephen, *Water Disputes Defined: Characteristics and Trends for Resolving Them*, in International Bureau of the Permanent Court of Arbitration (ed.), *Resolution of International Water Disputes*, The Permanent Court of Arbitration/Peace Palace Papers 2003, Papers emanating from the Sixth PCA International Law Seminar, November 8, 2002, p. 49.

193 Richard E Miller, Sustin Sarat, *Grievances, Claims, and Disputes: Assessing the Adversary Culture*, 15 Law & Society Review 1980-81, p. 525, in Alan Scott Rau, Edward F Sherman and Scott R Peppet, Processes of Dispute Resolution: the role of Lawyers, 3d. ed. 2002, p. 3, cited in McCaffrey at p. 50.

194 "Historically, in the communities of the Ahaggar, in modern day Algeria, the right to possession of land was formed once an individual brought water there; the right so created applied to all of the irrigable land. The rights to land and water ran together and could only lawfully be determined with the permission of the original owner (right holder)." From M. Maceau, GAST, *Naissance et vie d'une communauté saharienne*, p

A.3 LEGAL SYSTEMS OF WATER RIGHTS

The focus of this Report is on formal water rights within legal systems, with only limited consideration of less-common approaches. At this level, one of the main distinctions is between civil law jurisdictions like Germany and The Netherlands, and common law jurisdictions such as Australia, England and the US. Broadly speaking, in the common law tradition, the courts have a greater role in development of the legal system through so-called "judge-made" law alongside the enactment of legislation, while the laws of the civil tradition have been subject to a much more significant degree of codification, with the courts perceived as having a more interpretative role. It is important to note, however, that many modern water law systems contain elements of more than one tradition.

The following section briefly examines the traditional approaches of the two historical legal traditions, their derivatives and some alternative or hybrid systems. Treatment of water from sources other than rivers, lakes and streams will be addressed briefly.

A.3.1 Roman Law

Roman water law conferred a privileged position on the owners of land adjacent to watercourses, and had a major influence on European legal traditions. Roman law did not allow private ownership of running water,[195] but it did recognise that running water was a resource that could be used, and that its use needed to be regulated to prevent over-exploitation.

Roman law distinguished the more important streams and rivers, which were considered to be public, from the less important, which could be private. The right to use a public river or stream was open to all who had access to them. Roman law did, however, allow for government regulation of water use, its right to prohibit the use of any public water, and to require authorisation for taking water from navigable streams.

A.3.2 Civil Law

The Roman law distinction between public and private waters was influential in the countries with a civil law tradition. Generally speaking, while administrative permission was necessary for the use of public water, it was not necessary for the use of private water.[196] An example is the French Civil Code (*Code Napoleon*), under which public waters were those that were navigable or floatable. They were considered public or national domain, and required a permit for use. Private waters, located below, along or on private land, could be used within limitations.[197] Similarly, surface water in Spain, arising from a privately owned parcel or rainfall on the land, were private property, but only for use on the land.[198]

One shortcoming of this system is that the distinction between public and private waters was shown to be illogical from a hydrological perspective. In civil law jurisdictions, competing claims resulted in increased restrictions on water rights.

9, M Ramazzotti, *Readings in African Customary Water Law*, FAO Legislative Study No. 58, Food and Agriculture Organisation of the United Nations, Rome, 1996.

195 The Institutes of Justinian (AD 533-34) included water with the air, the seas, and wildlife as part of a 'negative community' of things that could not be owned. See FAO, note 116.

196 See e.g. 1886 Spanish Water Act, French Civil Code.

197 For instance, servitudes and rights of way.

198 Spanish Water Act 1886. The water could also be used on the estate of which the land formed a part.

A.3.3 Common Law

Common law tradition did not follow the Roman law distinction between public and private waters. It did, however, maintain the principle of Roman law that running waters are public property, and that those with access to them might reasonably use them. This privilege of landowners adjacent to watercourses developed into the doctrine of riparianism in England and North America in the 19th century. An earlier conception of water rights based on priority of use, not as closely tied to ownership of land, may be seen as precursor to prior appropriation rights, also developed in the 19th century in the United States.

A.3.4 Doctrine of Riparian Rights

The doctrine of riparian rights was developed gradually over the years, through a series of court decisions. Riparian rights were not considered to be subsidiary land tenure rights like easements or servitudes, but were an integral part of the right of ownership of the land. They were interests in real property.

A riparian right holder had the right to make "ordinary" use of the water flowing in the watercourse, including use for domestic purposes and watering of livestock. Abstraction was permitted without regard to the affect it might have had on downstream proprietors. In addition, a riparian landowner had the right to use water for any other purpose, provided it did not interfere with the rights of other proprietors upstream or downstream. This use had to be reasonable, connected with the abstractor's land, and the water had to be restored to the watercourse substantially unaltered and undiminished. In addition to these natural riparian rights, a riparian owner could acquire additional rights in the nature of easements, subject to the relevant rules of land tenure.

These land-based approaches to water rights had advantages. They could be easily articulated, claimed and exercised by landowners without the need for state intervention. There were disadvantages, though, including the definition of reasonable use. Detailed rules were drawn up in some jurisdictions, but with increased pressure on water resources, they were not always found to be superior. In addition, riparian doctrine, arising as it did in climates rich in water, was not as useful in arid countries. Agricultural irrigation was not possible without physical proximity to water, and whole regions were effectively prohibited irrigation.

A.3.5 Doctrine of Prior Appropriation

In the arid climate of the American West, the practical limitations of riparian rights led to the development of the doctrine of prior appropriation in the 19th century. It originated in the customs of miners on federal public lands who accorded the best rights to those who first used water, just as they had accorded mining rights to those who first located ore.

Under the prior appropriation doctrine, the link between land ownership and water rights is severed. Water rights are granted where a person diverts water from its natural source, and applies a particular quantity of water to a particular beneficial use. The right continues as long as the beneficial use is maintained. If water is insufficient to meet all needs, those who hold the earliest appropriation will obtain all of their allocated water, while those who appropriated later may receive only some, or none, of the water over which they have rights. US States using elements of prior appropriation include Alaska, Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming. In addition, a number of US states, including

California, have hybrid systems that combine the doctrines of prior appropriation and riparian rights, in addition to minor elements of other systems.[199]

While there are problems associated with this doctrine, for instance the lack of incentive to save water by senior appropriators, it is still widely used.

A.3.6 Law Concerning Surface, Ground Water and Artificial Watercourses

Water from some sources may be treated differently under both systems, when compared to river, stream or lake sources. Under common law, the owner of land adjacent to a canal or other artificial watercourse has no rights to the water in the absence of some form of "grant or arrangement".[200] The position is broadly similar in civil water law. It is the operator of the canal or irrigation scheme, the person who abstracts water from a natural source, who will usually require a water right.

Within both the common and civil law traditions, groundwater was traditionally seen as the property of the owner of the land above it.[201] Surface water arising from a privately owned parcel or rainfall on the land, for example, was generally considered private property, as in Spain.[202]

Aquifers are complex types of groundwater, as they generally extend beyond the boundaries of a parcel of land, state or even country. Their overuse is a feature of modern pressures, and is the subject of many attempts to update water law, as will be seen below.

A.3.7 Modern Water Rights[203]

Many jurisdictions are now marked by new approaches to water rights, with management plans and water laws legislated to overcome some of the problems outlined above, as well as new issues such as climate change and increasing population. Water resources have largely been brought under state control, with formal and explicit "modern" water rights articulated, increasingly divorced from land ownership or specific parcels of land. The weakening of this connection between land ownership and water rights has gone so far as to allow the introduction of fully tradable water rights.

Statutory mechanisms such as river basin plans, establishment of use priorities, minimum flow requirements, creation of water reserves and in-stream rights, and environmental impact or public welfare requirements are increasingly affecting water allocation decisions, and as a consequence, water law. Sophisticated modern water regimes permit secure legal rights combined with flexibility for future water requirements. The state has an interest in ensuring that water rights are properly implemented, and rights holders have an actionable interest in ensuring that this happens. Water rights holders are able to take legal action to ensure that their rights are respected and that the states fulfil their legal obligations, which in turn strengthens compliance.

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199 See http://www.blm.gov/nstc/WaterLaws/abstract1.html for summaries of water laws applied in western states.

200 See Rameshur Pershand Narain Singh v Koonj Behari Pattuk (1878) 4 A.C. 121 P.C.

201 See e.g. French Civil Code Art 552.

202 Spanish Water Act 1886. The water could only be used on the land, or on the estate of which the land formed a part.

203 See Hodgson, *Modern Water Rights*, pp. 4 and 9-14. See also Stefano Burchi, Andriella D'Andrea, *Preparing national regulation for water resources management principles and practice*, FAO Legisative Study 80, FAO Legislative Study, Food and Agriculture Organisation, FAO, Rome 2003 p.80; Bruns, Bryan Randolph; Ringler, Claudia; Meinzen-Dick, Ruth Suseela (eds.), *Water rights reform: lessons for institutional design* (International Food Policy Research Institute 2005).

A.3.8 Hybrid Systems and Other Traditions

Not all systems are characterised by a single historical legal doctrine. Modifications have occurred through practice, legislation or court decisions. In addition, there are jurisdictions with elements of water rights that are peculiar to them. Customary, religious or local law and practice can play a part in water allocation decisions, particularly in many developing countries and in rural areas, and as a consequence, have significance in water disputes.

Indigenous water rights have been a feature of some US state adjudications, and appear as pueblo rights in some jurisdictions.[204] Indigenous populations may consider water bodies as essential to cultural, spiritual and physical wellbeing. These waters may have been appropriated or at times polluted. What are viewed by indigenous peoples as customary rights and access to water have been at risk. These cultures often lacked institutional structures to protect their perceived rights, which have not always been recognised by modern states, especially those with a legal tradition deriving from water-rich regions. There have been attempts to rectify these problems, with the result that indigenous water rights have been to some extent recognized, or at least addressed, in recent years. For instance, the World Commission on Dams (2000) endorsed the principle of free and informed consent concerning displacement. The World Water Forum in Kyoto (2003), in Mexico City (2007) and Istanbul (2009) also notably invited input from indigenous peoples.[205]

A.4 WATER AT A NATIONAL LEVEL

Most water is owned and regulated at a national level. Water rights and water management are important elements in many national legal regimes, in resolving water disputes, preventing them from occurring and planning for future water use.

At the national or state level, special rules and mechanisms for the solution of water disputes include the establishment of specialist Water Courts or the conferment of a quasi-judicial function to a government administrator.[206] In the United States, Colorado and Montana have special water courts, which determine and administer water rights. In US states without a special water court, such as Utah, there may be a water division. Most water courts have specific rules of evidence. The water claim examination rules specific to Montana's water court do not mention satellite evidence, but they do make reference to aerial photography in the context of identifying means of diversion.[207]

Many jurisdictions provide statutory procedures for the acquisition of water rights under the supervision of a central state administrative agency. In issuing permits to appropriate water, or refusing to issue permits, these administrators exercise quasi-judicial powers. They also often have considerable technical expertise.

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204 See for example California, whose system of water rights is referred to as a "dual system" in which both the riparian doctrine and the prior appropriation doctrine apply to water rights. There is also a separate doctrinal basis for ground water, as well as pueblo rights, so a more accurate classification of California's system would be a "plural system". Water rights in California are use rights. All waters are the property of the state. A water right in California is a property right allowing the use of water, but it does not involve ownership of the water. See National Science and Technology Center, Bureau of Land Management, *Western States Water Laws: Water Appropriation Systems, California Water Rights Fact Sheet*, 2001, http://www.blm.gov/nstc/WaterLaws/california.html, accessed 16 January 2012.

205 See http://www.waterculture.org/IndigenousWater.html

206 Stefano Burchi, Andriella D'Andrea, *Preparing national regulation for water resources management principles and practice,* FAO Legisative Study 80, FAO Legislative Study, Food and Agriculture Organisation, FAO, Rome 2003 p.80.

207 See http://courts.mt.gov/content/water/rules/claim_exam_rules.pdf, p.28 (1).

In India's eastern state of Jharkhand, for example, demands for industrial water are submitted to the government's Water Resources Department (WRD).[208] According to a water industry newsletter,[209] the WRD is considering using a satellite imaging system to monitor water supply to industrial units.

In Spain, water courts have existed for hundreds of years, most notably the Valencia Water Court (Tribunal de las Aguas)[210] and the South Eastern Alicante Water Courts (Tribunales Privativos de Aguas). In recent decades however, conflicts over water usage have taken on a regional dimension that far outreaches the control of these institutions, and are addressed by the Supreme Court or Constitutional Tribunal.[211]

In January 2011 there were five regional inter-state Water Tribunals operating in India. The federal Water Resources Ministry was reportedly considering setting up an integrated tribunal.[212] This Study found no information on special evidence rules relating to satellite-derived EO data in this jurisdiction.

This Report touches on dispute-prevention and management plans in a very limited way. There are also many environmental considerations on a national level, most of which fall outside the scope of this Report.

A.5 WATER AT A REGIONAL LEVEL

At the regional level, water disputes may be resolved or prevented through adjudications, as between states in the western US and in Spain.

Within the European Union, the Water Framework Directive[213] creates a legal framework for the protection and restoration of clean waters across the EU. The Directive, which entered into force in December 2000, addresses EU surface waters including coastal waters, and groundwater, and provides common principles, approaches and requirements for water management in the European Union. However, it leaves broad leeway for individual approaches by Member States.

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208 See http://jharkhand.gov.in/DEPTDOCUPLOAD/uploads/4/D200904002.pdf; see also: Department of Water Resources website, http://jharkhand.gov.in/new_depts/water/water_fr.html

209 OOSKA News, 02 Aug 2011.

210 The Valencia Water Court reportedly meets weekly in the doorway of Valencia Cathedral to settle water disputes between irrigators along the Turia River and the Orchard of Valencia. The judges are irrigators, elected by other irrigators in the valley, from the various irrigation canals of the region. No lawyers are used, but witnesses may be called and land may be inspected by judges. Court verdicts cannot be appealed by either party and apparently, the court functions without paperwork. See: Avella, Llorenc and Garcia-Molla, Marta, *Institutional Factors and Technology Adoption in Irrigated Farming in Spain: Impacts on Water Consumption*, p.199 (199), in: Albiac, Jose and Dinar, Ariel, *The management of water quality and irrigation technologies* (Earthscan, 2009).

211 Avella, Llorenc and Garcia-Molla, Marta, *Institutional factors and technology adoption in irrigated farming in Spain: Impacts on water consumption*, p.3-4; available at: http://admin.cita-aragon.es/pub/documentos/documentos_Avella_8a4654ac.pdf.

212 Ghosh, Abantika, *One tribunal for all water disputes*, TNN, 31 January 2011, The Times of India; available at: http://articles.timesofindia.indiatimes.com/2011-01-31/india/28366420_1_tribunal-cauvery-dispute-inter-state-water-disputes-act.

213 Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, http://ec.europa.eu/environment/water/water-framework/index_en.html.

A.6 WATER AT AN INTERNATIONAL LEVEL

At the international level, there are a number of mixed systems for the integrated management of international watercourses, some of which may exercise dispute settlement functions. An example is the Indus Waters Treaty,[214] which includes as a signatory for specific purposes the World Bank. Under the terms of this treaty, the Kishenganga Dam Arbitration (*Pakistan v India*),[215] a water dispute of agricultural, economic environmental and political dimensions, was brought before the Permanent Court of Arbitration in 2011. The parties to the case have agreed to keep evidence confidential, so it is not clear whether satellite-derived EO data was officially submitted to the Court as evidence. However, both parties have, in public statements, made reference to satellite data that supports their view.

Others include the Niger Basin Agreement, and the US/Canada and US/Mexico boundary Water Commissions, which can perform adjudicatory functions only with the consent of the parties to the dispute.[216]

There are also proposed international rules such as:

- The 1997 *United Nations Convention on the Law of Non-Navigational Uses of International Watercourses*;[217]
- The 1921 *Convention and Statute on the Regime of Navigable Waterways of International Concern* (Barcelona Convention);
- The 1966 *Helsinki Rules on the Uses of Waters of International Rivers;*
- The *Hague Declaration on Water Security in the 21st Century*;
- The International Law Commission's 1994 *Resolution on Confined Trans-boundary Groundwater*; and
- The 2004 *Berlin Rules on Water Resources.*

While these are useful in providing guidelines and principles on water rights, none of these instruments can be regarded as legally binding. They make no explicit mention of the role of EO data in water rights management.[218]

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214 Concluded by India and Pakistan on September 19, 1960. Under the Treaty, questions are examined by the Permanent Indus Commission; differences by a Neutral Expert; and disputes by a Court of Arbitration. For an explanation of the role of the World Bank in this connection, please see the following: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/0,,contentMDK:22557065~pagePK:146736~piPK:146830~theSitePK:223547,00.html; and for the full text of the Indus Water Treaty,http://siteresources.worldbank.org/INTSOUTHASIA/Resources/223497-1105737253588/IndusWatersTreaty1960.pdf

215 Order on the Interim Measures Application of Pakistan, Permanent Court of Arbitration, 6 June 2011, www.pca-cpa.org/showfile.asp?fil_id=1726, accessed 1 April 2012.

216 Lucius Caflish, *Judicial Means for Settling Water Disputes*, in International Bureau of the Permanent Court of Arbitration (ed.), *Resolution of International Water Disputes*, The Permanent Court of Arbitration/Peace Palace Papers 2003, Papers emanating from the Sixth PCA International Law Seminar, November 8, 2002.

217 Adopted by the UN General Assembly on 21 May 1997. Not yet in force. See GA Res 51/229, Annex, Official Records of the GA, Fifty-first Session, Supplement No. 49 (A/51/49); available at: http://untreaty.un.org/ilc/texts/instruments/english/conventions/8_3_1997.pdf.

218 Article 31 of the 1997 United Nations Convention on the Law of Non-Navigational Uses of International Watercourses reads "Nothing in the present Convention obliges a watercourse State to provide data or information vital to its national defence or security. Nevertheless, that State shall cooperate in good faith with the other watercourse States with a view to providing as much information as possible under the

There are, however, many bilateral and multilateral treaties, as well as other joint mechanisms, that do play an important role in determining cross-border water rights. Such instruments often serve to lay down the boundary lines between the parties.[219] In addition, they may specify water rights and may include environmental protection provisions, which can be invoked in international court cases.[220]

These mechanisms not only play an important role in the judicial resolution of water disputes, but may also provide their own conflict resolution mechanisms. There appears to be increased reliance on these institutions to resolve disputes that already exist between parties. This has been the case with two North American institutions, the International Joint Commission between the US and Canada and the International Boundary and Water Commission (IBWC) between the US and Mexico.[221]

The latter concerns several watercourses, including the Rio Grande, which forms part of the border between Mexico and the US. It has been the subject of many disputes, and is currently heavily overused. Under a 1944 treaty,[222] water quantities were allocated and the IBWC entrusted with dispute settlement.[223] Decisions of the IWBC become binding if not disapproved within thirty days,[224] a procedure which effectively permits the agreement to be kept up to date by amendments, and allows the parties to respond to current problems.[225]

Water management bodies contribute a combination of legal and diplomatic methods of dispute resolution. These bodies may also provide opportunities for assisted or unassisted negotiation,[226] and facilitate ongoing communication and may well have been helpful in avoiding conflicts that would otherwise have arisen.

Despite these international diplomatic and legal tools, however, disputes continue to occur. International water disputes arise in cases where there is no applicable treaty or joint mechanism, where there is a treaty but it is not functional, and in cases where there is a functional treaty, sometimes including a joint mechanism.[227]

A.7 EO Information as Evidence in Water Law

Water disputes are generally dealt with in accordance with standard evidential rules and procedures governing litigation before the courts of law or administrative tribunals. However,

circumstances." While this provision could be applied to satellite data, it does not explicitly mention satellite data.

219 This Annex does not deal with disputes arising over boundaries which are defined by watercourses.

220 See e.g. the *Pulp Mills Case* before the ICJ.

221 See http://www.ijc.org/en/home/main_accueil.htm and http://www.ibwc.state.gov/home.html, respectively.

222 Treaty Between the United States of America and Mexico Relating to the Utilization of the Waters of the Colorado and Tijuana Rivers, and of the Rio Grande (Rio Bravo) from Fort Quitman, Texas to the Gulf of Mexico, February 3, 1944, 3 U.N.T.S. p. 314.

223 Art 2 of the 1944 Treaty.

224 Art 25 of the 1944 Treaty.

225 McCaffrey, p. 69. This Study has found no explicit mention of EO information in IBWC minutes. See also See Minutes Between the United States and Mexican Sections of the IBWC, IBWC, http://www.ibwc.gov/Treaties_Minutes/Minutes.html, accessed 24 September 2011.

226 Caflish, Lucius, Judicial Means for Settling Water Disputes, in: International Bureau of the Permanent Court of Arbitration (ed.), Resolution of International Water Disputes, Papers emanating from the Sixth PCA International Law Seminar, November 8, 2002, The Permanent Court of Arbitration/Peace Palace Papers (Kluwer 2003), para IIA.

227 McCaffrey, 2003, p. 53.

due to the unusually complex mix of questions of hydrological fact and law in water-related disputes, there are special rules and dispute mechanisms for water disputes in some jurisdictions.

The Workshop Report of this Study contains a discussion of EO information as evidence.[228] Different jurisdictions (for instance common law or civil law approach) and different branches of law (civil law as compared to criminal law) often apply very different evidence rules, making comparisons and generalisations difficult. However, the Workshop identified three factors that are likely to negatively affect the admissibility or probative value of satellite data:

- Quality of data (Reliability);
- Presentation and interpretation of data (Experts); and
- Limitations (e.g. Privacy, national security).

As EO information will very rarely be the only evidence in a dispute, an examination of the practical relevance of these factors should always take into account other evidence offered. Law prescribing or regulating the use of EO information, as well as commercial factors such as availability and price, may also influence the frequency with which this information is submitted as evidence.

228 See Annex 1: Workshop Report, Section 2.

APPENDIX B: SOME SATELLITE SENSORS AND THEIR CAPABILITIES

The following are examples of some EO system sensors used by WaterWatch,[229] as an indication of those that are useful for gathering evidence in water disputes.

PI Mapping technology, developed by WaterWatch, is used to provide data on water consumption, water use efficiency and biomass production (among others). This information is used by farmers, water managers, water authorities, and also in legal disputes worldwide. To provide the data the company can use any multispectral satellite sensor with spatial resolutions ranging from 10-m to 1-km. This data is used to calculate the vegetation index NDVI and the albedo. Thermal infrared satellite sensors are used to obtain the surface temperature.

TERRE (SPOT) 2, 4, 5

Temporal resolution	2-3 days
Spatial resolution	20 meter (visible and infrared bands) (SPOT 5: 10 meter) 10 meter (pan-chromatic bands) (SPOT 5: 2.5-5 meter)
Spatial coverage	600 x 60 km to 80 km at nadir
Operational since	1990 (SPOT2), 1998 (SPOT4) and 2002 (SPOT 5)
Costs	~ €2700
More info	www.spotimage.com

AQUA ADVANCED MICROWAVE SCANNING RADIOMETER (AMSR-E)

Temporal resolution	~daily
Spatial resolution	25 km
Spatial coverage	global (swath with 1445 km)
Operational since	May 4, 2002
Costs	free of charge
More info	www-nsidc.colorado.edu/data/amsre/

TROPICAL RAINFALL MEASURING MISSION (TRMM)

Temporal resolution	3-hourly and daily
Spatial resolution	25 km
Spatial coverage	global coverage from 50 degrees north to 50 degrees south, (combination of sensors)
Operational since	1998
Costs	free of charge
More info	trmm.gsfc.nasa.gov/3b42

229 See http://www.waterwatch.nl/tools0/satellites/liss-iii.html, accessed 22 January 2012. WaterWatch has now merged with eLeaf, www.eLeaf.com.

DISASTER MONITORING CONSTELLATION

Temporal resolution	daily (constellation of satellites)
Spatial resolution	32 meter (visible and near-infrared bands)
Spatial coverage	660 x 4100 km
Operational since	2002-2005
Costs	depending on size
More info	www.dmcii.com

SPOT VEGETATION

Temporal resolution	daily
Spatial resolution	1000 meter (red, NIR, SWIR)
Spatial coverage	continents
Operational since	1998
Costs	free for NDVI images older than three months
More info	free.vgt.vito.be

TERRA ADVANCED SPACEBORNE THERMAL EMISSION AND REFLECTION RADIOMETER (ASTER)

Temporal resolution	ordering needed
Spatial resolution	15 meter (VNIR) 30 meter (SWIR) 90 meter (TIR)
Spatial coverage	60 km
Operational since	1999
Costs	$80
More info	asterweb.jpl.nasa.gov

NOAA ADVANCED VERY HIGH RESOLUTION RADIOMETER (AVHRR)

Temporal resolution	14 times a day
Spatial resolution	1000 meter
Spatial coverage	2399 km
Operational since	since 1978, last launch in 1998
Costs	free of charge
More info	www.noaa.gov

TERRA/AQUA MODERATE RESOLUTION IMAGING SPECTRORADIOMETER (MODIS)

Temporal resolution	daily
Spatial resolution	250 meter (red and infrared bands) 500 meter (other visible and infrared bands) 1000 meter (thermal bands)
Spatial coverage	2330 km
Operational since	1999 (Terra) and 2002 (Aqua)
Costs	free of charge
More info	modis.gsfc.nasa.gov

LANDSAT 5 THEMATIC MAPPER (TM) / LANDSAT 7 ENHANCED THEMATIC MAPPER (ETM)

Temporal resolution	16 days
Spatial resolution	30 meter (visible and infrared bands) 60 meter (thermal bands) 15 meter (pan-chromatic bands
Spatial coverage	180 x 180 km
Operational since	1985 (5-TM) and 1999 (7-ETM)
Costs	free of charge up to $1500
More info	www.landsat.org

The following are no longer used by WaterWatch.[230]

IRS-P6 (RESOURCESAT-1) LINEAR IMAGING SELF-SCANNING SYSTEM (LISS-III)

Temporal resolution	5 days
Spatial resolution	23 meter (visible and near-infrared bands) 50 meter (mid-infrared bands) 6 meter (pan-chromatic bands
Spatial coverage	142 km
Operational since	2003
Costs	€4500
More info	www.euromap.de

IRS-P6 (RESOURCESAT-1) ADVANCED WIDE FIELD SENSOR (AWIFS)

Temporal resolution	5 days
Spatial resolution	56-70 meter (visible and infrared bands)
Spatial coverage	370-740 km
Operational since	2003
Costs	€1600
More info	www.euromap.de

230 Personal communication, Annemarie Klaasse, email 12 April 2012.

APPENDIX C: DETERMINATION OF WATER RIGHTS INVOLVING EO[231]

SITUATION	INFORMATION SOUGHT FROM SATELLITE EO	EO DATA	UTILISATION	COMMENTS
Arizona, USA **JURISDICTION:** Arizona, USA 1998	Identification of priority areas for in-situ inspection related to water over-utilisation.		EO information was used to identified anomalies which were then the basis for an optimised in-situ inspection regime.	EO information was not evidence per se in this situation.
EC v UK[232] **JURISDICTION:** EU 2009	Occurrence of algal bloom on Humber estuary, and implied non- compliance with Urban Waste Water Directive, identified in 1996.	CASI[233]	EO offered to demonstrate that the eutrophication level in the estuary had increased, and therefore the UK was in contravention of UWWD. Decision was that single image was not conclusive.	The link between the detected phenomenon and contravention of the UWWD would be very difficult to make.
Guadiana River, Castilla La Mancha **JURISDICTION:** Spain 1997[234]	Baseline map of the extent of irrigated fields as of 1985. Irrigated fields are identified through land cover classification analysis.	Landsat 5 TM & LISS III (MSS)	Fraud control for farm water use. Water Act 1985 requires fields to be registered as irrigated before 1 January 1986. Fields reported as being irrigated post-1992 are compared with fields classified as irrigated in 1985.	EO derived information is used initially as a control in this situation.
Pulp Mills on the River Uruguay (Argentina v Uruguay)[235] **JURISDICTION:** ICJ 2010	Presence, extent and location of algal bloom and link of bloom to outflow from Uruguayan pulp mill.	Landsat TM	EO imagery adduced to identify algal bloom along with laboratory samples to demonstrate presence of bacteria and waste products claimed to have originated in the pulp mill. Court ruled that the pulp mill was not proved as the source.	EO information was a component of the submitted evidence. Evidence insufficient to establish cause and effect. (and it would be very difficult to do so.)

[231] Thanks to Gordon Campbell, ESA ESRIN, for his generous contribution to this Appendix.

[232] See Para 91 of Judgement ECJ 2009, Case C-390/07, at Section 6.5 of this Annex.

[233] Compact Airborne Spectrographic Imager. See Section 6.5 of this Annex.

[234] Annual Exploitation Regime for 1997 [CHG, 1997] established by Guadiana River Basin Authority decision of 27 Feb 1997. See Sections 5.2.2 and 5.3.2.4 of this Annex.

[235] See Section 6.4 of this Annex.

SITUATION	INFORMATION SOUGHT FROM SATELLITE EO	EO DATA	UTILISATION	COMMENTS
South Australia **JURISDICTION:** South Australia, Australia approx. 2006[236]	Satellite-based assessment of the extent of irrigated land.	MODIS[237]	Extent of irrigated land was found to be significantly in excess of the level of irrigation granted under licence.	EO evidence demonstrated non-compliance with water extraction licence.
Queensland **JURISDICTION:** Queensland, Australia 2007[235]	Evidence of unlicensed irrigation.	Landsat TM	Unlicensed irrigator detected through EO imagery in the first instance.	EO information was used both for initial verification and as legal evidence.
Snake River Adjudications Idaho **JURISDICTION:** Idaho, USA 1987 to date[238]	Land cover classification and extent of land irrigated by water extraction from the Snake River Basin.	Landsat (MSS)	Under a negotiated settlement all parties agreed to adjudication of water rights. EO was used to generate land cover classifications for reference years, including "irrigated land". Maintaining coverage of irrigated land was regarded as beneficial use of the water, and right of access was then retained. EO was validated by historic airborne survey data and limited in-situ inspections.	The IDWR is not required under the terms of the adjudication rules to utilise EO , but does so routinely in satisfying the need to provide the best possible information. The IDWR uses IR images. The Adjudication Court admits such evidence as a matter of course. However, the claimant is required under Rule 37.03.01 to produce a map and aerial images in support of his claim.[239]
US v Reserve Mining Co, Minnesota **JURISDICTION:** Federal & Minnesota,USA 1974	Identification of tailings and upwelling in Lake Superior.		The case concerned a violation of the Clean Water Act.	EO was used as a part of the submitted evidence.

236 Ray Purdy, Satellite Monitoring of Environmental Laws: Lessons to be Learnt from Australia, p 139.

237 Moderate Resolution Imaging Spectroradiometer, on Terra and Aqua satellites.

238 See Section 5.2.1.1 of this Annex.

239 Personal communication, Carter Fritschle, Section Manager, Adjudication Office, IDWR, 30 May 2012.

APPENDIX D: FURTHER REFERENCES

Anglian Water, Frontier Economics Ltd, *A right to water? Meeting the challenge of sustainable water allocation*, Report, February 2011, p.13, available at: http://www.anglianwater.co.uk/_assets/media/a-right-to-water-full-report.pdf

Anon., *Environmental Law-Water Pollution*, (1975-1976) 9 Ind.L.Rev.702.

Llorenc Avella, Marta Garcia-Molla, *Institutional Factors and Technology Adoption in Irrigated Farming in Spain: Impacts on Water Consumption*, in Jose Albiac, and Ariel Dinar, *The Management of Water Quality and Irrigation Technologies*, Earthscan, 2009.

Bedner, Adriaan, *Access to environmental justice in Indonesia*, in Andrew Harding, *Access To Environmental Justice, A Comparative Study*.

Bruns, Bryan, Claudia Randolph, Ruth Ringler, Suseela Meinzen-Dick, (eds.), *Water Rights Reform: Lessons For Institutional Design,* International Food Policy Research Institute, 2005.

Burchi, Stefano, Andriella D'Andrea, *Preparing national regulation for water resources management principles and practice*, Food and Agriculture Organisation (FAO) Legislative Study 80, Rome, 2003.

Caflish, Lucius, *Judicial Means for Settling Water Disputes*, in: *Resolution of International Water Disputes,* 6th PCA International Law Seminar, 8 November 2002, The Permanent Court of Arbitration / Peach Palace Papers, Kluwer, 2003.

Eilperin, Juliet, *Water Rights Case Threatens Species Protection*, The Washington Post, 17 December 2004, p. A18.

Ghosh, Abantika, *One tribunal for all water disputes*, TNN, 31 January 2011, The Times of India; available at: http://articles.timesofindia.indiatimes.com/2011-01-31/india/28366420_1_tribunal-cauvery-dispute-inter-state-water-disputes-act

Hodge, Sharon Hatch, *Satellite Data and Environmental Law: Technology Ripe for Litigation*, 14 Pace Environmental Law Review, 691, 700 (1997).

Hutchins, Wells A., Harold H. Ellis and J. Peter DeBraal, *Water Rights Laws in the Nineteen Western States,* United States Department of Agriculture, 1971.

Macrory, Richard, *Technology and Environmental law Enforcement*, in: Ludwig Kramer, *Recht und Umwelt*: *Essays in Honour of Prof Dr Gerd Winter*, Europa Law Publishing, 2003.

McCaffrey, Stephen, *Water Disputes Defined: Characteristics and Trends for Resolving Them,* in: International Bureau of the Permanent Court of Arbitration, Resolution of International Water Disputes, Papers emanating from the Sixth PCA International Law Seminar, November 8, 2002, The Permanent Court of Arbitration/Peace Palace Papers, Kluwer, 2003.

Morse, Anthony, Richard Allen, *Application of the SEBAL Methodology for Estimating Evapotranspiration and Consumptive Use of Water through remote sensing*, Phase III, The Transition to an Operational System, 23 January 2003, available at: https://www.idwr.idaho.gov/GeographicInfo/METRIC/PDFs/phase_3_final_report.pdf

Mumme, Stephen P., *Engineering Diplomacy: The Evolving Role of the International Boundary and Water Commission, I (1) U.S.-Mexico Water Management* in Journal of Borderlands Studies, (1986) 73 (99), available at: http://journals.uvic.ca/index.php/borderlands/article/view/2488

Murphy, Dean E., In *Fish vs. Farmers Cases, the Fish Loses its Edge*, The New York Times, 22 February 2005.

Shapiro, Nick, *International Arbitration – ICSID Jurisdiction under NAFTA – Bayview Irrigation District v United Mexican States, ICSID Case No. ARB(AF)/05/1, Award 19 June 2007*, 32 (1) Suffolk Transnational Law Review (2008), available at: http://www.law.suffolk.edu/highlights/stuorgs/transnat/documents/ShapiroComment-forepublication.pdf

Zerhdoud, Badr, *Water in Investor-State Arbitration*, Inaugural ASIL Research Forum, UCLA Law School, 3-5 November 2011, available at: http://www.asil.org/midyearmeeting/pdfs/papers/November_5_9am/WATER%20IN%20INVESTOR-STATE%20ARBITRATION.pdf

ANNEX 4

EXPERT EVIDENCE AND EO SYSTEMS

A BASELINE FOR ADMISSIBLE SOURCES OF EVIDENCE

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1. INTRODUCTION

This Annex supplements the Study Report with consideration of the role and qualifications of expert witnesses, and guidance on how satellite systems will be viewed by courts as sources of evidence.

Section 2 reviews findings on these matters contained in the Study Workshop Report. Section 3 analyses in general terms the scope for expert evidence with respect to satellite EO information. Section 4 addresses factors that may influence reliance by a court on particular kinds of satellite systems. Section 5 presents the legal principles for introduction of expert evidence generally. Section 6 draws conclusions.

2. REVIEW OF FINDINGS ON EXPERT EVIDENCE IN THE WORKSHOP REPORT

The Workshop Report summed up the legal position, stating that: "In most cases satellite-derived information requires expert interpretation and validation. The normal rules for admission of expert witness testimony will apply."[1]

Such evidence is required as "Earth observation data is almost always a voltage out of an instrument. A model is needed to convert it into a geophysical quantity, so that there is the need for expert opinion."[2] It follows that generally a court requires expert interpretation of any information product based on EO information.

To arrive at a decision a court or any user of EO information will wish to establish the authenticity, value for a specific purpose and reliability of EO information. The need for expert opinion is, therefore, the same in most uses of EO information.

In relation to EO information, these requirements were identified in the Workshop Report as being authenticity, accuracy, integrity of a chain of custody, and assured quality where human intervention is involved.[3] In using EO information as evidence to prove a fact in a judicial setting, knowledge of standard practices, methods and models used will all be relevant in establishing the presence or absence of these elements.

Where standards exist, they may provide assistance for these purposes, and this is one of the primary issues the Study identified for subsequent consideration. This Annex will further consider the merits of standards, particularly in Section 4, discussing reliance on satellite systems.

3. THE SCOPE FOR EXPERT EVIDENCE IN SATELLITE IMAGERY

The general legal rules of evidence regarding the admission of expert opinion are discussed in Section 5, below. This section aims to identify the elements that may require explanation and interpretation by an expert.

Where information is generated by a remote, automated digital observation technology like a satellite sensor, it will first require processing in order for it to be intelligible and accessible, possibly by a number of people using different systems, beginning with the ground segment. Interpretation will then be required to attribute specific meaning to the sensed data, which will depend on the application of one or more models.

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[1] Annex 1: Workshop Report, Section 2.2.7.

[2] Annex 1: Workshop Report, Section 3.3.2.

[3] Annex 1: Workshop Report, Section 2.2.3.

These features make the use of EO information in particular different from the ordinary judicial evidence, where the courts rely on witnesses to facts apprehended directly through the human senses. Reliance is instead placed on automated methods and human interpretation. The essence of expert testimony is to render an opinion on the results according to the means and experience the expert has at his or her disposal.

The precise course of litigation cannot be predicted. The following four categories are intended to provide a baseline for design of any procedures and training to facilitate use of EO information before courts. Given the different processes involved, there are at least four areas for expert testimony that may be considered in relation to EO information, depending on the facts to be established:

3.1 THE INSTRUMENTATION GENERATING THE RAW DATA

The principal investigator or instrument designer may be a sufficient witness regarding the design characteristics of the instrument itself. In some cases its actual performance may call for further expertise regarding the spacecraft on which it flies, and spacecraft operations, in order to establish an accurate picture of mission and performance.

3.2 THE FEATURES OF THE GROUND SEGMENT, INCLUDING ANY DATA PROCESSING SYSTEM ASSOCIATED WITH THE INSTRUMENT

In this area, the expert may not necessarily be the same as one of those under the previous heading. For example, special procedures may be applied to the handling of certain kinds of data, calling for a different type of expertise. An expert on treating the data, assimilating it to other datasets and presenting the resultant information, may be necessary.

3.3 THE INTERPRETATION OF THE RESULTANT INFORMATION

Expertise in the particular field of knowledge or phenomena relevant to the facts at issue will be needed to interpret the significance of the information generated. This expert may also be able to assess related evidence in the case, such as ground truth samples.

3.4 SUMMARY

Generally, it will be only the last kind of expert who is likely to be called to testify. However, such an expert will be expected to be conversant with salient aspects of the other areas of expertise, particularly with the error metrics associated with source datasets and processing. Documentary evidence can assist the expert in this respect and in relation to the performance of the various systems involved. The expert will also be expected to be able to address aspects of correction and possible falsification of the EO information.

In a detailed study, different satellites and applications (e.g. Envisat-1 providing evidence of oil spill) can be simulated to determine more precise qualifications for experts.

Although the costs of satellite imagery are not negligible, those of multiple experts may be even greater. Such considerations may incline parties to litigation to reduce the number of experts called.

4. LEGAL PRINCIPLES FOR INTRODUCTION OF EXPERT EVIDENCE

As in the Final Study Report, this Annex focuses on the law of England and Wales in seeking to give insight into how expert opinion is admitted and treated in a judicial setting.

4.1 THE EXCEPTION REGARDING EXPERT OPINION

In judicial inquiry into fact, no witness is permitted to advance opinions on any fact in issue. The witness can only relate what was done, spoken, heard or otherwise transpired according to his or her senses. Causal inferences are to be made by the judge of fact, be it a judge or a jury.

The main exception to this is in relation to expert opinion, where the fact at issue requires special skill or knowledge that the court does not possess. Very frequently the interpretation of EO information and appraisal of the processes related to its collection and processing will fall outside the court's experience, and the court will require the assistance of those versed in the relevant scientific, technical and operational aspects.

4.2 THE CHOICE OF EXPERT WITNESS

The question of who may give expert testimony is determined by the trial judge on submission by the party seeking to introduce the witness. Formal qualifications and practical experience will be taken into consideration. The test for admissibility of expert testimony is whether the witness commands authority for the subject matter in question.[4] As with other evidence, the expert's opinion must be relevant and reliable. English courts have wide jurisdiction to admit or exclude expert testimony.

However, the discretion of the court is modified by the rule established in the US case of *Daubert v. Merrell Dow Pharmaceuticals Inc*,[5] adopted by English courts. This was a case in which a medicine was alleged to have led to birth defects and in regard to which the plaintiff sought to introduce non-traditional expert evidence. The US Supreme Court endorsed a general test already contained in federal evidence rules, for the judge to perform a preliminary inquiry into relevance and reliability as "gatekeeper."

In relation to admissibility of scientific evidence, *Daubert* established tests that include falsifiability, known error rates and peer review. Most US States apply the *Daubert* test for admissibility:

a. Whether the methodology has been peer reviewed;

b. Whether the methodology can be, and has been, tested;

c. What are the error metrics associated with the methodology; and

d. Whether the reasoning or methodology underlying the testimony is scientifically valid, and whether it can properly be applied to the facts in issue.

In English law, similar tests are applied. Admissibility depends on the reliability of the evidence adduced and its probative value. It is therefore necessary to show that the evidence relates to the fact being proved, and that is has been in safe and traceable custody without interference or inappropriate manipulation.

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4 See Bingham, LJ, in *R v Robb* [1991] 93 Cr.App.R 161, [1991] Crim LR 539, 135 Sol Jo 312.

5 *Daubert v. Merrell Dow Pharmaceuticals*, 509 U.S. 579 (1993)

4.3 ADMISSIBILITY IN CIVIL CASES

The standard for admissibility in civil cases is the same as in criminal cases, even though the standard of proof is the lighter one of the balance of probabilities rather than beyond a reasonable doubt.

4.4 THE ROLE OF THE EXPERT WITNESS

The role of the expert witness was laid down in the leading case of *National Justice Cia Naviera SA v. Prudential Assurance Co Ltd, The Ikarian Reefer* (1993)[6] as the follows:

> “The duties and responsibilities of expert witnesses in civil cases include the following:
>
> (1) Expert evidence presented to the court should be, and should be seen to be, the independent product of the expert uninfluenced as to form or content by the exigencies of litigation ….
>
> (2) An expert witness should provide independent assistance to the court by way of objective unbiased opinion in relation to matters within his expertise …. An expert witness in the High Court should never assume the role of an advocate.
>
> (3) An expert witness should state the facts or assumption upon which his opinion is based. He should not omit to consider material facts which could detract from his concluded opinion ….
>
> (4) An expert witness should make it clear when a particular question or issue falls outside his expertise.
>
> (5) If an expert's opinion is not properly researched because he considers that insufficient data is available, then this must be stated with an indication that the opinion is no more than a provisional one …. In cases where an expert witness who has prepared a report could not assert that the report contained the truth, the whole truth and nothing but the truth without some qualification, that qualification should be stated in the report ….
>
> (6) If, after exchange of reports, an expert witness changes his view on a material matter having read the other side's expert's report or for any other reason, such change of view should be communicated (through legal representatives) to the other side without delay and when appropriate to the court.
>
> (7) Where expert evidence refers to photographs, plans, calculations, analyses, measurements, survey reports or other similar documents, these must be provided to the opposite party at the same time as the exchange of reports ….”

This statement of the expert’s role is not exhaustive. Later cases have required the expert’s qualifications and experience to be included in his or her report, as well as methods used, relevant literature and an impartiality compliance statement. There are further rules on the content of expert opinions where hearsay is relied on.

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6 (1993) 2 Lloyds’ Rep., 68 at 81-82, endorsing Justice Moore in *Frazer v. Haukioja*, 2008 CanLII 42207 (O.S.C.), at paragraph 141.

In some jurisdictions, for example the International Court of Justice (ICJ), experts might appear as counsel. This potentially casts doubt on the evidence given, and has been the subject of criticism in relation to a case before the ICJ.[7]

5. CONCLUSION

The Study Team suggest that experts testifying in relation to EO information should consider offering datasets from at least two satellite systems, in order to satisfy the court of the validity of the information.

It is also proposed that there should be a database of experts, including information on types, qualifications and experience on satellite imagery and EO systems, including data handling.

A look forward to upcoming technologies, notably of the Sentinel generation,[8] is also recommended.

Certification should be considered, as well as development of a user requirement statement specifically tailored to foreseeable needs, on behalf of judicial authorities in particular.

Further consideration should also be given to any special cost or licensing conditions that may be useful in facilitating acceptance of this form of evidence.

A final matter that merits consideration is the role that Special Masters may play in reviewing and determining technical information offered by parties to any proceeding or hearing.[9] This is particularly relevant in the light of the discussions and criticism of the treatment of technical information in *Argentina v Uruguay*.

[7] See for *example Pulp Mills on the River Uruguay (Argentina v. Uruguay)*, Judgment 20 April 2010, Paragraphs 165-168, 229-236; http://www.icj-cij.org/docket/index.php?p1=3&p2=3&case=135. See Annex 3: Water Disputes, Section 6.4.

[8] ESA is developing five new missions called Sentinels specifically for the operational needs of the GMES programme, based on a constellation of two satellites to fulfil revisit and coverage requirements and to provide robust datasets for GMES Services. http://www.esa.int/esaLP/SEM097EH1TF_LPgmes_0.html.

[9] See Final Report, Section 4.2. See also Annex 3: Water Disputes, Section 6.4.

ANNEX 5

RELEVANT STANDARDS (INTERNATIONAL AND NATIONAL)

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1. OPEN GEOSPATIAL CONSORTIUM

The Open Geospatial Consortium aims to facilitate interoperability of systems for collection and processing geospatial data, including satellite systems. The standards are also intended to ease access to legacy archives in different formats. To this end, it has developed many open standards relating to such systems. They cover a range of standards dealing different aspects of geospatial information.[1] They include standards for the tasking of EO sensors, manner of access and retrieval of data, treatment of geospatial data, standards for a common out-put language, and its integration with other data.

2. ELECTRONIC EVIDENCE AND ITS ADMISSIBILITY AS EVIDENCE

The British Standards Institution's standard on electronic information and its admissibility into evidence[2] sets out the requirements for the implementation and operation of electronic information management systems. This includes data processing, information exchange between computers and electronic storage. The Standard addresses issues relating to the authenticity and integrity of data, helping organisations to comply with the law and legal procedures. The Standard also covers the process of electronic identity verification, such as the use of electronic signatures and electronic copyright systems. It applies to electronic information in any form.

By following this Standard's best practice guidelines, an entity can better manage the various risks that are associated with electronic information and data security. Other topics covered are policies, security issues, procedures, technology requirements and the auditability of electronic document management systems (EDMS).

BS 10008 specifies the requirements for:

1. addressing of issues relating to the authenticity and integrity of the electronic information;
2. electronic transfer of information from one computer system to another; and
3. implementation and operation of electronic information management systems.

These issues are essential where the electronic information could be used as evidence.

3. ISO SPACE DATA AND INFORMATION TRANSFER SYSTEMS

There are a number of International Organisation for Standardisation (ISO) Standards applicable to space systems and the data they provide.

3.1 AUDIT AND CERTIFICATION OF TRUSTWORTHY DIGITAL REPOSITORIES

The ISO's Standard on space data transfer systems[3] defines a recommended practice for assessing the trustworthiness of digital repositories. It is applicable to the entire range of digital repositories. It can be used as a basis for certification. The scope of application of this Standard is the entire range of digital repositories.

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1 The Standards are available at http://www.opengeospatial.org/standards.

2 BS 10008:2008, *Evidential weight and legal admissibility of electronic information. Specification*, Published November 2008.

3 ISO 1636:2012, *Space data and information transfer systems — Audit and certification of trustworthy digital* repositories.

3.2 Time Access Service

The ISO time access service Standard[4] defines services and service interfaces provided by the Spacecraft Onboard Interface Services (SOIS) time access service. It specifies only the service and not the methods of providing the service, although use of the SOIS sub-network services is assumed.

3.3 Time Code Formats

The ISO time code format Standard[5] establishes a small number of standardized recommended time code formats for use in data interchange applications between agencies of the Consultative Committee for Space Data Systems, CCSDS. This Standard does not address timing performance issues such as stability, precision, accuracy, etc.

3.4 XML Specification for Navigation Data Messages

This ISO Standard[6] specifies a format for use in exchanging spacecraft navigation data. Such exchanges are used for distributing attitude, orbit, and tracking data between space agencies. It specifies an integrated Extensible Markup Language (XML) schema set that applies to Navigation Data Messages (NDMs) defined in the CCSDS Recommended Standards for Attitude Data Messages (ADM), Orbit Data Messages (ODM), and Tracking Data Message (TDM).

The Standard is applicable only to the schema content and layout, and to instantiations of the schema, but not to the transmission of any instantiation of the schema. The potential for compression and decompression of the message is an aspect of the transmission that is not part of this specification.

[4] ISO 17214:2011, *Space data and information transfer systems - Spacecraft onboard interface services - Time access service.*

[5] ISO 11104:2011, *Space data and information transfer systems - Time code formats.*

[6] ISO 17107:2011, *Space data and information transfer systems - XML specification for navigation data messages*.

ANNEX 6

EO SYSTEM CAPABILITIES

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1. EO SYSTEM CHARACTERISTICS

There are a growing number of commercial and governmental EO systems in operation with a variety of sensors onboard. They have a number of common features that characterise and determine their usefulness for different applications. The most common characterization of different remote sensing (RS) satellite systems results from the systems' diverse spatial, temporal and spectral resolutions.[1]

Spatial resolution of a sensor specifies the size of the target area covered by one pixel. Different terms are used to denote the resolution level of sensors. Commonly sensors with resolutions of 0.6 to 4 metres are regarded as high spatial resolution; 4 to 30 metres are medium spatial resolution; and over 30 metres is regarded as low spatial resolution.

Temporal resolution denotes the frequency with which a sensor passes over the target location. Such resolutions of up to 3 days are high temporal resolutions; 4 to 16 days is medium temporal resolution and over 16 days is low.

Spectral resolution is dependent on both the number of spectral bands in which reflected radiance is collected and the spectral frequency of the bands. High spectral resolution falls at or over 220 bands; medium spectral resolution covers 3 to 15 bands; and les than 3 bands is a low spectral resolution sensor.

The resolution characteristics of the sensor will determine the applications to which the sensors are suited. There is a trade-off between spatial and spectral resolutions. Therefore, users will need to determine which characteristic is the more important for a particular application.

With the vast number of possible applications of EO information, a comprehensive list of characteristics relevant to each application is not within the scope of this Report. However, two examples can shed light on some of the relevant considerations.

2. RADAR SENSORS AND OIL POLLUTION

From the 1980s, ESA Member States wanted to monitor oil pollution at sea. They developed air and sea tools. Satellite observation dates from the mid-90s with the launch of ERS2 and RadarSat1 satellites, although few countries used SAR (Synthetic Aperture Radar) to detect oil spills.

SAR emits a signal that is back-scattered to the emitter. The level of this back-scatter signal is measured. If there is no wind on the sea surface, there will be no waves and no signal coming back to the radar. If there is slight wind, there is a signal. An oil spill will smooth the sea surface, and the signal will not come back. Oil spills will appear as black features on SAR images. In high wind, the signal is lost, and the oil slick gets broken and weathered by the natural dispersal of the water column. As an estimate, oil slick detection is done using SAR images in good wind conditions, between 2 and 3 metres per second and up to 12-15 m/s.

Radar Satellite can monitor up to 400 kilometres wide strips looking for oil spills. An ENVISAT image covers up to 400 x 400 kilometres, and even longer, and RADARSAT covers something like 300 x 300 kilometres in one image. Satellite constraints limit temporal coverage. These polar orbiting satellites pass more often over the poles than the equator. There may be 5 images per week in the Mediterranean, with 3 satellites, but about 14 images per week in northern Norway.

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1 See Satellite Imaging Corporation, SIC, at http://www.satimagingcorp.com/characterization-of-satellite-remote-sensing-systems.html

Time is a crucial element to deal with illegal discharges. CleanSeaNet is a near real time service. There is less than 30 minutes between acquisition of data by the satellite, and delivery of the alert to the Member States that a possible spill may have been detected.

3. RADAR SENSORS AND LAND MOVEMENT

Synthetic Aperture Radar (SAR) images are helpful in the detection of ground deformation. Differential SAR (DInSAR) compares images taken at different times using slightly different angles, giving an overview of deformation along the sensor-target line of sight (LOS) on areas covering up to hundreds or thousands of square kilometres.

Conventional DInSAR uses two radar scans over the same area at different times. It can detect sub-centimetre ground movement in the form of a phase-change interferogram. It is dependent on such variables as the availability of archival radar data around the time of the event, suitable satellite baseline geometry, retrieval of coherent phase data and identification and removal of phase changes not related to the ground deformation, such as topography, satellite orbital error, and atmospheric artifacts.

InSAR is limited by temporal and geometric decorrelations. These may be partly overcome by the use of the permanent scatterer method (PSInSAR) method.[2] PSInSAR relies on identification and use of individual radar reflectors, smaller than the resolution pixel cell, and coherent over long time intervals, to develop a displacement time series. Such reflectors might man-made, such as street lights, or natural features like rocks. It identifies, estimates and removes atmospheric distortions, leaving an indication of the PS displacement as the only contribution to the signal phase shift.

This method is used in a wide range of natural hazards, such as landslides, subsidence and aquifer response to pumping and emptying, and tectonic movement. It is capable of providing fast, updatable results over large areas as well as small, and may be integrated with conventional investigation methods such as field surveys and aerial photography. It may be combined with geological data in a geographical information system (GIS).[3]

SAR and InSAR have been used in Arizona since 2002 to monitor land subsidence.[4]

4. OPTICAL IMAGERY AND INTERNATIONAL CRIMES

Optical sensors are available onboard many satellites. Because of their coverage of large geographic areas, the images are useful tools in land use, agriculture, forestry, geology, cartography, regional planning, water resources and GIS applications.

Satellite imagery is an established basemap source ideal for updating project databases. It delivers added value for many applications including crop detection and mapping. These together with radar analysis methods, such as PSInSAR techniques, measuring changes in land elevation, can provide evidence of humanitarian crimes. Both radar and infra-red sensors record information at night and in cloudy conditions, which can be valuable in such circumstances.

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2 See TRE, *Technology Evolution: InSAR, DInSAR and PSInSAR, InSAR Evolution*, http://www.treuropa.com/Home/Technique/InSAREvolution/tabid/404/Default.aspx.

3 See Claudia Meisina, Francesco Zucca, Davide Notti, Alessio Columbo, Anselmo Cucchi, Giuliano Savio, Chiara Giannico, and Marco Bianchi, Geological Interpretation of PSInSAR Data at Regional Scale, Sensors, 2008, 7469-7492, DOI: 10.2290/s8117469. See also A Ferretti, C Prati, F Rocca, Permanent Scatterers InSAR Interferometry, IEEE Trans. Geosci. Remote Sens. 2001, 39, 8-20.

4 See www.azwater.gov/azdwr/Hydrology/Geophysics/InSAR.htm.

5. GRAVITATIONAL METHODS

A non-spectral technique is used to assess changes in water storage. This is based on the changes in the gravity of the Earth due to the presence of water stored over or under the surface.

Known as the Gravity Recovery and Climate Experiment (GRACE), two satellites were launched by NASA on 17 March 2002, orbiting about 220 kilometres apart, one behind the other. Unlike other missions, the satellites themselves act as measuring devices. As gravity increases the first satellite accelerates before the second accelerates and catches up. The gravity variations induce distance changes between the satellites that are precisely measured by a microwave ranging system to an accuracy of 10 µm.[5] By this technique changes in water levels are recorded monthly.

The gravity variations are then used to provide averaged variations to provide monthly estimates of terrestrial water storage (TWS) changes. However, continuing research into the methods employed and models used may lead to improving measurements of water in aquifers and other TWS.

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5 See Gil Strassberg, Bridget R. Scanlon, and Don Chambers, *Evaluation of groundwater storage monitoring with the GRACE satellite: Case study of the High Plains aquifer, central United States*, Water Resources Research, Vol. 45, W05410, doi:10.1029/2008WR006892, 2009, http://www.beg.utexas.edu/staffinfo/Scanlon_pdf/Strassberg_Scanlon_Chambers_WRR_09_GRACE_HP.pdf. See also *Gravity Recovery and Earth Climate Experiment*, NASA Earth Observatory, http://earthobservatory.nasa.gov/Features/GRACE/.

ANNEX 7

COUNTRY REPORTS

ANNEX 7.1

USE OF EO INFORMATION AS EVIDENCE IN AUSTRALIA

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1. INTRODUCTION

This paper considers the current Australian case law and legislation on the use of earth observation (EO) information as evidence in civil and administrative proceedings. The focus of the research was on the use of this evidence in proceedings relating to subsidence, however it was found that there are no cases or legislative provisions that have specifically dealt with this point. Furthermore, the jurisprudence in the civil and administrative cases in which EO evidence has been used is disparate and unclear as to the admissibility and weight to be accorded to EO evidence and appears in most cases to depend heavily on the factual circumstances. Nonetheless, the case law and legislation give some broad indication of how EO evidence may be treated in proceedings relating to subsidence.

The paper first sets out the main potential causes of action in cases of subsidence and then considers the relevant legislation and case law on the use of EO evidence in Australia, focusing on civil and administrative actions. The paper then very briefly considers the potential legal limitations on the collection and use of this evidence. Finally, it considers the case law on analogous evidence (e.g. aerial photography and surveys).

2. POTENTIAL CAUSES OF ACTION IN CASES OF SUBSIDENCE

Subsidence[1] of land may be caused by the removal of soil or water through a range of activities. For example, subsidence may be the result of construction and mining activities on the subject land or adjacent land. There are a number of potential civil causes of action where subsidence has occurred. These could include:

- Contract – construction or insurance
- Torts – negligence, nuisance, trespass or a strict liability tort such as the removal of lateral and subjacent support

EO evidence may have a role in proving the various elements of these causes of action. For example, it may be used to show the fact and extent of subsidence, causation and fault and reasonable steps that could have been taken to prevent damage. The evidence may also be used to address the issue of damages and remedies.

3. AUSTRALIAN LEGISLATION, REGULATIONS AND CASE LAW RELATING TO EO EVIDENCE

This section sets out the current treatment of EO evidence in Australian law including legislation, regulations and case law. The focus of the research was on civil proceedings and public or administrative law actions.

None of the legislation, regulations or case law located relates directly to the use of EO evidence in subsidence cases. It appears that EO evidence has not been adduced in these types of cases in Australia. However, the nascent case law in other civil and administrative proceedings (and the limited legislation on EO evidence) demonstrate how EO evidence has been used and indicate, at least in an ad hoc and partial manner, the standards that must be met for this evidence to be admitted and deemed to be probative. However, the cases appear to turn on their facts and do not set out clear admissibility criteria. Therefore, no strict conclusions can be drawn as to how Australian courts may handle this type of evidence in the future.

[1] Defined by the Shorter Oxford English Dictionary (6th Edition) as 'The sinking of liquid, ground, a structure, etc., to a low, lower or normal level…the gradual caving in or settling down of a piece of ground due to disturbance…'.

3.1 LEGISLATION

There are a small number of Australian legislative provisions that make reference to EO information in an evidentiary or administrative context, usually referred to as 'remotely sensed image(s)' or 'remotely sensed data'.

Three Queensland Acts provide that a report or certificate from a qualified person is evidence of the content and date of a remotely sensed image in the absence of evidence to the contrary. Two of these Acts also provide for a presumption of the accuracy and precision of instruments, equipment or apparatus, and the appropriate qualifications of their operators, unless evidence is provided to the contrary, which may include remote sensing technology. One provision in a NSW Act also provides for a certificate that a remotely sensed image is an image of a particular kind and portrays specified land as at a specified date, which is taken to be evidence of those facts.

In effect, these provisions reverse the burden of proof. This evidence is conferred 'stand alone' admissibility and probative value, removing any need for any 'audit trail' or ground truth evidence, unless challenged by a party to the proceedings.

- Section 50 of *Survey and Mapping Infrastructure Act 2003 (QLD)* provides that the Chief Executive defined by the *Land Act 1994* (QLD) must maintain a 'state remotely sensed image library' containing the remotely sensed images of land and coastal waters of the State that the Chief Executive considers valuable for survey and mapping infrastructure purposes and the definition of administrative area or boundary.

  Section 131 of the Act entitled 'Evidentiary provisions about State remotely sensed image' provides that *in any proceeding:*

  > A certificate, purporting to be signed by the chief executive or by a person authorised by the chief executive, and stating any of the following matters about a State remotely sensed image of land or coastal waters accompanying the certificate is evidence of the matters stated:
  >
  > (a) the image is a State remotely sensed image, or a copy of a State remotely sensed image of a stated area;
  > (b) the location of the area shown in the image;
  > (c) a feature or point, or the location of a feature or point, shown in the image;
  > (d) the date and time when the image was taken or made;
  > (e) the approximate scale of the image.

  A 'State remotely sensed image' is defined in subsection (6) as 'a remotely sensed image taken or copied from the State remotely sensed image library'.

- Section 431D of the *Land Act 1994* (QLD) provides that:

  > An instrument, equipment or installation prescribed under a regulation that is used in accordance with any conditions prescribed under a regulation is taken, in the absence of evidence to the contrary—
  > (a) to be accurate and precise; and
  > (b) to have been used by an appropriately qualified person.

A party to the proceeding can challenge either of these two aspects by providing 28 days notice (section 431D(2)). It is unclear whether this provision would apply to remote sensing technology.[2]

Section 431E provides for the issuance by an 'appropriately qualified person' of a 'certificate or report about remotely sensed image' for the purposes of proceedings under the Act which is 'evidence of the matters stated in the absence of evidence to the contrary'.

Subsection (2) provides that a certificate or report can include a statement that 'a stated document is a remotely sensed image, or a copy of a remotely sensed image, of a stated area', a statement as to 'the date on which a stated remotely sensed image was produced', 'the person's stated conclusions drawn from a stated remotely sensed image', 'the location of a stated area' and 'whether a stated area is or is likely to be an area of remnant vegetation'. The statement can be challenged by a party to the proceeding if that party gives 28 days notice to the other parties to the proceedings (subsection (3)).

- Section 66A of the *Vegetation Management Act 1999* (QLD) provides for an presumption of accuracy and qualification similar to section 431D of the *Land Act 1994* (QLD), however the notice required to challenge the evidence is 20 days (subsection (2)) and the notice must state the 'the grounds on which the party intends to rely to prove' that the instrument was not accurate or the operator was not qualified (subsection (3)).

- Section 66B provides for the issuance of a 'certificate or report' similar to that under the *Land Act 1994* (QLD), but subsections (2)(f) and (g) additionally provides that the certificate or report can state 'whether vegetation in a stated area has been cleared' or 'whether a stated area is or is likely to be an area of remnant vegetation or regulated regrowth vegetation'. Notice of 20 days is required to challenge the statement (subsection (3)) and the notice must state the 'the grounds on which the party intends to rely to prove that the statement was not correct' (subsection (4)).

- Section 367 of the *Water Management Act 2000* (NSW) provides that a certificate issued by the relevant Minister 'that states that that an image, a copy of which is set out in or annexed to the certificate…is a photograph or other remotely-sensed image of a specified kind, and portrays specified land as at a specified date is admissible in any legal proceedings and is evidence of the fact or facts so stated'.

Other provisions referring to EO information:

- The definitions in the *Land Act 1994* (QLD) (Schedule 6) define a term 'image base' to mean 'an image or mosaic of images, including, for example an aerial photograph or a satellite image'. Satellite images can be used as part of the 'required particulars' for the mapping of 'a future conservation area or a part of lease land'. Regulation 1A of the

[2] The Explanatory Memorandum to the Natural Resources and Other Legislation Amendment Bill 2003 (QLD) that introduced the report or certificate provisions into the Land Act and the Vegetation Management Act contemplates that remote sensing technology would be covered by this provision (at page 14), although no regulations have been located that explicitly state this. The Explanatory Memorandum also provides:

> A certificate summarising evidence is evidence that could otherwise be given by an expert or series of experts during a legal proceeding. The provision merely makes the certificate self-evident of the stated facts in the absence of contrary evidence;
>
> With regard to proving the readings of instruments such as Global Positioning Systems and proving the analysis of remotely sensed images, the information that would be provided by experts about these matters is standard information for most vegetation clearing prosecutions;

Vegetation Management Regulation 2000 (QLD) also includes this definition and under section 3, provides for the use of satellite evidence in setting out the location and extent of land proposed to be cleared under a 'property vegetation management plan'. The term 'image base' is also used in the *Chemical Usage (Agricultural and Veterinary) Control Regulation 1999* (QLD), permitting satellite images to be used as part of the information forming an 'appropriate map' for the purposes of using chemical products from aircraft (regulation 12V(4)).

- Regulations 13B and 14B of the *Mineral Resources Regulation 2003* (QLD) provides that a full annual report required as a condition of a exploration permit issued or a mineral development licence (respectively) under the *Mineral Resources Act* 1989 (QLD) must include 'a full technical summary of the authorised activities for the permit carried out during the reporting period, including […] geological, geophysical, geochemical, drilling or remote sensing data, including maps showing the geophysical and geochemical anomalies and prospects or mineralisation in the area. A similar provision exists in Regulation 59 of the *Aboriginal Heritage Regulations 2007* (Vic) that permits the use of various 'sub-surface investigations' including 'remote sensing' for purposes of preparation of a ground survey for a 'standard assessment' under the Act.

- Regulation 16 of the *Surveying and Spatial Information Regulation 2006* (NSW) permits surveyors to use measurements derived from approved photogrammetry or approved remote-sensing methods, but must indicate the methods used on the survey. This provision is also reflected in the practice regulations for NSW surveyors

- *Mine Subsidence Compensation Act 1961* (NSW): NSW legislation regarding compensation fund for subsidence caused by coal mining – Act does not appear to set out any evidentiary requirements and perusal of cases brought pursuant to its provisions do not indicate use of satellite or aerial evidence. The Mine Subsidence Board was established pursuant to the Act to decide claims for compensation under the Act.

3.2 CASES WHERE EO EVIDENCE WAS OFFERED IN EVIDENCE AND ACCEPTED

EO information has been offered and accepted in evidence in proceedings in a number of Australian jurisdictions. As noted above, it has not been possible to locate any subsidence cases in which EO information has been used. However there has been a range of cases that have emerged from various civil and administrative actions in which EO information has been adduced.

3.2.1 General Civil Cases

3.2.1.1 **Byron Shire Council v Archibald** (2001) 119 LGERA 23; [2001] NSWLEC 262; BC200107992 (13 December 2001) (NSW Land and Environment Court)

*Note also appeal below that overturned this decision

Use of EO evidence: Satellite imagery combined with aerial photography and a ground survey was accepted as evidence to show lateral expansion of an area of quarrying.

Discussion: In *Archibald,* the Byron Shire Council sought two declarations relating to the unlawful use of the land and an injunction restraining the respondent from using the land for the purposes of particular extractive industries until the consent of the council was obtained under the relevant legislation. The council's expert relied upon 'commercially available satellite imagery of '*infra-red reflectivity*'. As to the use and presentation of this evidence, the Court said:

> 13. Dr Button interpreted the results of satellite imagery of the site, which had been recorded by satellite and processed by computer. Using such data, he concluded that there were two periods of significant expansion in the area of the quarry. The first was during the period between January and September 1990 in which the shape of the quarry ‘grew from an almost triangular shape to a regular shaped trapezoid (a quadrilateral plane figure of which two sides are parallel)’. Dr Button said that the area of the quarry increased mainly towards the south-east.
>
> 14. Dr Button considered that a the [sic] second period of expansion occurred between 1993 and 1995 `when there was a considerable increase in the land cleared for the quarry area which is unmistakable upon visual as well as statistical analysis'. Dr Button said that this area of expansion was also in a south-south-easterly direction. Significantly, Dr Button's assessment did not rely upon personal observation or assessment. Rather, Dr Button's conclusions were based upon the result of calculations by computer of the date derived from satellite observation.

Other aerial photography, computer surveying software results and ground evidence were also tendered by the council:

> 15. In addition, Mr Scott Thompson, a surveyor, was called by the council. Mr Thompson plotted the distance between two fixed points, namely road bridges, which were visible on a 1990 aerial photograph of the site, to produce a scale. The survey data from the quarry was then scaled to the 1990 photograph with the use of computer surveying software known as Geocomp. By such process the cleared quarry area shown on the 1990 photograph could be related to the scale and utilising that data a line delineating the cleared area of the quarry could be produced by computer analysis of the date.
>
> 16. Mr Thompson concluded that the cleared area was extended by approximately 6,500 m2 between the clearing shown in the aerial photograph taken on 19 January 1990 compared to that taken on 15 August 1997. Mr Thompson acknowledged that a margin of error of about 5 m in radius around each of his selected survey points could exist, resulting in a 15% margin of error in his conclusion.

A basic ground survey was also tendered in evidence that compared current quarry measurements to those provided in a previous survey. The combination of this evidence satisfied the Court that there had been an increase in the area of the quarry and led to it granting the requested declaratory relief. The question of injunctive relief was reserved pending a view of the site.

3.2.1.2 **Archibald v Byron Shire Council** [2003] NSWCA 292 (5 November 2003) (Supreme Court of New South Wales – Court of Appeal)

<u>Use of EO evidence</u>: Findings of first instance Court based (inter alia) on satellite evidence were overturned on appeal because expert evidence given on basis of satellite imagery was not reliable in the absence of ground evidence and was contradicted by the ground evidence also submitted by the council.

<u>Discussion</u>: Archibald appealed the decision of the NSW Land and Environment Court (directly above). Archibald successfully argued that the quarry had not been expanded, the use of the land had not intensified and the activities undertaken were a ‘continuing use’.

With regard to the EO evidence, the Meagher JA noted that the trial Judge had evidence before him of ‘comparatively restricted compass’ including:

> Spot Pan satellite imagery said to determine the area, location and date of vegetation removal or loss, which were relied on by a Dr Button (called by the Council); aerial photography said to be capable of being used to determine the area location and date of quarrying (used by Surveyor Thompson, called by the Council); expert surveys of the quarry site.

Meagher JA criticized the council for only tendering evidence of one surveyor and indicated that the trial Judge should have given more weight to this evidence:

> But the most important (and perhaps the most obvious) observation is that there was only one surveyor who gave evidence, i.e. only one professionally qualified witness who measured all relevant boundaries on the ground, Mr Surveyor Loomes, and it almost beggars belief either that the Council would embark on this type of litigation without engaging such a surveyor or that his Honour would virtually disregard the testimony of such a surveyor. This is all the more so in light of the admitted inadequacies of satellite and aerial surveys.

Meagher JA also found that the trial Judge misunderstood the Geocomp evidence (which itself was unreliable) and that there was no evidence at all of expansion.

> Sheller JA also held that the Geocomp evidence and the evidence based on satellite imagery were not sufficiently reliable and were not sufficiently cross-examined upon. According to Sheller JA, the satellite evidence was unreliable without ground examination because the cleared area deemed to be expansion of the quarry was in fact what was known as the ‘slip area’, an area of land slippage that was not a part of the quarry. At para. 50, Sheller JA noted that ‘He [Mr. Button, the expert who interpreted the satellite imagery] accepted in cross-examination that if the area had been the subject of a landslip his methods did not establish that the apparently cleared area was actively working as a quarry.’ It was held that the satellite and aerial evidence ‘should have been rejected as unreliable and inconsistent with…[the] unchallenged evidence [from the ground survey]’.

3.2.1.3 **Max Hams and 1 Ors v CGU Insurance Limited** [2002] NSWSC 273 (12 April 2002) (New South Wales Supreme Court)

<u>Use of EO evidence</u>: Satellite imagery was used to show the source, composition and movement of water on a property. There is mention of an expert report asserting the ‘authenticity’ of the image tendered. The Court accepted that the evidence could show the ‘low sediment load’ in the water though the dark blue coloration on the satellite image (known as ‘spectral response’) and said that it ‘*lends further credence to the plaintiffs’ case’.*

<u>Discussion</u>: *Max Hams* was a dispute between an insurer and a policyholder relating to whether an inundation of water onto farm property was a ‘flood’ and therefore within the scope of an exclusion under an insurance policy. Both parties submitted ‘maps, charts, diagrams, photographs, satellite images and analyses’ to support theories as to the source and movement of the water and called expert witnesses. The satellite evidence used was both contemporaneous and historical.

One relevant passage about the use of the evidence:

> An important satellite image [Exhibit P3] was captured at approximately 11:13am on 22 February 2000. It became the subject of the closest attention during the hearing. In order not to interfere with the image, a number of transparencies were overlaid upon the image and the various witnesses who were taken to the image marked the transparencies. The interpretation of the image was also the subject of expert evidence particularly that given by Professor Forster. Some assistance is gained by comparing a satellite image captured on 27 January 1994.

The technical aspects of the image were described by Professor Forster (the plaintiff's expert) in his evidence as follows:

> So the satellite image itself was taken - well it has got seven bands, but you can only display three because you have only got blue, green and red to display it with, so that in this particular case the image is band 2 of what is called LandSat, the thermatics map, and band 2 is approximately in the middle of the visible, about .5 to .6, which is where you get maximum penetration for very clear water. Later, the effective resolution image is described as representing 50 x 50 m per cell .

The satellite image was situated by Professor Forster by reference to maps and an aerial photo also submitted in evidence. Professor Forster submitted evidence in the form of a report in which he interpreted a satellite image and stated that it showed that the water that had inundated the property had a 'lower level of sediment load' and was therefore not floodwater. In his report he noted the following:

> The satellite image is authentic, and was acquired from an appropriately authorised organization and was processed according to standard practice.
>
> The contents of the data contained on the satellite image were not proven in the reports of Drs Porter and Markar [NB: Defendant's experts], and they did not establish whether proper and acceptable digital image processing techniques were used.

Paragraphs 72-75 recite the evidence regarding the expert interpretation of the satellite image. Note evidence was given by an expert that satellite imagery would not be an accurate assessment of 'defined catchment areas' in bodies of water without additional topographical evidence. There is also a following discussion of the accuracy of satellites in determining the depth of water in a depression and their general 'resolution'.

The Court held that:

> Whilst I readily accept the difficulties involved in terms of the interpretation and weight to be given to the Tuesday Satellite image, at the least Professor Forster, who clearly has an enormous amount of experience in interpreting satellite images, has now given expert evidence to the effect that in the analyses which he has identified the water which inundated the Homestead and outbuildings prior to the time when the Satellite Image was taken was surface run-off water not sediment laden flow water. His evidence was that by reference to the coloration, a distinct body of clear water on the western edge of the depression could be seen such that at the time of the image the flood driven, sediment laden water had not reached the clear water on the western edge of the depression. Run off water would have had a much lower sediment load than flow water and would be much clearer, and thus dark blue on the image. It does not seem to me appropriate that this evidence simply be disregarded. To the contrary it lends further credence to

> the plaintiffs' case and provides a further basis for simply holding that the defendant failed to discharge their onus of proof.

In the case report, the Court does not explicitly address the admissibility requirements for this evidence, either in terms of the process of its collection, analysis and presentation or its probity. However, it does discuss the limitations of the expert scientific evidence submitted (including the images and other graphs, analyses, modelling etc) and notes that they are far from certain and that there were 'significant problems in terms of aspects of their evidence where they had either not visited the site *at all* or had only been in a position to view *certain parts* of the local topography.'

Yet it did not specifically address this issue with the regard to the satellite imagery taken alone. It appears that the evidence was accepted in conjunction with expert evidence and other evidence from a range of different sources. As both parties were relying on the satellite images, it appears that the admissibility of this evidence was not in dispute. However, the evidence of the plaintiff's expert suggests that there are perhaps some baseline standards to be met as to the source and processing of satellite images that courts may require.

3.2.1.4 McConnell Dowell Middle East LLC v Royal & Sun Alliance Insurance Plc [2008] VSC 501 (Victorian Supreme Court)

Use of EO evidence: Satellite images were used to show absence of goods in a location in the Central African Republic, leading to a successful claim for indemnity under an insurance contract . The images are only briefly mentioned.

3.2.2 Land Clearing Cases

3.2.2.1 John Nominees Pty Ltd v Dixon [2003] WASCA 51 (21 March 2003) (Supreme Court of Western Australia)

Use of EO evidence: Satellite imagery (recorded by Landsat and gathered by the Australian Governing Mapping Organisation) was tendered to show land clearing.

Discussion: The Court discussed but did not decide issues relating to the possible need to verify or authenticate satellite evidence and based its decision on other evidence. The Court suggests that satellite images may be treated as photographs and that perhaps even CDs containing satellite images produced by the Australian Government Mapping Organisation could be automatically admitted on judicial notice. However, in this case there had been no attempt to have the 'CDs certified as containing true copies of the original data received and held in the custody of the Australian Government Mapping Organisation, or of certifying the photographs tendered by [expert] in this way'. Aerial photographs were also tendered and were accepted to have been properly admitted as public documents on judicial notice and certified as copies of the original, pursuant to s 65 of the *Evidence Act.*

An appeal against conviction under the *Soil and Land Conservation Regulations 1992* for the offence of 'failing, before commencing clearing, to give notice of its intention to clear land of which it was the owner, when the clearing would result in a change in the use of the land'.

The appellant argued that satellite images tendered by the relevant authority were wrongfully admitted because the person admitting them was not ‘adequately qualified as an expert’.[3]

Parker J explained the image and its practical aspects as follows:

> The consequence is that the digital data can be directly used by the CSIRO and others to produce a true colour image which is exactly equivalent to an aerial photograph, a colour aerial photograph, except for scale. What is produced is a direct representation of the earth's surface in true colour.
>
> With respect to the question of the scale of this image data, it is the evidence that when each CD containing the image data is received by CSIRO in Perth, it is processed according to a standard methodology to conform to a map grid and the images are calibrated to a standard so that they are comparable over time and can be compared for visual inspection.

Parker J discusses the possible need for ‘verification’ or ‘authentication’ of sources of satellite evidence, as is required for photographic evidence. He said:

> A photograph needs to be authenticated to be received in evidence for the purpose for which these satellite photographs were tendered. One method of authentication is evidence from the photographer, where there is one, to verify what it is that is depicted on the photograph. But such authentication may well be provided by a witness, other than the photographer, who can verify what is depicted.
>
> With regard to the distinct question of the accuracy or reliability of what is depicted, the satellite photographs were produced by technology far more complex than an everyday camera. That technology and the accuracy and reliability of its product are matters beyond ordinary knowledge and experience. Although the issue was not directly ventilated in argument before me, it appears that it was open to the learned Magistrate to accept from the evidence of Mr Wallace that the satellite photographs or images could be accepted as accurate photographic depictions of that part of the earth's surface which they portrayed. In this connection, I note the discussion in Phipson on Evidence, 15th ed pp 647 - 649, par 25-19.

He later goes on to say:

> That being so, the admissibility of the satellite photographs, and indeed of the evidence of Mr Wallace insofar as it is based on his interpretation of those

3 Note that the Court dismissed this argument. It said ‘Mr Wallace is an image processing scientist of some 12 years experience with the CSIRO in the Remote Sensing and Image Integration Group of the Mathematical and Information Sciences Division. He has tertiary qualifications in mathematics and computing science, though not in botany. The evidence is that his experience is in extracting information from image data, in particular satellite image data, and using that data to monitor changes in land condition and vegetation condition, especially in respect of salinity and perennial vegetation change. This work is an initiative of CSIRO and is provided to government agencies concerned with environmental monitoring, with specific attention to salinity and salinity change, perennial vegetation and perennial vegetation change. I have spelt out these aspects of the evidence because one contention of the appellant is that Mr Wallace had not been adequately qualified as an expert for the purposes of the evidence which he gave. The submission is that expertise in the field of botany was necessary. In my view, it was open to the learned Magistrate to be satisfied, as he was, on the basis of Mr Wallace's experience as a scientist in the work he described in his evidence, that he was adequately qualified as an expert to give the evidence and make the interpretations of satellite images on which his evidence was based.’

> photographs, appears to depend on the verification of the image data in CD form, which CSIRO received from the Australia Government Mapping Organisation. I have not been referred to any statutory provision which applies in this situation. There has been no attempt to have the CDs certified as containing true copies of the original data received and held in the custody of the Australian Government Mapping Organisation, or of certifying the photographs tendered by Mr Wallace in this way.
>
> Once again, this particular issue was not the subject of direct submissions by counsel. One possibility which could warrant closer examination is whether, after having due regard to advances in technology and in the means of its recording and distribution to interested members of the public and agencies, the image data in the CD form in which it is made available for sale to the public and other users might be regarded, today, on much the same basis for purposes of admissibility as published maps, dictionaries, histories, scientific and professional treatises, etcetera. Rather than venture unassisted into this field of inquiry, however, I prefer, for present purposes, to assume, without specifically deciding the issue, that the satellite photographs were not properly admitted in evidence. As a further consequence of this assumption, there was not an adequate foundation for the material conclusions given in the evidence of Mr Wallace.

He summarises the findings of the Magistrate at first instance and then concludes:

> In this respect, in his reasons for decision, the learned Magistrate made reference to Mr Wallace's evidence saying:
>
> "The aerial photos and the satellite imagery clearly show marked disturbance of the subject land. That would appear to me, and I can reasonably infer, is consistent with, clearing. The images are however not sufficient to show exactly what has occurred at ground level." (Punctuation corrected.)
>
> This indicates that his Worship saw in each of the aerial photographs and the satellite imagery that there had been a marked disturbance of the land consistent with clearing. Such a finding was clearly open with respect to the aerial photographs which, as I have indicated, were correctly received in evidence. The same finding was also open on an examination of the satellite photographs or imagery. However, for the reasons indicated, I proceed on the assumption that the satellite photographs were not correctly received in evidence.

The Court did not decide what is required to render satellite images admissible in this case as it found that the Magistrate would have come to the same decision without the satellite imagery and the evidence founded on it.

3.2.2.2 Dalimen P/L v Director General Department of Infrastructure Planning and Natural Resources [2005] NSWLEC 204 (29 April 2005) (Land and Environment Court of New South Wales)

<u>Use of EO evidence</u>: Satellite imagery (the precise technology used is not described) was used to corroborate on-ground assessment and aerial photography relating to land clearing, but would not be determinative on its own. The consistency between of satellite imagery evidence, land-based investigations and aerial photography assessments was held to provide clear indicators that clearing land was not undertaken by the former owner. Expert evidence tendered regarding satellite imagery was assessed to be more persuasive when confirmed through site inspections and correlation with actual vegetation and soil conditions.

Discussion: *Dalimen* was an appeal against issue of remediation direction by the Department requiring the applicant to carry out specified remedial work pursuant to (NSW) *Native Vegetation Conservation Act 1997* s 47(1)(a). Satellite imagery evidence was used by the Department in a corroborative manner alongside land-based details and aerial photography information to seek to show that clearing was not done by a former owner and therefore that the applicant was not simply removing regrowth vegetation. By clearing the land, the applicant had caused environmental harm and was consequently liable to remediate the land.

The satellite imagery evidence was assessed to be of limited evidentiary weight. Hussey C noted:

> The third level of evidence comprises the satellite imagery assessment undertaken by Dr Schelling and Mr Fitzpatrick, resulting in their joint conference and report (exhibit 24), which is focused on "subject area" that is subject to the remediation order. But the joint statement contains frequent qualifications and refinements of their responses on complex technical matters, which doesn't readily assist the Court. Consequently my impression is that this level of evidence can only be used as an indicator or guideline of clearing activity and not on a determinative basis.

Hussey C noted the limitations of satellite imagery in this context, stating that the experts agreed that:

> [*Satellite evidence*] *can detect any dramatic changes in wooded vegetation. However their ability to detect other more subtle changes, such as "light clearing" seems less reliable, depending on several factors including quality of the images, weather conditions and analytical techniques*.

The experts agreed that they would be able to detect dramatic change to the vegetation, such as the removal of the undergrowth that was in issue. On the precise extent of any prior clearing, the Court preferred the evidence of the expert who had also visited the site:

> In summary then, I am persuaded to accept the evidence of Dr Schelling because it appears that his approach is more detailed, and site-specific based on his field inspection of the site and correlation with actual vegetation and soil conditions. Whereas Mr Fitzpatrick evidence appears more as a review of Dr Schellings work and did not involve any site inspection to assess actual site conditions and correlation.

In its discussion of the aerial photography evidence the Court also noted the limitations of aerial photography to assess the height of vegetation and identify particular species. However, the technology was held to be sufficient accurate to be able to indicate the absence of any clearing during the relevant period, in combination with the land-based assessments. The Court did not assess the relative strength of the aerial photography and satellite imagery evidence or their precise admissibility requirements.

Note also *Witheyman v Van Riet — [2007] QDC 342; (2008) 29 Qld Lawyer Reps 109 (21 December 2007)* and on appeal *Witheyman v. Van Riet Ors [2008] QCA 168 (20 June 2008)* regarding limitations of time for prosecutions.

3.2.2.3 **Witheyman v Simpson** [2009] QCA 388 (15 December 2009) (Supreme Court of Queensland – Court of Appeal)

Use of EO evidence: Land clearing case that involved use of 'remotely sensed images' (the precise technology used is not described) admitted in a certificate under s 66B of the *Vegetation Management Act 1999*. Case suggests that remotely sensed evidence can be sufficient without ground visual observations depending on the 'reliability of the methodology and techniques…employed' to interpret the image.

Discussion: *Witheyman* was an appeal against the dismissal of an appeal against a decision of a Magistrate to acquit the defendant for three charges of offences under the *Integrated Planning Act 1997* (QLD) for clearing native vegetation on freehold land.

Remotely sensed images were submitted in evidence of the alleged offence, in the form of a certificate under s 66B of the *Vegetation Management Act 1999*. Muir JA set out the findings of the Magistrate at first instance regarding the remotely sensed imagery and the limitations of what they can prove:

> Evidence may be derived from the comparison of remotely sensed images that can prove a change in vegetation cover. The remotely sensed images cannot provide proof of the nature of the vegetation on the land. These images cannot show whether vegetation is remnant or non-remnant. Nor can they prove whether the change occurred from natural factors such as fire, drought, flood, storm or wind or by mechanical clearing or some other form of human intervention.
> The certificates provide evidence that the remotely sensed images reveal a reduction in vegetation in the stated areas. If these certificates can be linked to evidence obtained from a site inspection that mechanical clearing has occurred at specific indicative sites, and linked further to evidence as to the relevant mapping according to the regional ecosystem maps, the prosecution may establish a case against the defendant.

The person who provides the certificate compared the remotely sensed images to 'Regional Ecosystem mapping data and the survey boundary location information'. The Regional Ecosystem mapping data was provided by a colleague:

> In determining whether vegetation was remnant, Ms Cartan took the approach that the vegetation in any area which "had any disturbance is considered remnant." The disturbance had to be by mechanical means only and not by fire, storm or, presumably, flood. She later appeared to modify this opinion by confining burning to "natural burning" but conceded that she could not determine from a satellite image whether burning had been natural or not. Ms Cartan accepted that she had not carried out any field inspections for the purposes of her assessment and had not relied on data collected in the field. She said, however, that she had been "on several properties adjacent to [the subject property] and [had] seen these eco system types that we are talking about that are existing on this property – on adjacent properties and in the broader landscape ...".
>
> Senior counsel for the respondent in his oral submissions criticised the prosecution case at first instance for being "modern" and not "relying on old-fashioned techniques of a botanist going out to the land" and swearing to the nature of the vegetation on the basis of personal observations. But whether what was done was sufficient to identify the vegetation types which existed on the cleared land prior to clearing depended on whether the Magistrate accepted Ms Cartan's evidence and, in particular, the reliability of the methodology and techniques which she employed. If, which I doubt, the Magistrate's observations

> meant that as a matter of law or practicality the techniques utilised by Ms Cartan to identify vegetation type were incapable of proving vegetation type without supplementation by visual observations she erred.

3.2.2.4 Department of Environment and Climate Change v Olmwood Pty Limited [2010] NSWLEC 15 (9 February 2010) (New South Wales Land and Environment Court)

Use of EO evidence: SPOT 5 satellite images were used alongside site inspection, aerial photographs and GPS data to show changes in vegetation in a land clearing case [at para. 251]. There was some discussion of the need for the verification and authentication of the provenance of satellite images and aerial photographs and the technical limitations of satellite images.

The images used were:

> Two pairs of SPOT5 images for 30 April 2005 and for 30 May 2006 respectively were supplied to the Department of Infrastructure, Planning and Natural Resources (DIPNR) by SIS. For each date one image was a 10m resolution (one pixel representing 10m x 10m on the ground) colour image and the other was a 2.5m resolution (one pixel representing 2.5m x 2.5m on the ground) black and white image.

The satellite image was presented as follows:

> Using Geographic Information Software and the GPS data, Mr Gibson [NB: an expert witness] produced a marked up SPOT5 satellite image on 30 July 2008 (annexure B) showing the property boundaries, the three vegetation quadrants (two within the property, one outside) and the location where photographs were taken by Mr Gibson.

As to the images and their resolution [at para. 103]:

> Mr Palmer [NB: an expert witness] also analysed SPOT5 satellite imagery for dates in 2005 and 2006 in order to determine if there were any detectable changes in the woody vegetation (see par 132-136 for evidence in relation to the source and explanation of SPOT5 imagery). Mr Palmer stated that on a SPOT5 image a pixel represents a 2.5m x 2.5m square of land which means that objects smaller than that size cannot be seen with any clarity. A pixel takes its colour from the object with the dominant colour in the pixel area. Contiguous areas of clearing greater than 2.5m x 2.5m are made visible. Soil disturbance shows up as bright pink coloured bleaching in SPOT5 images. Mr Palmer viewed the SPOT5 imagery using a computer program after the images were orthorectified and a cadastral layer imposed (see par 133 and 136).

Mr Palmer draws a number of conclusions from the changes in the satellite images, but the Court notes that:

> The western strip of vegetation appears different from the vegetation identified there in the 2006 SPOT5 image but Mr Palmer states that he cannot say whether this is due to a real structural change, possible climatic factors or a lack of depth of field with SPOT5 imagery.

It goes on to discuss the oral evidence of Mr Palmer that notes the shortcomings of the SPOT5 imagery:

> In relation to the use of SPOT5 imagery, Mr Palmer explained that the images are based on variations in the emission of radiation from different surfaces. Colours are assigned according to the wavelength of the radiation emitted. SPOT5 images cannot be used to assess the relative heights of vegetation. The opinions expressed by Mr Palmer in his first affidavit were based on photographs and images of the property up to 30 May 2006, meaning he did not have the benefit of any post-clearing images. Asked whether the colour variations in the SPOT5 image dated 6 May 2008 were a reliable basis for assessing the different types of vegetation on the property, Mr Palmer stated that the image only allows for a comparison of the different types of vegetation within the area of the image. He was able to discern parts of the property had vegetation comparable to that to the east of the property and other parts of the property which appeared as pale green to yellowish in colour represented in Mr Palmer's opinion non-weed vegetation, such as grass cover or sedges. He stated that he drew these conclusions after viewing the image on a computer screen which gave a better quality image than the printed copies annexed to his affidavits.

It is also noted that aerial photographs, when in colour and viewed through a device called a stereoscope 'allows for a comparison of the relative heights of different plants'.

Is it noted that 'Mr Palmer stated that he did not do any ground truthing to confirm any interpretation of the aerial photographs.' No mention is made as to whether any such activities were carried out to confirm the interpretation of the SPOT5 images but presumably as the images would relate to the same land as the aerial photographs, it can be presumed that they were not.

Note that the court sets out the various affidavits of the satellite imagery company that provided the raw SPOT5 images, the image processing company that orthorectified the images and the government department that produced the aerial photographs – it does not state the precise content of these affidavits but suggests that they were required to authenticate the source and production process of the images and address issues relating to margins of error.

See also other land clearing cases: *Director-General of the Department of Environment and Climate Change v Taylor [2007] NSWLEC 530 (9 November 2007); Walker Corporation Pty Ltd v Director-General of the Department of Environment and Climate Change (No. 2) [2009] NSWLEC 177 (19 October 2009).*

3.3 CASES WHERE EO EVIDENCE WAS AVAILABLE BUT WAS NOT USED, OR WAS OFFERED AND WAS REJECTED

This research found no examples in the cases where it was noted that EO evidence was available but was not used.

It appears that the only example of where a court has rejected EO evidence is *Archibald v Byron Shire Council [2003] NSWCA 292 (5 November 2003) (Supreme Court of New South Wales – Court of Appeal)*, above. Furthermore, there were no cases located where evidence was rejected and it was indicated or apparent that a different cause of action could have been proved with that evidence.

As noted in the discussion above, in the majority of cases EO information was accepted but held to be corroborative evidence only and of limited weight. In some cases it was found to have technical limitations to prove the matters it was adduced to prove, for example whether the technology could identify certain types of land or vegetation or certain types of activities. It would appear that the current technology and the manner in which it is used to detect land subsidence (e.g. Permanent (or Persistent) Scatterer Technique – PSInSAR) is better adapted and more precise in showing the movement of land or buildings and would be less open to these types of concerns about what the images or data show.

4. POTENTIAL LEGAL LIMITATIONS ON THE COLLECTION AND USE OF EO EVIDENCE

There may be limitations on the collection and use of EO information on the grounds of privacy, intellectual property rights, trade or business secrets, monitoring rules and national security. It may also be possible that courts could exercise their discretion to decline to admit evidence that is considered to be contrary to public policy. None of these potential challenges were raised in the cases located during this research.

5. CASES WHERE OTHER FORMS OF EVIDENCE WERE USED AND ACCEPTED (E.G. AERIAL PHOTOGRAPHY AND SURVEYS)

Aerial surveys or photography were adduced in combination with EO evidence in most of the cases discussed above. In those cases, the courts did not set out any more detailed rules for to the admissibility and weight of aerial surveys or photography than for satellite evidence. Nor does it appear there is a greater demand for 'ground truth' requirements in the case of aerial surveys or photography. In the cases above, it appears that aerial photographs and satellite images are generally seen to be analogous.

Detailed research was also undertaken of cases in which aerial surveys and photography were used, but EO information was not used. No subsidence related cases were located. A number of land clearing cases were located but these did not appear to take a different approach to the case law discussed above.

One case of possible interest is *Michael Norvill v Kevin Stokes [2006] NSWLEC 622 (18 October 2006)* which finds that aerial photographic evidence combined with GPS generated data is not reliable due to lack of evidence as to authenticity and lack of clarity about the relationship between points on the ground and features shown in the photograph.

In *Dobra & Anor v Brennan & Ors [1999] WASC 98 (23 July 1999)* the Supreme Court of Western Australia expressed concerns regarding the qualifications of an expert to interpret aerial photographs and the reliability of using two overlaid images to show the extent of land clearing and ruled that evidence to be inadmissible. The Commissioner (judge) said 'I far prefer the reliability of the direct evidence of persons on the ground who live and work such properties as part of their daily lives.'

6. CONCLUSION

The research indicates that there is a nascent use of satellite evidence in civil and administrative proceedings in Australia. These indicate certain acceptable and unacceptable methods of collection, processing and use of EO information for evidential purposes.

6.1 COLLECTION OF INFORMATION

Australian case law and legislation does not set down any requirements for the collection of EO information. However, the court requires that the information be demonstrated to be accurate and reliable. This will include calibration of the system and clear indication that the EO information faithfully represents the position on the ground.

6.2 PROCESSING OF INFORMATION

Similarly, although the courts allude to the need for reliability and authentication, there has been no clear statement as to what this would require. Presumably, it would involve expert assessment of the technology used, the process used to gather the data, including any modelling used, the custody or audit trail, processing methods and the general compliance of the methods used with standard EO practice.

6.3 USE AS PRIMARY OR CORROBORATIVE EVIDENCE

The cases suggest that EO information, at least to the extent it has been presented in cases to date, will be used as corroborative rather than primary evidence.

6.4 LIMITATIONS ON USE

As noted, Australian courts have not considered any of the potential limitations on the use of EO information as evidence.

A court presented with reliable EO evidence alone may take a different view, particularly if there is no ground evidence available or the evidence is being adduced to show historical events. It would seem clear that the view adopted by the court would depend on the particular factual circumstances and the technical capabilities of the EO system and the quality of the EO information. Clearer rules on authenticity and the audit trail may make EO information more readily accepted as evidence in increasingly complex factual scenarios.

APPENDIX: LIST OF CASES

- Byron Shire Council v Archibald (2001) 119 LGERA 23; [2001] NSWLEC 262; BC200107992 (13 December 2001) (NSW Land and Environment Court) (first instance)

- Archibald v Byron Shire Council [2003] NSWCA 292 (5 November 2003) (Supreme Court of New South Wales – Court of Appeal) (on appeal)

- Max Hams and 1 Ors v CGU Insurance Limited [2002] NSWSC 273 (12 April 2002) (New South Wales Supreme Court)

- McConnell Dowell Middle East LLC v Royal & Sun Alliance Insurance Plc [2008] VSC 501 (Victorian Supreme Court)

- John Nominees Pty Ltd v Dixon [2003] WASCA 51 (21 March 2003) (Supreme Court of Western Australia)

- Dalimen P/L v Director General Department of Infrastructure Planning and Natural Resources [2005] NSWLEC 204 (29 April 2005) (Land and Environment Court of New South Wales)

- Witheyman v Van Riet — [2007] QDC 342; (2008) 29 Qld Lawyer Reps 109 (21 December 2007) (first instance)

- Witheyman v. Van Riet Ors [2008] QCA 168 (20 June 2008) (on appeal)

- Witheyman v Simpson [2009] QCA 388 (15 December 2009) (Supreme Court of Queensland – Court of Appeal)

- Department of Environment and Climate Change v Olmwood Pty Limited [2010] NSWLEC 15 (9 February 2010) (New South Wales Land and Environment Court)

- Director-General of the Department of Environment and Climate Change v Taylor [2007] NSWLEC 530 (9 November 2007)

- Walker Corporation Pty Ltd v Director-General of the Department of Environment and Climate Change (No. 2) [2009] NSWLEC 177 (19 October 2009)

ANNEX 7.2

THE USE OF EO IN CRIMINAL PROCEEDINGS IN BELGIUM

TABLE OF CONTENTS

1. INTRODUCTION[1]

This Annex examines the use of Earth Observation data in criminal proceedings in Belgium and illegal oil discharge at sea, especially in connection with Workshop I of this Study. There is a list of the relevant legislation and cases about oil pollution in Belgium.

Another area of focus is what steps would be necessary to replace aircraft-gathered information by EO information. Finally, it looks at limitations on the gathering and use of Earth Observation information.

2. THE USE OF EO INFORMATION AS EVIDENCE IN CRIMINAL PROCEEDINGS

2.1 EVIDENCE IN BELGIAN COURTS

Article 154 the Code of Criminal Procedure summarizes types of evidence in Belgium.[2] The Supreme Court decided that this list is illustrative.[3] The judge is free to accept other evidence.[4]

There is no national legislation in Belgian that prohibits the use of satellite images as evidence in legal proceedings.

2.2 THE CASE OF OIL POLLUTION AT SEA

The international legal regime concerning pollution from ships is defined in the Marpol Convention.[5] Annex I deals with prevention of pollution by oil. ‘Special areas’ are areas that, due to their special ecological conditions, are considered to be so vulnerable to pollution that especially far reaching and mandatory regulations are needed to limit discharges of pollutants. Almost all the seas around Europe have been designated Special Areas, except for the Norwegian Sea, the Bay of Biscay and the Iberian Coast.

Oil pollution at sea is not easily detected and proved, unless the violation has been discovered on the spot by vessels in the neighbourhood or by surveillance airplanes. Satellites equipped with Synthetic Aperture Radar (SAR) can provide information on the presence of oil at sea. Oil registers as a dark area in the satellite image. However, the so-called ‘look-alikes’ can also register as dark areas, such as algal growth, wind front areas and internal waves. Contextual information will be required to clarify the nature of the dark area.

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1 This Annex is based on a report of substantive law by Professor Frank Maes and Sarah Moens, Ghent University.

2 For an outline of Belgian criminal procedure, see: Organization for Security and Co-operation in Europe, *Report to the Belgian OSCE Chairmanship on the Elaboration of a Reference Guide to Criminal Procedure*, December 2006, http:*//www.osce.org/cio/29043*.

3 Cass., 27 April 1925, *Pas.*, 1925, I, 222; Cass., 17 August 1978, *Pas.*, 1978, I, 1259; Cass., nr. 6288 18 November 1987.

4 Traest, Ph., *Het bewijs in strafzaken*, Gent, Mys en Breesch, 1992, 153-196.

5 International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL) 12 *I.L.M.* 1319 (1973).

To identify the polluter, the AIS position data are necessary.[6] Back-tracking can link the illegal oil discharge and the polluter.

Directive 2005/35/EC[7] tasks EMSA to contribute to the enhancement of the overall maritime safety system within the European Union. One of the goals is to reduce the risk of marine pollution. EMSA works with Member States to develop technical solutions and provide technical assistance in activities such as tracing illegal oil discharges by satellite monitoring and surveillance.

It is for this purpose that CleanSeanet[8] was established. It is a satellite-based monitoring system for marine oil spill detection and surveillance in European waters. The service provides a range of detailed information including oil spill alerts to Member States, rapid delivery of available satellite images and oil slick position.

In relation to Belgium, the images are mainly from RADARSAT or ENVISAT. The experts of Kongsberg Satellite Services (KSAT) analyse the images and send them to the Management Unit of the North Sea Mathematical Models and the Scheldt estuary (MUMM)[9] MUMM is a department of the Royal Belgian Institute of Natural Sciences (RBINS), a federal scientific establishment that comes under the Federal Science Policy (previously known as OSTC). Since December 1990, MUMM has been carrying out aerial monitoring of maritime areas for which Belgium is responsible. This airborne surveillance of the North Sea is undertaken in the context of the Bonn agreement. Each country organises its own surveillance programme in accordance with the guidelines laid down in this Agreement, and joint international exercises are carried out several times a year.

MUMM checks the images, and can decide to send a surveillance airplane or ship to the location of a possible oil spill, upon which they inform the Public Prosecutor.

2.2.1 Cases in Belgium

No cases have been identified in Belgium in which satellite EO information has been used as evidence for illegal oil discharge by vessels at sea. The following is a case in which aerial observations took place, which can be seen as analogous to satellite EO information.

On 27 November 1997, the Court of First Instance Bruges convicted a Belgian captain to pay a fine for discharging oil into Belgian territorial waters, a violation of the MARPOL convention. A Dutch airplane carried out the observation. There were no samples taken. The Court of Appeal Ghent, however, decided on 29 January 1999 that the oil discharge was necessary for the safety of the ship and its crew.

In the *Spyros* case from 19 December 2003, before the Court of Appeal Ghent, the captain of the ship was accused of illegal oil discharge within the Belgian exclusive economic zone. In this case, only pictures, videos taken by an airplane and a report from the agents of MUMM were used as an evidence. The agents told the court that they saw an oil slick behind a ship.

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6 The Automatic Identification System (AIS) is made mandatory within the European Union by Directive 2002/59/EC of the European Parliament and of the Council of 27 June 2002 establishing a Community vessel traffic monitoring and information system and repealing Council Directive 93/75/EC, *OJ L* 208/10, 5 August 2002.

7 Directive 2005/35/EC of the European Parliament and of the Council of 7 September 2005 on ship-source pollution and on the introduction of penalties for infringements, OJ L 255, 30 September 2005, 11.

8 See http://cleanseanet.emsa.europa.eu.

9 See http://www.mumm.ac.be.

When they came closer, they could read the name of the ship. The court accepted this evidence and convicted the captain. There was no discussion about the use of images taken from an airplane as evidence.

2.2.2 Oil Spill as a Case Study in Workshop I

Oil spill as a case study can require a very complex analysis. Depending on where the illegal oil discharge has taken place (in the territorial waters, the exclusive economic zone or the high seas), there can be a different jurisdiction. Normally, the coast state can start proceedings if the illegal discharge took place at his territory. However, the flag state can choose to bring the proceedings in its jurisdiction.[10] The question is whether the evidence, collected by the coast state, such as satellite images, is accepted by the courts of the flag state. If the court of the flag state needs a sample of the oil, but there is no sample taken because it is not obliged by the law of the coast state, there might be a problem.

2.2.3 The Replacement of Aircraft-gathered Information by EO Images

It is possible to replace aircraft gathered-information by satellite data. However, aircraft-gathered information has an advantage in Belgium, as MUMM agents can be regarded as eyewitnesses. Their report can be used as evidence. In addition, with satellite imagery, there is a problem with look-alikes. Only a surveillance airplane or ship can verify this. In some national legislation, a sample is needed. A harmonization of the legislation can be useful to promote the use of satellite images as evidence in criminal proceedings.

Each satellite image has a ‘confidence level’. This indicates the radar quality. External factors such as the wind speed or the surface tension may affect this quality. However, some judges think that this level indicates the probability of an oil slick. To avoid legal counterproductivity, other terminology should be used.[11]

Since article 5bis of the Act of 6 April 1995[12] mentions aerial photography, this is accepted as evidence in court. It might be useful to mention satellite images as a specific form of evidence in national legislation.

2.2.4 Limitations on the Gathering and Use of EO Information as Evidence

2.2.4.1 Privacy

The Act of 8 December 1992 on the protection of privacy concerning the incorporation of personal data deals with privacy issues in Belgium.[13]

The Commission for the Protection of Privacy, also known as the Belgian Privacy Commission, is an independent authority ensuring the protection of privacy during the processing of personal data. The Commission issues opinions and makes recommendations, grants authorizations, checks the way in which personal data are processed, informs and

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10 Article 228, *United Nations Convention on the Law of the Sea*, 1982, 21 *ILM* 1261 (1982).

11 Ferraro G., Baschek B., De Montpellier G., Njoten O., Perkovic M., Vespe M., *On the SAR derived alert in the detection of oil spills according tot the analysis of the EGEMP*, *Marine Pollution Bulletin* 60, 2010, 92.

12 Act of 6 April 1995 for the prevention of pollution from ships, *BS* 27 June 1995 (MARPOL Act).

13 The Act of 8 December 1992 on the protection of privacy concerning the incorporation of personal data, *BS* 18 March 1993.

provides assistance. The Commission was established by the Belgian Federal House of Representatives with the Act of 8 December 1992.[14]

The Privacy Commission has specified that satellite images are regulated by the Act of 8 December 1992.[15] The question was whether satellite images were allowed to be used to determine building offences. Satellite images can be seen as information and the properties on the pictures can be identified.[16] There are enough similarities between satellite images of building offences and satellite images of illegal oil discharges at sea that it is likely that the Commission will give the same advice on satellite images of illegal oil discharges.

This means that the gathering of satellite images of illegal oil discharges must follow the requirements of the Act. First, they can only be used for the specified purpose. Second, it is prohibited to save the information longer then is necessary. As there are criminal sanctions on illegal oil discharges, as described in the Marpol Act, article 8 of the Act of 8 December 1992 applies. The incorporation of judicial data is prohibited, unless they are necessary to achieve a purpose that is described by an Act.

Pro-active investigation, as described in Article 28bis of the Code of Criminal Proceedings, is only allowed for serious crimes and when there is a prior written permission by the public prosecutor.[17] But the permission can only be given when an investigation takes place. And this is not always the case with an illegal oil discharge at sea.

The commission stated that this article must be respected since satellite images are a part of an investigation into offences that have not yet been committed.

Already in her advice of 2006, the Privacy Commission declares that there must be an information campaign about the use of satellite images, because of the serious impact they have on privacy.

3. CONCLUSION

Although EO information has not so far been used as evidence in legal proceedings, Belgian law does not prohibit the use of such information as evidence. However, the specific privacy barriers to the use of EO information need to be recognised and accommodated in its use as evidence.

To be used as evidence the EO information will need to be reliable. For example, in the case of oil pollution at sea, the problem of look-alikes needs to be overcome.

Aerial photography, which is mentioned in legislation, is accepted as evidence in court without difficulty. By analogy, legislation recognising the utility of EO images and other EO information would be useful in promoting their use as evidence in administrative and legal proceedings.

[14] See http://www.privacycommission.be.

[15] Advice nr. 26 / 2006, 12 July 2006.

[16] Article 1 § 1 Act of 8 December 1992 on the protection of the privacy concerning the incorporation of personal data, *BS* 18 March 1993.

[17] *Procureur des Konings.*

APPENDIX: LEGISLATION

International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL) 12 *I.L.M.* 1319 (1973) (adopted by the Act of 17 January 1984 for the adaptation of the International Convention for the Prevention of Pollution from Ships, 1973 and the Protocol of 1978, *BS* 24 May 1984)

The Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances, 13 September 1983 (Bonn Agreement) (Belgium is a contracting party)

Directive 2009/123/EC of the European Parliament and of the Council of 21 October 2009 amending Directive 2005/35/EC on ship-source pollution and on the introduction of penalties for infringements, *OJ L* 280, 27 October 2009, 52

Directive 2005/35/EC of the European Parliament and of the Council of 7 September 2005 on ship-source pollution and on the introduction of penalties for infringements, *OJ L* 255, 30 September 2005, 11

Act of 6 April 1995 for the prevention of pollution from ships, *BS* 27 June 1995 (MARPOL-act)

Article 5bis of the Act of 6 April 1995 mentions that the government can use all kinds of evidence to proof an illegal oil discharge. Evidence can be based on but is not limited to eyewitness reports, pictures and videos.

ANNEX 7.3

USE OF EO INFORMATION AS EVIDENCE IN GERMANY

TABLE OF CONTENTS

1. INTRODUCTION AND METHODOLOGY[1]

The present Report aims to explore when and how space-derived Earth Observation (EO) information can be used as evidence in legal proceedings in Germany. The study sets out to achieve this goal by:

- Examining the legal framework determining the admissibility of EO information as evidence in court;
- Identifying civil, administrative and criminal proceedings in which EO information has been used as evidence; and
- Identifying potential legal and practical problems that lawyers may encounter when attempting to rely on EO information in a judicial setting.

The result of this methodology will be a clearer assessment of:

- How space-derived Earth observation tools relate to judicial procedures now; and
- How they could do so in the future.

All translations are unofficial translations prepared for the benefit of non-German speaking readers. All references to EO information relate specifically to that derived from satellites.

2. LEGISLATIVE FRAMEWORK

There are no specific provisions on the use of EO information in German evidence law. Therefore general rules have to be applied.

2.1 CIVIL LAW

2.1.1 Means of Proof [2]

In most civil proceedings, only five means of presenting evidence are permitted under the German Civil Procedure Code (ZPO):[3]

- Judicial inspection;[4]
- Witness evidence;[5]
- Experts;[6]
- Documents;[7] and
- Questioning of parties.[8]

Each type is regulated by specific provisions of the ZPO.

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1 This Annex is based on research by Johanna Symmons.

2 Beweismittel.

3 Zivilprozessordnung. This principle is called Strengbeweis, and is laid down in sec 284 ZPO.

4 Augenschein, secs 371 to 372a ZPO.

5 Zeugen, secs 373 to 401 ZPO.

6 Sachverständige, secs 402 to 414 ZPO.

7 Urkunden, secs 415 to 444 ZPO.

2.1.1.1 Judicial Inspection

Judicial inspection is direct physical inspection of the evidence by the judge, and is understood to include touching, smelling, listening and tasting. Consequently sound and video recordings and computer records can also be inspected.[9] EO information presented to the court for visual inspection falls into this category, regardless of whether it is presented in electronic or printed form. The court can order that one or more experts be consulted at the time of judicial inspection.[10]

2.1.1.2 Witness Evidence

Witnesses can confirm events that took place in the past that they personally witnessed. They are not parties to the dispute.

2.1.1.3 Experts

In Germany there are formal rules governing experts and the manner in which technical and scientific facts are established. In contrast with common law jurisdictions, in most cases experts are called and examined by the Court. The parties may object to the expert selected by the Court for specific reasons. There are circumstances in which each party appoints its own expert. Such experts are not witnesses, but present written reports to the Court.[11]

Most courts are likely to lack specialist knowledge about the highly sophisticated scientific techniques used in EO technology, and may therefore have to rely on experts, who provide the judge with specialist knowledge he does not possess in order to assess the facts.[12] Only if specialist expert knowledge is required to establish the facts can an expert be asked to give his conclusions.[13] An expert opinion is based on an expert's ability to generate a scientific opinion, based on his practical knowledge or the fact that he is capable of drawing conclusions.[14] Experts do not establish the facts themselves, but are simply required to explain and interpret established facts.

A private expert report commissioned by one of the parties may be admitted as expert evidence only in exceptional cases, with the consent of the other party.

There have been cases in which EO information has been included in expert testimony. Where neither the court nor any other party questions the EO information, judges may accept it without going into much detail, especially if other evidence supports it.[15]

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8 Parteivernehmung, secs 445 to 455 ZPO.

9 See European Commission, European Judicial Network in civil and commercial matters, *Taking evidence and mode of proof – Germany*, http://ec.europa.eu/civiljustice/evidence/evidence_ger_en.htm#5.a.

10 Sec 372 ZPO.

11 For a fuller discussion of the role of experts in the German system see Sven Timerbeil, The Role of Expert Witnesses in German and US Civil Litigation, Annual Survey of International & Comparative Law, Vol 9, Iss 1, Art 8; http://digitalcommons.law.ggu.edu/annalsurvey/vol9/iss1/8

12 Clemens Arzt, *Use of Satellite Imagery in Legal Proceedings*, 24 Air & Space Law 4/5 (1999), p. 195 (199).

13 An example would be a doctor's diagnosis.

14 German Federal Supreme Court (BGH), Decision of 23 November 1973, Monatsschrift des deutschen Rechts 1974, p. 382.

15 Personal communication from Schimmelpfennig and Becke, consulting engineers who specialise in providing expert opinion reconstructing traffic accidents. Satellite information, on-demand digital maps and aerial images are used in the reconstructions. According to the company, the courts have not questioned the accuracy, reliability or authenticity of the EO data used. Also see Arzt, p.203.

2.1.1.4 Documents

Documents within the meaning of the ZPO are written declarations. The law draws a distinction between the evidential value of public documents[16] and of private documents.[17]

Satellite images are not regarded as documents.[18] This is mainly because documents within the meaning of the ZPO must embody human thoughts. Even though the software used to generate satellite images from the raw data is based on human thought, the images themselves do not embody human thoughts. Like photographs, they merely mirror natural phenomena, which are detected by electronic sensors.[19] Even if they did embody human thoughts, satellite images could not be classed as "written" as they cannot be read out in the courtroom.

2.1.1.5 Questioning of Parties

The questioning of parties is subsidiary to other forms of evidence, and is only admissible for the purposes of the main evidence.[20] Parties may only be questioned with the consent of the opposing party or the court.

2.1.1.6 Summary

EO information physically presented in court proceedings is considered evidence for judicial inspection, and not classed as a document. It may need to be accompanied by expert witness testimony.

2.1.2 Probative Value[21]

As satellite images cannot be classed as documents, they do not benefit from the formal probative value assigned to documents.[22] They are therefore subject to the general principle of free evaluation of evidence.[23]

2.1.3 Evaluation of Evidence[24]

The principle of free evaluation of evidence means that the court is free to weigh the reliability or probative value of all available evidence on a case-by-case basis. The judge is bound only by logic, the laws of nature, prior experience and the rules of evidence; otherwise, he may evaluate findings made in the course of the trial according to his own assessment. He is, for example, allowed to believe one party more than a sworn witness or to ascertain that

16 Secs 415, 417 and 418 ZPO. See Reinhold Geimer, Zöller, Kommentar zur ZPO, vor §415, Rn. 4: [Offentliche Urkunden sind]"von Behörden oder hierfür öffentlich bestellten Personen [...] erstellte Zeugnisse über [...] Erklärungen Dritter (§415), über behördliche Erklärungen und Entscheidungen (§417) und über Wahrnehmungen (§418)."

17 Sec 416 ZPO. See http://ec.europa.eu/civiljustice/evidence/evidence_ger_en.htm.

18 VG Regensburg, Final decision of 25.04.1996 (RO7 K94.1846) at p.7 (unpublished).

19 See Arzt, p. 199.

20 Sec 445(2) ZPO.

21 Beweiswert.

22 Sec 415 to 418 ZPO.

23 Sec 286 ZPO.

24 Beweiswürdigung.

the burden of proof has not been satisfied, despite several contrary witness statements.[25] In principle, a judge could decide to favour evidence from EO technology over human evidence.

In its judgment the court must present in a comprehensible way the main reasons and the fundamental viewpoints leading to the formation of its opinion. It is not necessary for the court to go into detail about the claims of each party and the evidence presented; it is sufficient if the reasons in their entirety have led to the relevant judgment having been made.[26] As a result, the use of satellite evidence may not always be documented in the final judgment.

2.1.4 Standard of Proof[27]

The principle of free evaluation of evidence does not mean that that the judge is free to decide what is required to prove the existence of fact.[28] The standard of proof is prescribed by law and, for all legal areas, requires the full conviction of a judge that an alleged fact is true.

2.1.5 Burden of Proof and Disclosure

German civil law is based on the concept that each party produces the evidence on which it relies to support its case.[29] Generally, each party bears the burden of proof for those facts that are advantageous to it. Unlike common law jurisdictions, in German civil law there is no concept of discovery.[30] Subject to the prohibition of misleading the court, a party is under no obligation to provide evidence that may adversely affect its own case or assist its adversary. The court has control over the evidentiary proceedings and can order production of a specific document,[31] but this power is only sparingly used. If certain pieces of evidence are not on record, the court will tend to find that one of the parties has not met its burden of proof.

If EO information could help prove those facts for which a party bears the burden of proof, the extent to which that party has knowledge of and access to the relevant data could influence its chance of winning the case. However, in certain areas of tort law such as producers' liability[32] and environmental liability,[33] there is often a shifting of the burden of proof to the party that has access to the evidence.[34] It remains to be seen how this could become relevant to tort cases involving EO evidence, but possible applications could include tort cases involving environmental disasters such as the Deepwater Horizon.

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25 Zöller/Greger, ZPO, 28th ed. 2010, sec 286 Rn 13.

26 Thomas and Putzo, ZPO, 30th ed 2009, sec 286, Rn 3, 5.

27 Beweismass.

28 Musielak/Stadler, Grundfragen des Beweisrechts (1984), 76f, Benzing 507.

29 Beibringungsgrundsatz, cf. sec 282 ZPO.

30 Hartwig Sprau in Palandt, Kommentar zum BGB, §823, Rn. 183; see also http://www.lk-k.com/data/document/discovery-international-arbitration-how-much-too-much-schiedsvz-2004-pp.13-21-co-author.pdf.

31 The amended version of sec 142 ZPO, which came into force on 1 January 2002, not only gives the court the right to order the production of a document which is in possession of a party or a third party, but it also makes it clear that if the party so ordered fails to come forward with the document, the court may draw adverse inferences from this and deem the alleged facts about the documents to be true.

32 See Hühnerpest Case, BGHZ 51, 91.

33 See Kupolofen Case, BGHZ 143, NJW 1985,47; cf also sec 6 Environmental Liability Act (Umwelthaftungsgesetz –UmweltHG), which makes it easier to prove causality.

34 Beweislastumkehr.

2.2 ADMINISTRATIVE LAW

The taking of evidence generally follows the rules contained in the Civil Code of Procedure (ZPO), according to sec 98 of the Code of Administrative Court Procedure (VwGO),[35] as far as it is not explicitly provided otherwise by the Federal Administrative Court Procedure Act (VwVfG).[36] Admissible evidence may include any means of cognition that is suitable to convince the authority's officer about the existence or non-existence of facts, such as experts, witnesses, judicial inspection and other enquiries of any kind.[37] The court has discretion in assessing the probative value of the evidence submitted.[38]

Unlike in civil proceedings, the inquisitorial principle[39] applies, which means that the court must investigate all facts by suitable means of evidence. However, the principle of proportionality,[40] which is fundamental to German public law, could prevent administrative authorities from using satellite images as evidence if the cost of providing satellite imagery is significantly higher than other means of evidence supporting the same facts.

2.3 CRIMINAL LAW

The Criminal Procedure Code (StPO)[41] lists the following permitted ways to present evidence to the court:

- Witnesses;[42]
- Experts;[43]
- Judicial inspection;[44]
- Documents;[45] and
- The testimony of the accused.[46]

If presented at trial without the explanation of a witness or expert, EO information will be considered as evidence for judicial inspection. Often there will be a need for EO evidence to be accompanied by testimony of the person who produced that piece of evidence.[47] Standardised devices and methods could relieve the court from having to rely on expert opinion when deciding a specific case.[48] Satellite images may also constitute part of an expert

35 Verwaltungsgerichtsordnung.

36 Verwaltungsverfahrensgesetz.

37 Sec 26 VwVfG.

38 Sec 24 VwVfG.

39 Untersuchungsgrundsatz, sec 24 VwVfG.

40 Verhältnismässigkeit.

41 Strafprozessordnung.

42 Sec 48ff StPO.

43 Chapter VII, secs 72 ff, StPO, and sec 85.

44 Sec 86 StPO.

45 Sec 249 StPO.

46 Sec 136 StPO.

47 Arzt, p.200.

48 Cf German Federal Penal Court (BGH), Neue Zeitschrift fur Verkehrsrecht 1993, 485.

opinion or act as a visual aid to testimony.[49] As in civil law, EO information cannot be classed as documentary evidence[50] because it cannot be read out in the courtroom, which in general is a requirement for documentary evidence.[51]

The Court has discretion in assessing the probative value of evidence.[52] Given the potentially serious repercussions for the accused, the court has to investigate[53] the facts of a criminal case even more thoroughly than in administrative cases.

3. CASES

A search for specific keywords[54] in the German legal database *juris*[55] revealed less than 20 cases that mention the use of EO information as evidence.[56]

It is possible that there are more cases involving EO information as evidence, but these are not reported in *juris*.[57] However, this Study has found that references to EO in the literature are not consistent: terms used include earth observation, remote sensing, satellite imagery, satellite data, satellite monitoring and combinations of these and other terms, making it difficult to identify the use of this technology from database searches alone.

Furthermore, the results found on *juris* may not accurately reflect the actual usage of satellite data before German courts because *juris* does not list unpublished cases.[58] In addition, the keyword search would only identify cases in which the EO information was explicitly mentioned in the court's decision. Cases where EO information was submitted as part of an expert opinion, but not mentioned in the judgment, will not appear in *juris*.

The cases that do mention EO information as evidence range from tort cases involving personal injury and libel, to administrative cases involving street cleaning charges, urban planning law, agricultural subsidies, forestation and emissions permits. The EO information was mainly used in the same way as an aerial photograph, to show the location of an object or the character of the area.

In most cases, the satellite images used were Google Earth pictures, and no expert opinion or expert witness statement was required. Overall, the number of cases in which satellite images were used appears to have increased over the last five years, possibly owing to increased awareness and the availability of such products.

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49 Vernehmungshilfe.

50 Urkundenbeweis, sec. 249 StPO.

51 Meyer-Goβner, Strafprozessordnung, 51 ed. 2008, Rn 49; U. Eisenberg, Beweisrecht der StPO, 3rd ed. 1999, Rn. 2003.

52 Sec 261 StPO.

53 Sec 244 (2) StPO.

54 Search terms and their approximate English equivalents: Satellitenfotos (satellite photos), Satellitenbilder (satellite pictures), and Satellitenaufnahmen (satellite images).

55 See www.juris.de.

56 Most of the cases found on juris were administrative law cases. No criminal law cases were reported.

57 This is supported by a personal communication from Prof Helmut Ruessman, 9 November 2010.

58 Unpublished cases which deal with the use of satellite EO data as evidence and involve an expert opinion, but do not appear in juris include VG Regensburg, Final Decision of 25.04.1996 (RO 7 K94.1846) at p.7; see supra Fn.7.

None of these cases relate to subsidence or marine oil spills, which form Case Studies in this Study.[59] Interviews with relevant parties[60] suggest that satellite images have not yet been used as evidence in these contexts. The *juris* search results contain only one example of an expert opinion involving EO information.[61] The question of admissibility of the satellite evidence was raised in only one case. Similarly, only one case touched on the accuracy and evidentiary value of data obtained through satellite EO.

Some cases are summarised below. More detailed case summaries, as well as excerpts from some cases, can be found in Appendix C: Cases.

3.1 CIVIL LAW: TORT

All four tort cases found on *juris* were appeals before Higher Regional Courts (OLG), including the Upper Court (KG) Berlin.[62] In all four cases, Google Earth images were used. The (KG) Berlin decided two cases, both related to traffic accidents.[63]

3.1.1 **KG Berlin**, 12. Zivilsenat, Decision of 07/01/2010, 12 U 20/09[64]

The parties had used pen markings on satellite images to describe the location of objects at the time of the accident. The parties presented conflicting versions of the events and the lower court dismissed the defendant's version. Based on the satellite picture and the court's knowledge of the area, the KG Berlin confirmed the lower court's decision that held that the demarcation posts at the scene of the accidents would have been damaged if the defendant's account were accurate. The Appeals Court also upheld the lower court's rejection of an expert opinion reconstructing the traffic accident because it was impossible to determine the exact final position of the vehicles involved in the accident.

3.1.2 **KG Berlin**, 12. Zivilsenat, Decision of 28/05/2009, 12 U 43/09[65]

The court used a satellite image to dismiss the appellant's claim that there was no free viewpoint at the scene of the accident.

3.1.3 **OLG München**,1. Zivilsenat, Judgment of15.03.2007, 1 U 5030/06

The Oberlandesgericht (OLG) München decided a case concerning a woman who slipped on icy ground while on her way to a curling match. The EO image presented to the court provided evidence of the location.

59 Annex 1: Workshop Report, , pp. 127-136, Sections 7 and 8..

60 These two categories are relevant to the Final Report of this Project. Personal communication with Katrin Hiersemenzel, Oberstaatsanwältin, Staatsanwaltschaften Hamburg; Dirk Reichenbach, Expert, Havariekommando Cuxhaven and Dr Hannes Taubenböck, Scientist, German Remote Sensing Data Centre (DFD) of the German Aerospace Centre (DLR); Josef W Wagerer, consultant, Wagerer Geoconsult.

61 VG Minden, 3. Kammer , Judgment of 16/11/2005, 3K 2986/03; reported in AUR 2006, 433-437.

62 The German Higher Regional Courts are the OLG (Oberlandesgericht), or the equivalent KG (Kammergericht) Berlin. These Courts function between the regional court *(Landgericht)* and the Federal Court of Justice BGH *(Bundesgerichtshof)*.

63 See Appendix B.2 of this Annex.

64 Reported in MDR 2010, 748.

65 Reported in MDR 2009, 1244.

3.1.4 OLG Düsseldorf,15. Zivilsenat, Judgment of 20/12/2008, I-15 U 176/07, 15 U 176/07

The OLG Düsseldorf decided a libel case relating to the publication of a satellite image.[66] A German magazine had published an article about the dangers that Google Earth poses to privacy, which included a Google Earth image of the property of a well-known German quizmaster showing what it claimed was "a yacht bobbing up and down in the water by the pier" in a lake where motorised boats are banned. The quizmaster argued that the object visible on the satellite image was not a motorboat, that he did not own one, and that the magazine should publish a clarification to that effect. The court held that the object was a boat, but that the article did not necessarily suggest that this boat belonged to the quizmaster.

3.2 ADMINISTRATIVE LAW

As with civil law cases, there has been a marked increase in reported administrative cases since 2006. The *juris* search returned a total of 11 relevant cases. The courts included lower level administrative courts (VG),[67] higher level administrative courts (OVG)[68] and Verwaltungsgerichtshof, and the Federal Administrative Court (BVerwG).[69] The OVG Sachsen and the Bayerischer Verwaltungsgerichtshof were the most active users of satellite evidence, with three cases each. Google Earth images are commonly used.

All these cases involved land use, and most concerned urban zoning:

- Three concerned a judicial review of the council's decision to charge the owners of a specific property street-cleaning fees;[70]
- Three concerned planning permission;.[71]
- One concerned the validity of a binding land use plan or zoning map more generally;.[72]
- One concerned agricultural subsidies;[73]
- One concerned a forestation permit;[74]
- One concerned a pollution control permit;[75] and
- One concerned reclaiming property in the former GDR.[76]

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66 Reported in NJW 2008, 1825-1826.

67 Verwaltungsgericht.

68 Oberverwaltungsgericht.

69 Bundesverwaltungsgericht.

70 Bayerischer Verwaltungsgerichtshof Munchen, 4. Senat, Decision of 04/08/2008, 4 ZB 08.59; Bayerischer Verwaltungsgerichtshof München, 4. Senat, Decision of 04/08/2008, 4 ZB 08.55; Sächsisches Oberverwaltungsgericht, 5. Senat, Judgment of 28/03/2007, 5B 45/05; reported in LKV 2008, 176-178.

71 Oberverwaltungsgericht des Landes Sachsen-Anhalt, 2. Senat, Decision of 21/01/2010, 2 L 54/09; reported in NVwZ-RR 2010, 465-468; Oberverwaltungsgericht des Landes Sachsen-Anhalt, 2. Senat, Judgment of 22/06/2006; 2 L 910/03; reported in BauR 2006, 1943; Verwaltungsgericht Ansbach, 9. Kammer, Judgment of 11/06/2008, AN 9 K 07.02197.

72 Bundesverwaltungsgericht, Decision of 2 December 2008, BVerwG 4BN14.08BVerwG.

73 VG Minden, 3. Kammer, Judgment of 16/11/2005, 3K 2986/03; reported in AUR 2006, 433-437.

74 Bayerischer Verwaltungsgerichtshof München, 19.Senat, Judgment of 26/01/2000, 19B 96.3382.

75 Oberverwaltungsgericht des Landes Sachsen-Anhalt, 2. Senat, Decision of 29/01/2010, 2 M226/09; reported in BauR 2010, 888-893.

In each case in which the satellite images were used, it was usually in conjunction with other plans and maps, and in some cases also by physical inspection, to help assess the location and the character of the area as a *continuously built up area*.[77]

Only one case touched on the admissibility of satellite evidence. In the case before the Federal Administrative Court,[78] the local municipality challenged a court decision to declare invalid the local municipality's binding land, use on the basis that it had not seen the Google Earth image on which the court had based its decision. The court dismissed this objection on the grounds that Google Earth was freely available to all and that they had also based their decision on physical inspection.

The evidentiary value of EO information was mentioned in an agricultural subsidies case decided by the administrative court of Minden.[79] Here, the court referred to an expert opinion in which the expert explained that measurements obtained using remote sensing were not exact because they had been made using satellite imagery that was itself imprecise.

Separately, the Administrative Court of Frankfurt (Oder) held that a Google Earth picture with hand-drawn boundaries of a property did not prove the claimant's assertion regarding boundaries and location of objects.[80]

3.3 CRIMINAL LAW

It was not possible to identify cases in which EO information was used as evidence in criminal proceedings. No reported cases were found in which satellite data was used as evidence for illegal oil discharge by vessels at sea. At present, the facts found during aerial surveillance alone are not sufficient to justify a conviction, even if SLAR, IR/UV Scanner, MWR and photo or video camera systems are employed.[81] This evidence must be supplemented by technical inspection onboard, and oil samples. Similarly, non-space based thermal camera pictures have reportedly only been used as supporting evidence, in criminal cases relating to marijuana production. [82]

4. POTENTIAL LIMITATIONS

There are some legal constraints on the use of EO information as evidence in courts and tribunals. These are summarised below.

4.1 ADMISSIBILITY OF SATELLITE EVIDENCE

Violation of privacy is a constitutional concern that may arise when using EO information. Other possible areas of concern are violations of industrial trade secrets and national security.

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76 Verwaltungsgericht Frankfurt (Oder), 8.Kammer, Judgment of 27/11/2006, 8K 1020/01.

77 Geschlossene Ortslage.

78 Bundesverwaltungsgericht, Decision of 2 December 2008, BVerwG 4BN14.08.

79 VG Minden, 3. Kammer , Judgment of 16/11/2005, 3K 2986/03; reported in AUR 2006, 433-437.

80 Verwaltungsgericht Frankfurt (Oder), 8.Kammer, Judgment of 27/11/2006, 8K 1020/01.

81 Bonn Agreement, Oil Pollution at Sea Manual, Effective Prosecution of Offenders, Chapter 3, Evidence required in different Bonn Agreement countries; http://www.bonnagreement.org/eng/html/fepo_manual/chapter_3.htm#GERMANY.

82 Personal communication from Clemens Louis, Rechtsanwalt, 10 November 2010.

4.1.1 Privacy

Satellite evidence could violate the fundamental right to informational self-determination,[83] rooted in the German Basic Law[84] and articulated by the German Federal Constitutional Court[85] in its 1983 Census decision.[86]

This fundamental right was understood by the court to be the authority of an individual to decide, on the basis of the principle of self-determination, when and within what limits information about his or her private life should be committed to others. It protects the individual against unrestricted inquiry, storage, use, and circulation of his personal data, and forms the core principle of German data protection legislation.[87]

With regard to satellite images, the fundamental right to informational self-determination was successfully invoked in a 2006 decision of the Federal Constitutional Court.[88] The court held that a person's privacy rights are affected if satellite pictures of otherwise publicly inaccessible property are published in conjunction with the address or directions, thereby revealing the identity of the occupants.

The Constitutional Court did not address the issue of the admissibility of such satellite images as evidence. However, potential limitations could be derived from Constitutional Court decisions concerning the use of automated speed camera evidence. In 2008 and 2009, the Constitutional Court held that certain automated video recordings taken in the course of automatic number plate recognition (ANPR) and speed controls violated the fundamental right to informational self-determination,[89] which put into question their use as evidence.[90]

However, the right to informational self-determination is not unlimited. First, data is only protected if it is related to an individual. Under the Law relating to intellectual property in works of art and photography,[91] every individual has the right to decide when and how he wants to present his picture to the public.

The Federal Data Protection Law contains similar provisions.[92] Satellite images on which individuals are clearly recognisable may therefore not be published without those individuals' consent, although the law provides an exception for persons accidentally captured in the background.[93] Generally, satellite or aerial images are not deemed to be personal if they have

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83 Recht auf informationelle Selbstbestimmung, Art 1 (1) and Art 2(1).

84 Grundgesetz (GG); see also Art 8 European Convention on Human Rights (ECHR).

85 Bundesverfassungsgericht (BVerfG).

86 Amtliche Sammlung des Bundesverfassungsgerichts (BVerfGE) 65,1- Volkszählung. Urteil des Ersten Senats vom 15. 12. 1983 – 1 BvR 209, 269, 362, 420, 440, 483, 484; see also NJW 1984, 419.

87 See e.g. Federal Data Protection Law, Bundesdatenschutzgesetz (BDSG).

88 BVerfGE vom 02.05.2006, 1 BvR 507/01, NJW 2006, 2836, 2837.

89 BVerfG, 1 BvR 2047/05 vom 11.3.2008, Absatz-Nr (1-85), http://www.bverfg.de/entscheidungen/rs20080311_1bvr207405.html; BVerfG, Geschwindigkeitsmessung durch Videoaufzeichnung, NZV 2009, 618.

90 Cf. Meyer-Goβner, Rn.56

91 Gesetz betreffend das Urheberrecht an Werken der bildenden Künste und der Photographie (KunstUrhG), sec 22 ff.

92 Bundesdatenschutzgesetz (BDSG); Sec 4 (1) BDSG, see also sec 1 (1) and sec 3(1) BDSG.

93 Sec 23 (1) KunstUrhG.

a pixel size of more than 40 cm, although case by case analysis is necessary.[94] This value is based on case law of the Federal Constitutional Court relating to aerial pictures.[95]

Satellite images of buildings may usually be published without the owner's consent, unless the images capture a part of the property not usually visible to third parties,[96] create a false image of the owner,[97] or reveal the identity of the occupants coupled with a description of how to get to the property.[98] The recent launch of Google Street View Germany has sparked a debate in this context,[99] resulting in an agreement by Google to blur certain properties if requested to do so by the owner.[100]

Second, even if the data is related to a person, the right to informational self-determination may be limited if there is a prevalent public interest. In a July 2010 ruling,[101] the Constitutional Court ruled that the right of drivers to safe roads is such a prevalent public interest and the use of automated speed cameras is therefore not unconstitutional, provided that it is based on an Act of Parliament and not a Ministerial Decree.

4.1.2 Trade Secrets

The right to property under Art 14 German Basic Law (GG)[102] includes the right to intellectual property. Protection is not limited to copyright, patents and trademarks, but also includes business and trade secrets. Such trade secrets can often be linked to a tangible piece of land. The dissemination of satellite information about a particular plot of land that could have an economic impact, such as information about flooding, landslide risk or soil quality, could therefore violate fundamental rights,[103] and render it more difficult to use such data as evidence at trial. However, like the right to informational self-determination, the right to property can be limited under Art 14 (2), if it is in the public interest.

The dissemination of EO information could violate the fundamental rights contained in Art 14 and possibly also Art 12 GG and therefore should be treated as an issue of privacy with concerns similar to those for an individual mentioned above where.

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94 Karg, *Datenschutzrechtliche Rahmenbedingungen fur die Bereitstellung von Geodaten fur die Wirtschaft* [Ampelstudie], p.67; http://www.datenschutzzentrum.de/geodaten/datenschutzrechtliche-rahmenbedingungen-bereitstellung-geodaten.pdf.

95 BVerfG, Beschl. v. 02. Mai 2006, 1 BvR 507/01, NJW 2006, 2836, 2837.

96 BGH NJW 2004, 762 (762).

97 See OLG Dusseldorf, ZUM-RD 2008, 469, discussed in tort section above.

98 BVerfG ZUM 2006, 631.

99 See Lindner, *Persönlichkeitsrecht und Geo-Dienste im Internet – z.B. Google Street View/Google Earth*, ZUM (2010), 29.

100 Ingram, *Google Street View Opt Out Goes Live in Germany While Spain Investigates*, Gigaom, 18 Aug 2010, http://gigaom.com/2010/08/18/google-street-view-opt-out-goes-live-in-germany-while-spain-investigates/; see also BBC News, German vandals target Street View opt-out homes, 24 November 2010, and http://www.bbc.co.uk/news/technology-11827862.

101 BVerfG, Beschl. V. 05. Juli 2010, 2 BvR 759/10.

102 Grundgesetz.

103 See Karg and Weichert, *Datenschutz und Geoinformationen* (2007), p. 11, https://www.datenschutzzentrum.de/geodaten/Datenschutz-und-Geoinformationen.pdf; Brammsen, Wirtschaftsgeheimnisse als Verfassungseigentum, DÖV 2007, 10 ff.

4.1.3 National Security

Under Germany's 2007 Satellite Data Security Act (SatDSiG),[104] all providers of "high-grade"[105] satellite EO data require a licence to operate.

National security concerns could limit access to certain satellite EO data for certain parties. SatDSiG[106] prescribes a procedure and defines criteria for data sensitivity checks for customer requests, to determine any potential security risk. As regards target area, access to very high-resolution data of some regions, for example regions with military operation zones, will be excluded for almost all customers.[107]

Separately, public access to spatial data and spatial service providers can also be restricted under the (Federal) Spatial Data Access Law (GeoZG),[108] if access could negatively affect international relations, public security or national security.

4.2 PROBATIVE VALUE OF SATELLITE EVIDENCE

4.2.1 Accuracy

If scientific evidence carries a high margin of error, German courts will often require additional supporting evidence. DNA-fingerprinting is a case in point.[109] In 1992 the German Federal Court quashed a conviction in which a DNA-fingerprint was used as the only piece of evidence for the conviction of a man accused of rape. Based on an expert opinion that established a 0.014 % chance that the man in question was not the rapist, the court concluded that 35 out of the 250,000 inhabitants could have been the rapist based on DNA-fingerprinting results, a number too significant to exclude anybody else from being the possible rapist.[110] For this reason, the court demands that DNA-fingerprints are accompanied with other evidence for a conviction.

Given, for example, the reported high number of false positives in satellite identification of oil spills,[111] certain applications of satellite earth observation technology could face similar problems over acceptable margins of error. This would not exclude satellite imagery from being used in court, but it might result in the need for additional supportive evidence.

4.2.2 Reliability of Technology

A court may question certain technical assumptions, such as whether the satellite has been working properly. Proof of correct functioning and processing from expert witnesses might

104 Satellitendatensicherheitsgesetz.

105 Sec 2 (1) 4 SatDSiG says these are systems with sensors that are capable of capturing imagery with an especially high amount of information ("...Sensoren technisch in der Lage...Daten mit besonders hohem Informationsgehalt..."). According to Leif Orvald, Legal & Finance at RapidEye, it seems the authorities draw the line at 2.5m resolution,17 May 2010, Personal Communication.

106 Sec 17.

107 Schmidt-Tedd and Kroyman, Developments in German Remote Sensing Law, 34 Journal of Space Law (2008), 97 (115).

108 Sec 12 I.

109 Arzt, p.201.

110 BGHSt 38, 320. See also Arzt, p.201; and CCG Aitken, B Schafer and D Mavridis, Expert Statistics, 20 June 2008, p.35, http://www.maths.ed.ac.uk/~cgga/expert-statistics-lpr.pdf.

111 See Linda Corucci, Fabio Nardelli and Marco Cococcini, Remote Sensing, Detecting Oil Spills from Space, 21 Oct 2010, Spie Newsroom, http://spie.org/x42014.xml?ArticleID=x42014.

be necessary. Case law related to speed camera evidence shows that standardised devices and methods can relieve the court from having to rely on expert opinion on a regular basis,[112] but expert opinion is still needed where a case shows specific difficulty or where inaccuracy is likely.

4.2.3 Authenticity of Data

A court may require evidence that a EO information comes from the original data and has not been changed in a way that could affect its probity.[113]

4.3 PROPORTIONALITY AND COSTS

As mentioned in Section 1 of this Report, the principle of proportionality[114] is fundamental to German public law, and could prevent administrative authorities from using satellite images as evidence if the cost of providing satellite imagery is significantly higher than other means of evidence supporting the same facts.

5. CONCLUSIONS

5.1 ADMISSIBILITY

There are few legal obstacles to the admissibility of EO information as evidence. Only one case could be found in which the admissibility of satellite evidence was challenged, and the court rejected the claim.[115]

Privacy rights are a hotly debated issue in Germany, but their violation will not necessarily prohibit the use of satellite EO data in court if the data is not of a personal nature or can be justified in the public interest.

5.2 PROBATIVE VALUE OF SATELLITE EVIDENCE

Accuracy, reliability and authenticity are issues which affect not only satellite data, but all forms of scientific and technical evidence. Where there are large margins of error, additional evidence will generally be required.

Advances in technology and the standardisation of data collection, storage, processing and handling procedures should build trust in satellite data, as has been demonstrated for devices testing blood alcohol level and for speed cameras. The Draft International Standard for audit and certification of trustworthy digital repositories, proposed by the International standards Organisation (ISO) is a step in this direction.[116] However, standardisation is not binding upon the court. German courts do not regard such standards as being "objective" even those established by highly respected organisations like the German Standards Institution (DIN).[117]

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112 BGHSt in: Neue Zeitschrift für Verkehrsrecht 1993, p.485.

113 Cf Kopp, Rechtliche Perspektiven zur digitalen Beweisführung, 5.1 ff, http://subs.emis.de/LNI/Proceedings/Proceedings154/gi-proc-154-116.pdf

114 Verhältnismässigkeit.

115 Federal Administrative Court Decision of 2 December 2008, BVerwG 4BN14.08.

116 Draft International Standard ISO/DIS 16363, 2010, Space data and information transfer systems - Audit and certification of trustworthy digital repositories, http://www.iso.org/iso/catalogue_detail.htm?csnumber=56510

117 BVerfGE 77, 285 (291).

Although German courts have accepted Google Earth images as evidence without requiring an expert opinion, more sophisticated satellite evidence is likely to require validation and interpretation by an expert. However, it is unclear what minimum skills and knowledge an expert must possess to interpret EO information. Due to the many possible applications of EO information,[118] it is also unclear whether such core qualifications can be identified to apply to all, or whether specialist skills are needed for each area of application.

Dialogue with the computer law community may be fruitful, in particular as far as authentication of data and the accreditation of experts is concerned.[119]

5.3 COSTS, ACCESS AND AWARENESS

Although the cost of satellite imagery has been one the most prohibitive factors of its use in a legal context, an increase in numbers of operational satellites means that there is access to more timely, accurate and cost-effective data.[120] With increased commercial EO activity, there has been a sharp increase in awareness and access to EO technologies. German case reports show a corresponding increase in the use of EO evidence in a judicial setting.

The relatively widespread use of Google Earth images in a legal setting suggests that availability and familiarity with particular EO products can have an impact on its increased use. There may not be the same level of familiarity with complex and sophisticated EO technologies.

EO information has been used to form scientific and political opinions on urban planning, for instance in the REFINA project.[121] However, there may not be a parallel awareness of how EO information may fit into a legal framework.[122]

A significant potential use for EO technologies is to provide historical evidence.[123] Other uses of satellite evidence in judicial proceedings could include crop insurance claims and zoning disputes, or cases involving urban encroachment on a pipeline or other supply line.[124]

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118 See sec. 4 GeoZG.

119 Cf. Pan-European ITU survey on computer forensics, http://www.itu.int/osg/csd/cybersecurity/WSIS/3rd_meeting_docs/contributions/libro_aeec_en.pdf .

120 Purdy, Using earth observation technologies for better regulatory compliance and enforcement of environmental laws, J. Env.L 2010, 59 (61).

121 Research for the Reduction of Land Consumption and for Sustainable Land Management (REFINA), http://www.refina-info.de/.

122 Personal communication 4 October 2010 from Hannes Taubenböck, an editor of Fernerkundung im urbanen Raum, Erdbeobachtung auf dem Weg zur Planungspraxis, 2010, which concerns the use of EO information in urban planning. He also stated that he is "not aware of a legal framework in which satellite data was also used for legal processes in urban planning." Cf. also Höffken, Google Earth in der Stadtplanung, Berlin 2009, http://www.isr.tu-berlin.de/publikationen/popups/gr/gr19.html.

123 Reichenbach, Havariekommando expert, telephone interview, July 2010; VG Regensburg, Final decision of 25.04.1996 (RO7 K94.1846) at p.7 (unpublished).

124 Personal communication from Leif Orvald, Legal Head at German satellite service provider RapidEye, 27 May 2010.

APPENDIX A: LEGISLATION

A.1 LEGISLATION RELATING TO SECTION 2: LEGISLATIVE FRAMEWORK

Strafprozessordnung (StPO) (Criminal Procedure Code)
in der Fassung der Bekanntmachung)
vom 7. April 1987 (BGBl. I S. 1074, 1319), die zuletzt durch Artikel 3 des Gesetzes vom 30. Juli 2009 (BGBl. I S. 2437) geändert worden ist
German version: http://www.gesetze-im-internet.de/stpo/BJNR006290950.html
English translation: http://www.gesetze-im-internet.de/englisch_stpo/index.html

Umwelthaftungsgesetz (UmweltHG) (Environmental Liability Act)
vom 10. Dezember 1990 (BGBl. I S. 2634), das zuletzt durch Artikel 9 Absatz 5 des Gesetzes vom 23. November 2007 (BGBl. I S. 2631) geändert worden ist
German version: http://www.gesetze-im-internet.de/bundesrecht/umwelthg/gesamt.pdf

Verwaltungsgerichtsordnung (VwGO) (Code of Administrative Court Procedure)
in der Fassung der Bekanntmachung vom 19. März 1991 (BGBl. I S. 686), die zuletzt durch Artikel 3 des Gesetzes vom 21. August 2009 (BGBl. I S. 2870) geändert worden ist
German version: http://www.gesetze-im-internet.de/vwgo/BJNR000170960.html
English translation: http://www.gesetze-im-internet.de/englisch_vwgo/index.html

Verwaltungsverfahrensgesetz (VwVfG) ((Federal) Adminstrative Procedure Act)
in der Fassung der Bekanntmachung vom 23. Januar 2003 (BGBl. I S. 102), das zuletzt durch Artikel 2 Absatz 1 des Gesetzes vom 14. August 2009 (BGBl. I S. 2827) geändert worden ist
German version: http://www.gesetze-im-internet.de/bundesrecht/vwvfg/gesamt.pdf

Zivilprozessordnung (ZPO) (Civil Procedure Code)
in der Fassung der Bekanntmachung vom 5. Dezember 2005 (BGBl. I S. 3202; 2006 I S. 431; 2007 I S. 1781), die zuletzt durch Artikel 3 des Gesetzes vom 24. September 2009 (BGBl. I S. 3145) geändert worden ist
German version: http://www.gesetze-im-internet.de/zpo/BJNR005330950.html

A.2 LEGISLATION RELATING TO SECTION 3: CASES

Baugesetzbuch (BauGB) (Federal Building Code)
in der Fassung der Bekanntmachung vom 23. September 2004 (BGBl. I S. 2414), das zuletzt durch Artikel 4 des Gesetzes vom 31. Juli 2009 (BGBl. I S. 2585) geändert worden ist
German version: http://www.gesetze-im-internet.de/bbaug/BJNR003410960.html
English translation: http://www.iuscomp.org/gla/statutes/BauGB.htm

Bundesimmissionsschutzgesetz (BImSchG) (Federal Emission Control Law)
in der Fassung der Bekanntmachung vom 26. September 2002 (BGBl. I S. 3830), das zuletzt durch Artikel 3 des Gesetzes vom 11. August 2010 (BGBl. I S. 1163) geändert worden ist
German version: http://www.gesetze-im-internet.de/bimschg/BJNR007210974.html

Strassenreinigungs-und-sicherungsverordnung der Stadt Würzburg (Street Cleaning and Road Safety Regulation)
vom 30. Dezember 1998 (MP und VBl. Nr. 300)
letzte Änderung vom 08. Dezember 2006 (MP und VBl. Nr. 283), in Kraft ab 09. Dezember 2006
German version : http://www.wuerzburg.de/m_12429

Strassenverkehrs-Ordnung (StVO) (Road Traffic Law)
vom 16. November 1970 (BGBl. I S. 1565), die zuletzt durch
Artikel 1 der Verordnung vom 5. August 2009 (BGBl. I S. 2631) geändert worden ist
German version: http://www.gesetze-im-internet.de/bundesrecht/stvo/gesamt.pdf

A.3 LEGISLATION RELATING TO SECTION 4: POTENTIAL LIMITATIONS

Brandenburgisches Vermessungsgesetz (BbgVermG) (Land Brandenburg Surveying Law)
Vom27. Mai 2009, S.166), geändert durch Artikel 2 des Gesetzes vom 13. April 2010 (GVBl.I/10, (Nr. 17))
German version:
http://www.bravors.brandenburg.de/sixcms/detail.php?gsid=land_bb_bravors_01.c.48117.de

Bundesdatenschutzgesetz (BDSG) (Federal Data Protection Act)
in der Fassung der Bekanntmachung vom 14. Januar 2003 (BGBl. I S. 66), das zuletzt durch Artikel 1 des Gesetzes vom 14. August 2009 (BGBl. I S. 2814) geändert worden ist
German version: http://www.gesetze-im-internet.de/bdsg_1990/BJNR029550990.html
English translation:
http://www.bfdi.bund.de/cae/servlet/contentblob/411288/publicationFile/25384/Bundesdatenschutzgesetz-FederalDataProtectionAct.pdf

European Convention for the Protection of Human Rights and Fundamental Freedoms (ECHR)
English version: http://www.echr.coe.int/NR/rdonlyres/D5CC24A7-DC13-4318-B457-5C9014916D7A/0/ENG_CONV.pdf

Geodatenzugangsgesetz (GeoZG) ((Federal) Spatial Data Access Law)
vom 10. Februar 2009 (BGBl. I S. 278)
German version: http://www.gesetze-im-internet.de/bundesrecht/geozg/gesamt.pdf
English translation: N/A: law implements the EU's INSPIRE Directive (Directive 2007/2/EC
of 14 March 2007), http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2007:108:SOM:EN:HTML

Gesetz betreffend das Urheberrecht an Werken der bildenden Künste und der Photographie (KunstUrhG) (Law relating to intellectual property in works of art and photography)
in der im Bundesgesetzblatt Teil III, Gliederungsnummer 440-3, veröffentlichten bereinigten Fassung, das zuletzt durch Artikel 3 § 31 des Gesetzes vom 16. Februar 2001 (BGBl. I S. 266) geändert worden ist
German version: http://www.gesetze-im-internet.de/kunsturhg/BJNR000070907.html

Grundgesetz (GG) (German Basic Law)
für die Bundesrepublik Deutschland in der im Bundesgesetzblatt Teil III, Gliederungsnummer 100-1, veröffentlichten bereinigten Fassung, das zuletzt durch das Gesetz vom 21. Juli 2010 (BGBl. I S. 944) geändert worden ist
German version: http://www.gesetze-im-internet.de/gg/BJNR000010949.html
English translation: http://www.gesetze-im-internet.de/englisch_gg/index.html

Informationsfreiheitsgesetz (IFG) ((Federal) Freedom of Information Act)
vom 5. September 2005 (BGBl. I S. 2722)
German version: http://www.gesetze-im-internet.de/ifg/BJNR272200005.htm
English translation: http://www.gesetze-im-internet.de/englisch_ifg/index.html

Satellitendatensicherheitsgesetz (SatDSiG) (Satellite Data Security Law)
vom 23. November 2007 (BGBl. I S. 2590)
German version:
http://www.landtag.nrw.de/portal/WWW/dokumentenarchiv/Dokument/XBCBGI0758.pdf
English translation (unofficial): Schmidt-Tedd, Bernhard and Kroyman, Max, Developments in German Remote Sensing Law, 34 Journal of Space Law (2008), 97

Umweltinformationsgesetz (UIG) (Environmental Information Act)
vom 22. Dezember 2004 (BGBl. I S. 3704)
German version: http://www.gesetze-im-internet.de/bundesrecht/uig_2005/gesamt.pd
English translation: http://www.iuscomp.org/gla/statutes/UIG.htm

A.4 LEGISLATION RELATING TO SECTION 5: CONCLUSIONS

Directive 2007/2/EC of the European Parliament and the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)
English version: http://inspire.jrc.ec.europa.eu/index.cfm/pageid/3

Draft International Standard ISO/DIS 16363, 2010, Space data and information transfer systems - Audit and certification of trustworthy digital repositories
English version: http://www.iso.org/iso/catalogue_detail.htm?csnumber=56510

Verordnung ueber die Berufsausbildung in der Geoinformationstechnologie (Regulation concerning vocational training in spatial information technology)
vom 30. Mai 2010 (BGBl. I S.694)
German version: http://www.bibb.de/dokumente/pdf/10062010.pdf

APPENDIX B: CASES

B.1 CASES MENTIONED IN SECTION 2: LEGISLATIVE FRAMEWORK

BGH (Federal Supreme Court), Decision of 23 November 1973, Monatsschrift des deutschen Rechts 1974, p. 382

BGHSt, in: Neue Zeitschrift fur Verkehrsrecht 1993, 485.

BGHZ 51, 91 (Hühnerpest Case)

BGHZ 143, NJW 1985, 47 (Kupolofen Case)

VG Regensburg, Final decision of 25.04.1996 (RO7 K94.1846) at p.7 (unpublished)[125]

Case summary: (Agricultural subsidies) The administrative court of the City of Regensburg, in a1998 decision concerning the allowable quota of milk production in agriculture, considered the use of certain farmland back in 1988.

Use of EO information: In its decision, the court relied *inter alia* on a written expert opinion based on Landsat TM satellite image that was evaluated by a satellite imagery expert. The image, supported by collateral evidence, was considered visual evidence.
Issues: Procedural law: (Classification of Satellite Image) The court, after briefly discussing the legal classification of satellite imagery, explicitly ruled that satellite images are not private records (documents).

B.2 CASES MENTIONED IN SECTION 3: CASES

B.2.1 Cases Mentioned in Section 3.1. Civil Law: Tort

KG Berlin, 12. Zivilsenat, Decision of 28/05/2009, 12 U 43/09; reported in MDR 2009, 1244

Case summary: Unsuccessful appeal against traffic accident decision by the lower court (Landgericht). The court held that there was no fault with the lower court's conclusion about the facts of the case.

Use of EO information: [para 20] Simple inspection of the satellite image of the road junction in the LG transcript shows that, at the accident site, there is a place with a free viewpoint in the sense of sec. 8 para 3, sentence 3 of the Road Traffic Law (in the sense of sec 8 para 3 Satz 3 STVO). This means there is a location from which the waiting driver can see far enough down the priority road in order to decide whether to proceed without endangering or hindering traffic on the road ahead. [The claimant had argued that there was no free viewpoint at the accident site because of the road works situation.]

KG Berlin, 12. Zivilsenat, Decision of 07/01/2010, 12 U 20/09; reported in MDR 2010, 748

Case summary: Unsuccessful appeal against a traffic accident case decided by the lower court (Landgericht). According to sec 513 (1) ZPO an appeal can only be permitted if the contested decision is based on an infringement of the law (sec 546

[125] C Arzt, Use of Satellite Imagery in Legal Proceedings, 24 Air & Space Law 4/5 (1999) 195 (199).

ZPO) or if the facts upon which the case is based justify a different ruling (sec 529 ZPO). Neither is the case here.
Use of EO information: [paras 12-15] Both claimant and defendant marked their locations at the time of the accident on a satellite image. The lower court chose to believe the claimant rather than the defendant, and the KG Berlin followed this opinion. It based this decision on the fact that there was no damage to road marker posts, even though this would have been a result of the defendant's version of events. The existence of the road marker posts was known to the court and also visible on the satellite picture. But no such damage was reported by the parties and was not mentioned in the relevant file of the des Tiergarten local court (OWi 930/08). The court also took into account the schematic drawing made by the police in the accident file.

OLG Düsseldorf, 15. Zivilsenat, Judgment of 20/12/2008, I-15 U 176/07, 15 U 176/07;
reported in NJW 2008, 1825-1826

Case Summary: The OLG Dusseldorf decided against granting an injunction for the publication of a clarification, according to sec 11 of the State Press law for the state of Nordrhein-Westfalen (Landespressegesetz NRW). In the case of an ambiguous statement the right to publish a clarification is only given if a certain interpretation is unavoidable for the reader.

The background of this appeal hearing is a dispute between a business news publishing company (Wirtschaftswoche) and a TV Moderator/Quizmaster (Jauch). An article, published in September 2007 in a newspaper (defendant) under the headline "Spies in the Garden", drew attention to Google Earth's internet research potential. The piece included an aerial photograph that showed the villas of the claimant and his neighbour as well as the surrounding area. An object is visible in the picture, though whether it is a motorboat or something else is the subject of the dispute between the parties. The claimant demanded a counterstatement be published with the following text: "No motor-yacht is moored by my pier and I have never possessed such a yacht." Motor boats were forbidden in the lake.

Use of EO information: [para 13]: The defendant submitted to the court that the clarification was false and therefore inadmissible. It was not disputed that the Google Earth photograph showed the claimant's pier, though to its left a motorboat is visible in the water.

[para22] The claimant stated that it is not possible, through the aerial image, to determine whether or not there is a motorboat or even a boat at all, let alone some other object next to the pier.
[para 39] The article deals neither with the claimant personally nor his property or lifestyle, but rather with Google Earth's implications. Mention of the claimant served solely to give the story an interesting angle. Furthermore the article to which the objection applies should be considered together with the photograph accompanying it which shows – clearly recognizable to the reader –several seaside properties at some undisclosed time.

OLG München, 1. Zivilsenat, Judgment of15.03.2007, 1 U 5030/06,

Case Summary: Unsuccessful appeal against a decision by the LG München II from 11. September 2006 (11 O 3523/06). The claimant had slipped on ice while on her way to the curling match and sued the local authority in negligence. The court held that the local council did not have a duty of care towards the injured woman because there was no obligation to clear ice and snow or to spread grit or salt at the scene of the accident because it was located on the edge of the settlement. A possible duty of care for users of the containers located near the scene of the accident did not extend to the claimant because she was not using the container but on her way to a curling match. Moreover, the council had gritted the road in the early morning, which can be sufficient if traffic on a road is insignificant.

Use of EO information: [para 11] The aerial photograph from Google Earth produced in the proceedings on 15 March 2007 shows that [the scene of the accident] is clearly in a peripheral position.

B.2.2 Cases mentioned in Section 3.2 Administrative Law

Bayerischer Verwaltungsgerichtshof Munchen, 4. Senat, Decision of 04/08/2008, 4 ZB 08.55

Case Summary: Unsuccessful appeal against street cleaning charges decision. The claimants opposed the levying of street-cleaning charges for seven contiguous undeveloped properties. The properties border a public road belonging to an area served by a street-cleaning service which has been cleaned once a week since 2006. The administrative court rejected the action of the claimant against his land tax assessment with its verdict of 14 November 2007. The assessment is correct in law, because according to sec. 4 Para.1 of the street cleaning (and road safety) regulations, the claimant is liable to street cleaning charges because his property, adjacent to a public road, lies within a built-up area of the city.

Use of EO information: [para 8] After close examination of local conditions in the area of the …Weg" and its surroundings the administrative court came to the conclusion that the area in which the claimant's property is situated is part of a built-up area. The court demonstrated without problems that the property is bounded by lightly built-up land over a wider area and to the south from the systematically developed area in the "…Tal". This conclusion was confirmed by the building plans presented to court as well by the corresponding satellite images.

Bayerischer Verwaltungsgerichtshof Munchen, 4. Senat, Decision of 04/08/2008, 4 ZB 08.59

Case Summary: Unsuccessful appeal against street-cleaning charges decision. The claimant opposed the levying of street-cleaning charges for his property. The undeveloped piece of land is bordered by the "…Weg" that has been designated as a public road belonging to the area served by the street-cleaning service and has been cleaned once a week since 2006. The administrative court rejected the action of the claimant against his land tax assessment with its verdict of 14 November 2007. The assessment is correct in law, because according to sec. 4 Para.1 of the Street Cleaning and Road Safety Regulations the claimant is liable to street cleaning charges because his property adjacent to a public road lies within the built-up area of the city.

Use of EO information: [para 8] After close examination of local conditions in the area of the "…Weg" and its surroundings the administrative court came to the conclusion that the place in which the claimant's property is situated is part of a built-up area. The court demonstrated without problems that the property is bounded by lightly built-up land over a wider area and to the south from the systematically developed area in the "…Tal". This conclusion was confirmed by the building plans presented to court as well by the corresponding satellite images.

Bayerischer Verwaltungsgerichtshof Munchen, 19.Senat, Judgment of 26/01/2000, 19B 96.3382

Case Summary: The claimant opposed the refusal of his application for the first time re-forestation of his property. The appeal was rejected.

Use of EO information: [para 38]: Aspects of Nature Conservation and Countryside Protection would be affected, in particular because the de-forestation could alter the character of the landscape. The court reached this conclusion on the basis of an inspection of the area as well on the basis of satellite images presented to the court by representatives of the rural district office and discussed with all parties during the oral proceedings.

Bundesverwaltungsgericht (Federal Administrative Court), Decision of 2 December 2008, BVerwG 4BN14.08[126]

Case summary: Unsuccessful appeal by the municipal government against the decision of the higher administrative court (OVG) to declare invalid a legally binding land use plan/zoning map.

Use of EO information: (Character of an area, access to Google Earth data) The court used Google Earth satellite pictures to help determine the character of the area. The municipal government's claim that it did not know the pictures was not held to be valid because Google Earth pictures are freely available. The Court also made it clear that it did not solely rely on the satellite pictures, but combined these with charts and a physical visual inspection of the location.

Oberverwaltungsgericht des Landes Sachsen-Anhalt, 2. Senat, Judgment of 22/06/2006; 2 L910/03; reported in BauR 2006, 1943

Case Summary: Building permission for a roof terrace in the unplanned interior (ie, where no planning permission is required), according to sec 34 I German Federal Building Code (BauGB). The appeal is permitted for the following reasons: The claimant is entitled to receive the disputed building permission because it does not conflict with any public law regulations.

Use of EO information: [para 28] After the construction of the roof terrace the building conforms to the character of the local environment with respect to its structural dimensions. The Senate shares the opinion of the local administrative court that, according to the plans and satellite images presented to it, as well as an on the spot inspection, the "local environment" comprises the whole block between *x* and ***y*.**

Oberverwaltungsgericht des Landes Sachsen-Anhalt, 2. Senat, Decision of 21/01/2010, 2 L 54/09; reported in NVwZ-RR 2010, 465-468

Case Summary: The case concerns the building of a self-service shop on an "island" of undeveloped land; i.e. land not subject to the binding building plan (Aussenbereich). The claimant appealed against a decision by the administrative court (Verwaltungsgericht), which assumed that the land earmarked for the disputed shop was in an undeveloped area, although it was in fact surrounded by buildings.

Use of EO information: [para 10] The court used Google Maps satellite pictures to estimate that the distance between the open space and the buildings west and east of it

126 http://www.bverwg.de/enid/0,4b0197655f76696577092d0964657461696c093a09636f6e5f6964092d093131333830093a095f7472636964092d093132383235/Entscheidungen/Entscheidungssuche_8n.html.

was between 109m and 110m. Such a distance does not rule out the existence of an "island" of undeveloped land.

Oberverwaltungsgericht des Landes Sachsen-Anhalt, 2. Senat, Decision of 29/01/2010, 2 M226/09; reported in BauR 2010, 888-893

Case Summary: (Judicial review) The claimant appealed against a Federal Emmissions Control Act – (Bundesimmissionsschutzgesetz – BImSchG) authorisation for a pig farm and other associated installations which the administration had granted to a third entity, despite the claimant's objections. These were based mainly on the argument that the development was not sufficiently safeguarded and that, in particular, existing access to the planned project was unsuitable. Public property for the improvement of the existing road was only sparingly available.

Use of EO information: [para 46] Google Earth satellite pictures (as well as maps of the area) were used to assess whether transport to and from the farm premises would be assured the in the case of fire or any other disaster. According to maps and satellite images of the area, the F-weg (road) did not end at or on the farm premises but ran about 1km further to the east and joining up with another road. The satellite images indicated that the routes involved were not simply field or forest tracks that would be unsuitable for heavy goods vehicles.

Sächsisches Oberverwaltungsgericht, 5. Senat, Judgment of 28/03/2007, 5B 45/05; reported in LKV 2008, 176-178

Case Summary: Successful appeal against decision by the Chemnitz administrative court regarding street-cleaning charges for an agriculturally used property. An agriculturally used piece of land is not built-up in the sense of the street-cleaning regulations, because no possible economic advantage is associated with the street cleaning. The term "built-up" is to be more widely interpreted for street-cleaning regulations than in the sense used in the Building Regulations.

Use of EO information: [para 42] "Contrary to the claimant's opinion the claimant's property is situated in a built-up area. Copies of the land registry map already make the case for this. This evaluation is confirmed by the aerial photographs that were presented in the first instance. A developed area bordering on the open country is clearly recognisable on a larger map of the surroundings and the corresponding satellite photograph. (Quelle:http://maps.google.de/maps, Suchbegriff" Zwickau, H, L Strasse"). This classification is not contradicted by the photographs, presented by the claimant in a parallel hearing, that only show a smaller detail of the area and only convey a general impression."

Verwaltungsgericht (VG) Ansbach, 9. Kammer, Judgment of 11/06/2008, AN 9 K 07.02197

Case Summary: (urban zoning) Judicial review aimed at compelling the issuance of an outline building permit for the construction of a self-service car wash.

Part of the Claimant's property lies in an area designated as a residential area by the town's binding land-use plan. The other, much bigger, part of the property lies outside the area designated by the town's binding land-use plan.

Use of EO information: [para 12] The claimant argued that it was not an abstruse idea to include the whole area of the claimant's property within the inner city area of the planning regulations according to sec. 34 Para 1 of the German Federal Building

Code (BauGB). The piece of land in question is a corner property for which, according to the planning regulations, an individual inspection would be obligatory. On the basis of satellite images it is possible to see that, in the context of the construction plans, it would be quite possible to integrate the claimant's property into the character of the area.

Verwaltungsgericht (VG) Frankfurt (Oder), 8.Kammer, Judgment of 27/11/2006, 8K 1020/01

Case Summary: The claimant requested the return transfer of properties in accordance with the law regulating unsettled property questions. The appeal was rejected.

Use of EO information: [para 19] On 13 November 2006 the claimant presented two satellite images and Page 82 of the property register of the local district authority and stated that the claim to plot of land No. 52 only took place after German reunification in 1992/93.[The summoned party presented an aerial photograph and two maps of the area and stated that gravel sand quarry was already in operation in 1980 and that therefore the claim to plot of land No. 52 must certainly have been made before 1990, para 17]. The aerial photograph shows that the property is already slightly wooded. Regarding plot of land No. 119, the aerial photograph shows that it does not belong to the harbour (the summoned party claimed the opposite based on their aerial photograph).

[para 28] The claimant's assumption that the plot of land No. 119 does not belong to the harbour is unfounded. This is not substantiated by the satellite image from Google Earth dated 10 Nov 2006 on which the borders of plot of land No.119 have been drawn in with a blue ballpoint pen. Because the boundary line drawn in on the satellite picture after the fact does not agree with the boundary of plot No. 119, as it is reproduced in the authentic land register map (which, in the absence of any objection against its use, is deemed correct) and the surveyed map (1:2000) produced by the summoned party; and because a ship can be recognized by the harbour jetty on the satellite image, it follows that plot No. 119 is still being used operationally as a harbour.

(Boundaries) A Google Earth picture with hand-drawn boundaries of a property does not prove the claimant's claims regarding boundaries/location of objects.

[para 29] The fact that the plot of land is slightly wooded does not in itself warrant the release of the property from the jurisdiction of the Mining Authority. The slightly wooded state visible on the satellite image was independently observed on a spot inspection as vegetation.

Verwaltungsgericht (VG) Minden, 3. Kammer , Judgment of 16/11/2005, 3K 2986/03; reported in AUR 2006, 433-437

(Agricultural subsidies, margin of tolerance for aerial pictures) The administrative court of Minden mentions aerial photos and margin of tolerance under EU law, (Art 6 Abs 7 der Verordnung (EWG) Nr 3887/92)

Case summary: The claimant opposed the partial retraction of official subsidy notifications and also opposed the partial repayment of compensation claims (for the return of aid payments).
Use of EO information: [para 24] Because the claimant did not himself make any measurements of the area in the application, he cannot claim in the final instance that the error in the size of the area was not his fault. Negligence was involved in as much as he made a declaration about an exact size in his application with certainty,

although there were no grounds for such certainty. The converse does follow from the spot-checks that were made in 1999 (because the relevant areas were not controlled) nor from the remote sensing that took place in the same year. It is true that the remote sensing did not give rise to any objections about the claimed size areas of the units of land, "Schlag 11" and Schlag 8". It is not possible to draw the conclusion from this that the size of the area given by the claimant is correct. This is because remote sensing works with inexact satellite images and colour-coding that only provides an indication for additional controls.

[para 34] The fact that no complaint about the size of the area "Schlag 11" was made by the expert involved the remote sensing from 1999 does not argue against this. In the oral proceedings the expert "C1" stated that the remote sensing was carried out using satellite picture that were relatively inexact

[para 36] The fact that no objection was made about "Schlag 8" and "Schlag 11" by the remote sensing in 1999 does not by itself lead to the conclusion that the authorities accepted the alleged size of these units of land. On the one hand the satellite images used by the remote sensing were relatively inexact but, more importantly, the disputed units of land were not controlled during the random spot check in 1999. In addition, the objection by the claimant that he made his declaration about the size of the areas on the basis of land registry documentation and that he trusted their correctness does not lead to another conclusion. Land registry documents are generally trustworthy but only regarding information about a property in its entirety and not necessarily with respect to land used agriculturally.

Verwaltungsgericht (VG) Regensburg, Final decision of 25.04.1996 (RO7 K94.1846) at p.7 (unpublished)[127]

B.3 CASES MENTIONED IN CHAPTER 4: POTENTIAL LIMITATIONS

BGH NJW 2004, 762 (762)

BGHSt 38, 320 (DNA test)

BGHSt in: Neue Zeitschrift für Verkehrsrecht 1993, p.485

BVerfGE 65,1 Urteil des Ersten Senats vom 15. 12. 1983 – 1 BvR 209, 269, 362, 420, 440, 483, 484; see also NJW 1984, 419. (Census)

BVerfGE 77, 285 (291)

BVerfG, Beschl. v. 02. Mai 2006, 1 BvR 507/01, NJW 2006, 2836, 2837[128].

Privacy rights are affected if satellite pictures of private property not publicly accessible are coupled with an address or descriptions of how to get there, thus revealing the identity of the owner/occupier.

BVerfG, Beschl. v. 05. Juli 2010, 2 BvR 759/10 (Speed camera III)

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127 C Arzt, Use of Satellite Imagery in Legal Proceedings, 24 Air & Space Law 4/5 (1999) 195 (199).

128 See http://www.bundesverfassungsgericht.de/entscheidungen/rk20060502_1bvr050701.html; see also: ULD, Datenschutz und Geoinformation, 2007, http://www.geobusiness.org/Geobusiness/Redaktion/PDF/Publikationen/ampelstudie-datenschutzrechtliche-rahmenbedingungen-bereitstellung-geodaten-lang,property=pdf,bereich=geobusiness,sprache=de,rwb=true.pdf.

BVerfG in: Geschwindigkeitsmessung durch Videoaufzeichnung, NZV 2009, 618 (Speed camera II)

BVerfG vom 11.3.2008, 1 BvR 2047/05, Absatz-Nr (1-85)[129] (Speed camera I)

BVerfG ZUM 2006, 631

OLG Dusseldorf, ZUM-RD 2008, 469, discussed in tort section above.

B.4 CASES MENTIONED IN SECTION 5: CONCLUSIONS

Bundesverwaltungsgericht (Federal Administrative Court), Decision of 2 December 2008, BVerwG 4BN14.08

B.5 CASES MENTIONED IN APPENDIX A: EXPERTS AND EXPERT WITNESSES

German Federal Supreme Court (BGH), Decision of 23 November 1973, in: Monatsschrift des Deutschen Rechts 1974, p.382.

[129] http://www.bverfg.de/entscheidungen/rs20080311_1bvr207405.html.

APPENDIX C: BIBLIOGRAPHY

Aitken, CGG, Schafer, B and Mavridis, D, *Expert Statistics*, 20 June 2008, p.35, http://www.maths.ed.ac.uk/~cgga/expert-statistics-lpr.pdf

Arzt, Clemens, *Use of Satellite Imagery in Legal Proceedings*, 24 Air & Space Law 4/5 (1999), 195.

BBC News, *German vandals target Street View opt-out homes*, 24 November 2010, http://www.bbc.co.uk/news/technology-11827862

Benzing, Markus, *Das Beweisrecht vor internationalen Gerichten und Schiedsgerichten in zwischenstaatlichen Streitigkeiten*, Heidelberg 2010.

Bonn Agreement, Oil Pollution at Sea Manual, Effective Prosecution of Offenders, Chapter 3, Evidence required in different Bonn Agreement countries, http://www.bonnagreement.org/eng/html/fepo_manual/chapter_3.htm#GERMANY

Brammsen, Joerg, *Wirtschaftsgeheimnisse als Verfassungseigentum*, DÖV 2007, 10 ff.

Corucci, Linda, Nardelli, Fabio and Cococcini, Marco, *Remote Sensing, Detecting Oil Spills from Space*, 21 Oct 2010, Spie Newsroom, http://spie.org/x42014.xml?ArticleID=x42014

Eisenberg, Ulrich, *Beweisrecht der StPO*, 3rd ed. 1999.

European Judicial Network in Civil and Commercial Matters, European Commission, *Taking evidence and mode of proof – Germany*, http://ec.europa.eu/civiljustice/evidence/evidence_ger_en.htm#5.a

Global Monitoring for Environment and Security (GMES) programme, http://www.gmes.info/

Helbig, Felix, Der Spiegel, *Erdloch von Schmalkaden, Opfer der herrenlosen Hohlraeume*, 7 November 2010, http://www.spiegel.de/panorama/0,1518,727720,00.html

Höffken, Stefan, *Google Earth in der Stadtplanung*, Berlin 2009, http://www.isr.tu-berlin.de/publikationen/popups/gr/gr19.html

Ingram, Mathew, *Google Street View Opt Out Goes Live in Germany While Spain Investigates*, Gigaom, 18 Aug 2010, http://gigaom.com/2010/08/18/google-street-view-opt-out-goes-live-in-germany-while-spain-investigates/

ITU, *Pan-European Survey on Computer Forensics*, http://www.itu.int/osg/csd/cybersecurity/WSIS/3rd_meeting_docs/contributions/libro_aeec_en.pdf

Karg, Moritz and Weichert, Thilo, *Unabhängiges Landeszentrum für Datenschutz Schleswig-Holstein (ULD),Datenschutz und Geoinformationen (2007)*, https://www.datenschutzzentrum.de/geodaten/Datenschutz-und-Geoinformationen.pdf

Karg, Moritz, *Unabhängiges Landeszentrum für Datenschutz Schleswig-Holstein (ULD), Datenschutzrechtliche Rahmenbedingungen fur die Bereitstellung von Geodaten fur die Wirtschaft [Ampelstudie]*, (2008), http://www.datenschutzzentrum.de/geodaten/datenschutzrechtliche-rahmenbedingungen-bereitstellung-geodaten.pdf

Kaufmann-Kohler, Gabrielle, *Discovery in international arbitration: How much is too much?*, 1 SchiedsVz 2004, 13, http://www.lk-k.com/data/document/discovery-international-arbitration-how-much-too-much-schiedsvz-2004-pp.13-21-co-author.pdf

Koch, Harald and Diedrich, Frank, *Civil Procedure in Germany*, 1998.

Kopp, Michael, *Rechtliche Perspektiven zur digitalen Beweisführung*, http://subs.emis.de/LNI/Proceedings/Proceedings154/gi-proc-154-116.pdf

Körner, Markus and Picot, Henriette, Bird & Bird, *Experts German Civil Proceedings*, 9 Nov. 2006, http://www.twobirds.com/English/News/Articles/Pages/Experts_German_Civil_Proceedings.aspx

Lier, Monika, *Versicherungsgeschäft mit Überblick*, Versicherungs Wirtschaft (VW) [Insurance Industry], (2004), 702.

Lindner, Christian, *Persönlichkeitsrecht und Geo-Dienste im Internet – z.B. Google Street View / Google Earth*, ZUM (2010), 292.

Meyer-Gossner, Lutz, *Strafprozessordnung mit GVG und Nebengesetzen*, 51 ed. 2008.

MSDN Library, *Vekehrsgutachten schneller und kostengünstiger erstellen mit aktuellen Geodaten*, 24 June 2004, http://msdn.microsoft.com/de-de/library/cc431189.aspx

Musielak, Hans-Joachim and Stadler, Max, *Grundfragen des Beweisrechts*, 1984.

Musielak, Hans-Joachim, *Kommentar zur Zivilprozessordnung mit GVG*, 7th ed. 2009, http://beck-online.beck.de/default.aspx?vpath=bibdata/komm/MusielakZPOKO_7/ZPO/cont/MusielakZPOKO.ZPO.p414%2Ehtm

Palandt and Sprau, Hartwig, *BGB*, 69th ed. 2009.

Purdy, Ray, *Using earth observation technologies for better regulatory compliance and enforcement of environmental laws*, Journal of Environmental Law 2010, 59.

Research for the Reduction of Land Consumption and for Sustainable Land Management (REFINA) project, see: http://www.refina-info.de/

Schmidt-Tedd, Bernhard and Kroyman, Max, *Developments in German Remote Sensing Law*, 34 Journal of Space Law (2008), 97.

Siebert, Andreas, *Mit Satellitenbildern das Risikomanagement unterstutzen, Geoinformationen in der Versicherungswirtschaft*, VW (2007) 1455.

Sinss, Falk, *Unternehmen – Der Blick aus dem All*, VW (2010) 432.

Taubenböck, Hannes and Dech (ed.), *Fernerkundung im urbanen Raum, Erdbeobachtung auf dem Weg zur Planungspraxis*, 2010.

Thomas and Putzo, *ZPO*, 30th ed 2009.

Weichert, Thilo, *Geodaten – datenschutzrechtliche Erfahrungen, Erwartungen und Empfehlungen*, DuD 2009, 347.

Zöller, Richard, Greger, Reinhard, and Geimer, Reinhold, *Zivilprozessordnung*, 28th ed. 2010.

ANNEX 7.4

USE OF EO INFORMATION FOR EVIDENCE IN THE NETHERLANDS

TABLE OF CONTENTS

1. INTRODUCTION AND METHODOLOGY[1]

This Annex provides an overview of the use of Earth Observation (EO) information as evidence in legal and administrative proceedings in The Netherlands. It seeks to analyse the level of awareness, knowledge and understanding of the use of EO information for law enforcement in The Netherlands, and to see if there are ways to increase the use of EO information in these fields in the future, for instance by means of capacity building among the parties concerned.

The main questions that have been addressed are:

- Whether EO information has been used as evidence in The Netherlands;
- What the requirements were for EO information to be admitted as evidence in court; and
- What, if any, the grounds for refusal have been.

The Annex focuses on the use of EO information in administrative and criminal proceedings. While the EO information may be from sources not derived from satellites, the discussion will generally treat them as analogous to satellite-derived EO information for the purposes of this Annex. A few cases are presented, serving as a basis for a discussion of admissibility of EO information, conditions for acceptance or reasons for rejection, and issues for further consideration such as burden of proof and the use of expert witnesses.

The Annex briefly touches on two special applications, namely the use of EO information for water management and their use in proceedings before the International Court of Justice.

Conclusions are drawn regarding the use of EO information used as evidence in The Netherlands. Some recommendations on how to improve and increase this use are formulated.

2. THE LEGAL SYSTEM[2]

2.1 THE COURTS

The Netherlands is divided into 19 districts, each with its own District Court. The 19 districts are divided into five areas of Court of Appeal jurisdiction: The Hague and Amsterdam in the west, Arnhem in the east, 's-Hertogenbosch in the south and Leeuwarden in the north.

There are three special tribunals in the Netherlands that are competent in specific areas of administrative law.

- The Central Appeals Tribunal, based in Utrecht, is mainly active in legal areas pertaining to social security and the civil service.
- The Trade and Industry Tribunal, based in The Hague, is a specialized administrative court which rules on disputes in the area of social-economic administrative law. It

1 This Report is based on a report of the substantive law by Drs Tanja L Masson-Zwaan and Yeliz Korkmaz, International Institute of Air and Space Law, Leiden University.

2 For information on the judiciary systeem of the Netherlands in English, see http://www.rechtspraak.nl/English/Judicial-System/Pages/default.aspx.

also rules on appeals for specific laws, such as the Competition Act and the Telecommunications Act.

- The Administrative Jurisdiction Division of the Council of State in The Hague is the highest administrative court with general jurisdiction in the Netherlands. It hears appeals lodged by members of the public, associations or commercial companies against decisions by municipal, provincial or central governmental bodies. Disputes may also arise between two public authorities. The decisions on which the Division gives judgment include decisions in individual cases (e.g. refusal to grant a building permission) as well as decisions of a general nature (e.g. an urban zoning plan).

The Supreme Court,[3] the highest court in civil, criminal and tax law in the Netherlands, is responsible for hearing appeals in cassation and for a number of specific tasks with which it is charged by law. The aim of cassation is to promote legal uniformity and the development of law. The court examines whether a lower court observed proper application of the law in reaching its decision. At this stage, the facts of the case as established by the lower court are no longer subject to discussion.

An Attorney General's office is attached to the Supreme Court. Its members' main task is to provide the Supreme Court with independent advice, known as an advisory opinion, on how to rule in a case. Not only judgments of courts of appeal can be appealed in cassation, also judgments of the Joint Court of Justice of the Netherlands Antilles and Aruba can be appealed in cassation to the Supreme Court. The Supreme Court is located in The Hague.

2.2 JUDGES

Judges in the Netherlands are almost all professional. There are no juries. A small number of cases are tried by lay judges, such as tenancy or military crimes. Lay judges are academically qualified experts in a non-legal field such as psychiatry. Apart from these lay experts, all judges and deputy judges are learned in the law. Ad hoc judges, with experience of legal practice as well as legal degrees, are substantially, and increasingly, active in civil, criminal and administrative fields.

Judges are not elected, as is the case in some adversarial jurisdictions, but are appointed by government. Judges are independent and cannot be removed on the basis of their decisions.[4]

2.3 STANDARD OF PROOF

The standard of proof for evidence is similar to many other jurisdictions. In criminal law, evidence is assessed to a minimum required level of certainty, about 90%. In administrative law cases, a level of certainty of 60% is sufficient.

2.4 ELEMENTS OF ADMINISTRATIVE LAW[5]

Dutch administrative law regulates how public administration may intervene in the public legal order. Citizens, who are governed by private law, may do everything unless prohibited by law. In administrative law, a public authority may only act if so authorised by law.[6]

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3 High Council of the Netherlands, *Hoge Raad der Nederlanden.*

4 Marijke Malsch, *Lay Participation in the Netherlands Criminal Law System,* paper presented at the International Society for the Reform of Criminal Law, Convergence of Criminal Justice Systems: Building Bridges - Bridging the Gaps, 24028 August 2003, The Hague, www.isrcl.org/Papers/Malsch.pdf.

5 *Bestuursrecht*.

A significant difference between public and private law is that a private law agreement only has legal effect for the parties concerned, whereas in administrative law, a decision by an administrative authority applies to every citizen.

Administrative law has procedural and material elements. The latter consist of policies in areas such as tax, social security, environmental planning. The general rules of administrative law are laid down in the General Administrative Law Act.[7]

An administrative authority must use its powers in accordance with the regulations concerning administrative jurisdiction. The margin of discretionary power that the authority has in exercising its jurisdiction varies. For policies that are spelled out in great detail, the court is able to carry out a full assessment to verify whether the specified administrative powers have been used correctly. For policies that are spelled out in less precise terms and where the authority has more discretionary power, the court can only carry out a marginal assessment, it can only verify whether the authority could reasonably have reached a certain decision.[8]

3. USE OF EO INFORMATION IN ADMINISTRATIVE PROCEEDINGS

EO information has been used in a number of administrative cases. The Court will assess the evidence in the light of the required certainty level of 60%. A few cases are discussed below, along with issues arising from them.

3.1 FARM SUBSIDY CASE (1)

This case was lodged before the Trade and Industry Appeals Tribunal,[9] and involved the following parties: [10]

Partnership A and B, a farming enterprise (appellant, an interested party[11]) and
The Minister of Agriculture, Nature Management and Fisheries (defendant, the administrative authority[12]).

3.1.1 Summary of the Case

The case concerns an administrative procedure. The legal issue was the verification of European farm subsidies by satellite.[13] The appellant had requested a subsidy, which the Minister rejected under the General Administrative Law Act. The farming enterprise appealed

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6 This *principle of legality* is fundamental to Dutch law.

7 *Algemene Wet Bestuursrecht*. For information on the Dutch legal system, see http://www.rechtspraak.nl/english/Pages/default.aspx. (Note: all websites referenced in this report were accessed in April 2012; some sources are available in Dutch only).

8 Van Ballegooij, Barkhuysen, Brenninkmeijer, den Ouden & Polak, *Bestuursrecht in het Awb-tijdperk*, Deventer: Kluwer 2004, p.79-81.

9 *College van Beroep voor het bedrijfsleven (CBb)*.

10 LJN AD9994, College van Beroep voor het bedrijfsleven, AWB 01/550 (1 March 2002), http://jure.nl/ad9994.

11 Cf. Article 1:2(1) of the General Administrative Law Act: “a person whose interest is directly affected by an order”.

12 Cf. Article 1:1(1a) of the Act: “an organ of a legal entity which has been established under public law”.

13 *Satellietfoto*.

against this decision, and the Minister defended his decision in Court, using EO information to support his case.

3.1.2 Admissibility Of EO Information as Evidence

The Court stated that remote sensing is a common and accepted practice within the European Union.[14] Therefore, EO information was admitted as evidence. The reasoning of the court was indirectly based on Article 7 of Regulation EC No. 3508/92 in conjunction with Regulation EC No. 1036/1999.[15] This Regulation established the first integrated administration and control system for Community aid schemes.[16]

3.1.3 Judgment

The appellant had requested a subsidy for a specific crop. In order to verify whether that request was justified, the Minister introduced EO information to show that the crop growing on the appellant's land was not the crop for which a subsidy had been requested.

As the Court is not specialised in analysing EO information, the Minister brought an expert witness. The Court does not judge the quality of the expert's working methods, but determines whether the administrative authority, the Ministry, observed its own rules.[17]

The Court held that the Minister applied the rules correctly by providing sufficient opportunity for the appellant to prove that the parcel was eligible for subsidy on the basis of the Regulation. The burden of proof was with the appellant, although not for an indefinite period.

3.1.4 Position of the Expert Witness

According to the Court, EO images are not different from other pictures such as x-rays, aerial or ultrasound pictures, or DNA information. The Court will always need expert explanation of the correct meaning of the information.

As the Court is not specialist in analysing EO information, it may require specialist assistance. The Ministry under a tender process selects the specialist every three years. The selected specialist is expert in analysis and interpretation of EO data, generally supplied by another provider such as Landsat through the European Commission. The specialist processes the data and annually makes a return to the Commission, where the Joint Research Centre (JRC)[18] verifies the quality of the products. Verification by the JRC lends credibility to the EO

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14 *"Teledetectie is een binnen de Gemeenschap gebruikelijk en aanvaard systeem."*

15 Council Regulation (EEC) No 3508/92 of 27 November 1992 establishing an integrated administration and control system for certain Community aid schemes (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992R3508:EN:HTML) and Corrigendum to Council Regulation (EC) No 1036/1999 of 17 May 1999 amending Regulation (EEC) No 3508/92 establishing an integrated administration and control system for certain Community aid schemes as regards the deadlines for lodging applications for compensatory payments under the aid scheme for rice producers (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31999R1036R(01):EN:HTML)

16 Cf. The report 'Satellite Monitoring as a Legal Compliance Tool in the Environment Sector; Earth Observation and Agricultural Monitoring in the EC', Ref: AHRC Report 2, UCL. London, http://wwws-a.ucl.ac.uk/laws/environment/satellites/docs/2_AHRC_Agriculture.pdf.

17 This derives from the separation of powers; the Court, as judicial power, may only marginally assess the decision of the Minister, as legislative power.

18 See http://ec.europa.eu/dgs/jrc/index.cfm.

information.[19] Other parties may challenge the expert evidence by offering expert evidence of their own.

It has been suggested that it might be preferable for the Court, rather than the Ministry, to appoint an independent expert to analyse relevant EO information.[20] However, Judge Ms. S. Sicking of the District Court of Haarlem believes that the position of expert witness is not an issue in a case concerning an administrative procedure.[21] The judicial power is not specialised in analysing EO information and does not need to be. The *Trias Politica* (separation of legislative, judicial and executive powers) implies that the Court may assume that the Minister knows how to discharge his duties. The judge does not need to investigate the material part of the case, but only whether the Minister has observed his own rules. The judge thus maintains the principle of legal certainty.

3.1.5 Burden of Proof

The appellant farming enterprise asserted that it was not required to disprove the interpretation of EO information by the Ministry's expert witness,[22] and that the Minister should have to prove that the information was correct.

However, the Court held that the appellant, who applied for subsidy, must prove that the parcel is eligible for the subsidy. The issue was the extent of the farmer's burden of proof. The EO information in itself does not provide absolute proof, i.e. the introduction of EO information will not necessarily decide the case. The burden of proof will remain with the farmer in a subsidy case of this type.

Some issues arise in this regard. First, it has been asserted[23] that it would be contrary to the principle of legal certainty if the appellant is obliged to prove eligibility for the subsidy retroactively. It would be an unfair burden especially for small farmers, who may not be able to arrange for EO information concerning their parcel at a specific reference date. The Minister does have, or can obtain, this information from the expert witness, which has the raw data.

Second, there may be a cost issue. The expert witness does not collect the data, but buys and processes data supplied by ESA or another entity. Those suppliers generally supply the data without discrimination, but the cost of the data may be too great for some parties. This problem may be overcome by the disclosure requirements in Dutch court rules. The Ministry as the party to litigation will have to disclose the data on which it relies to the other party.

Third, data are not always kept indefinitely.

The Court does take into account that with the passage of time, it becomes harder for the farmer to prove eligibility for a subsidy. The farmer's burden of proof should therefore be reasonable.

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19 J-F Mayence, *The big eye in the sky – The satellite's testimony: The use of satellite data for law enforcement purpose in judicial and extra-judicial procedures*, ECSL Summer Course on Space Law and Policy, Lisbon, September 2009 (published on CD-rom).

20 The recently established Netherlands Space Office favours this view. See http://www.spaceoffice.nl/

21 Personal communication.

22 GeoRas.

23 Prof. Overkleeft-Verburg, personal communication.

3.2 FARM SUBSIDY CASE (2)[24]

This case, also before the Trade and Industry Appeals Tribunal, was between Farmer A. (appellant) and the Minister of Agriculture, Nature Management and Fisheries (defendant).

3.2.1 Summary of the Case

This case also concerned a farmer's request for subsidy, which had been rejected by the Minister. In this case, in addition to the Minister's expert witness, who introduced satellite images,[25] the farmer brought his own expert witness to Court.[26] The Court was therefore required to assess conflicting expert evidence, but did not call an independent witness to assists in its deliberations although it would have been within its power to do so.

3.2.2 Admissibility of EO Information as Evidence

The Court held that remote sensing is a common and accepted practice within the European Union, on the basis of article 7 of Regulation EC No. 3508/92, in conjunction with Regulation EC No. 1036/1999. Thus, the EO information was admitted as evidence.

3.2.3 Judgment

The Court's acceptance of the EO evidence was not at issue. At issue was the interpretation of the EO information and its bearing on the facts of the case. The European Commission provided Landsat images to the expert witnesses, which they interpreted by means of a consistent procedure.

Generally the Court will accept the interpretation of its expert witness, unless it is not convinced that the interpretation is correct. In this case, the Court concluded that the defendant's expert witness testimony was superior to that of the appellant's expert witness, having given a sufficiently careful and specific interpretation of the data relating to the particular parcel.

The Court evaluated the testimony of the expert witness, but did not investigate the technical information that EO information may provide.

4. USE OF EO INFORMATION AS EVIDENCE IN CRIMINAL PROCEEDINGS

Research for this Annex has not identified criminal cases in which EO information has been introduced. However, there has been a case in which aerial EO optical images have been introduced, which may be taken as an analogous application.

4.1 ILLEGAL CANNABIS PLANTATION CASE

The case of Anonymous (appellant) v the Board of Mayor and Aldermen of the Municipality of Eindhoven (defendant)[27] was heard in the Administrative High Court.[28]

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[24] LJN: BI4304, College van Beroep voor het bedrijfsleven, AWB 07/442 (28 April 2009), http://jure.nl/bi4304.

[25] *Satellietbeelden.*

[26] GeoRas represented the Minister. Water Watch represented the farmer. See http://www.georas.nl, http://www.waterwatch.nl/.

[27] LJN: AS7893, Centrale Raad van Beroep, 03/5257 NABW + 03/5259 NABW. http://jure.nl/as7893.

[28] *Centrale Raad van Beroep*.

The appellant, who had received social security assistance[29] from the municipality of Eindhoven, was prosecuted for failure to report income from dealing cannabis. In order to receive social security, an income statement must be presented to the authority. The appellant had failed to mention income from dealing, and was therefore charged with concealing income. The penalty was withdrawal of social security benefits.

The Dutch Opium Act punishes possession, commercial distribution, production, import, and export of all illicit drugs. Drug use, however, is not an offence for those over 18 years old. The act distinguishes between "hard" drugs that have "unacceptable" risks (e.g., heroin, cocaine, Ecstasy) and "soft" drugs (cannabis products), in order to separate the markets for soft and hard drugs so that soft drug users are less likely to come into contact with hard drugs. Sales of small quantities (under five grams) of cannabis products are tolerated in "coffee shops"[30] operating under strict conditions and controls. The Health Ministry coordinates drug policy, while the Ministry of Justice is responsible for law enforcement. At the municipal level, policy is coordinated in tripartite consultations among the mayor, the chief public prosecutor, and the police.[31]

Aerial optical pictures of appellant's private property, taken with a thermal camera[32] by The Aviation Police[33] of the National Police Services Agency,[34] were introduced as evidence. Thermal images were put forward by the prosecutor to document increased levels of heat, indicative of heat loss or radiation through walls, windows, roof and other building surfaces. This heat was alleged to be connected with artificial heat sources for the cannabis crop.

On the required statement of income, the appellant had failed to include income from dealing, which is an offence. The municipality penalised the appellant for the offence, and withdrew social security benefits. The case then went to appeal.

The thermal images did not provide evidence of the commission of the offence. They were not probative of the existence of an illegal plantation, but merely indicative of the probability that it might be present on the basis of heat.

5. USE OF EO INFORMATION AND THE SPECIAL POWERS OF INVESTIGATION ACT

5.1 SUMMARY OF THE ACT

It has been suggested that the Special Powers of Investigation Act (WetBOB)[35] should apply to cases such as these, involving thermal imagery.[36] This highlights the possibility that some

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[29] *Bijstand.*

[30] New rules will govern coffee shops from May 1, 2012. See http://www.justitie.nl/onderwerpen/criminaliteit/drugs/wetgeving/.

[31] US Department of State, *Background Notes: The Netherlands*, 22 March 2012, http://www.state.gov/r/pa/ei/bgn/3204.htm.

[32] *Thermische camera.*

[33] *Politie Luchtvaart Dienst (PLD).*

[34] *Korps Landelijke Politiediensten (KLPD).* See http://www.politie.nl/english/, and http://www.politie.nl/ImagesLandelijk/politie%20in%20nederland%20engels_tcm31-85725.pdf.

[35] *Bijzondere Opsporingsbevoegdheden, (Wet BOB*).

[36] Dutch lawyer Mr. Drs. A. Beckers provides his clients with legal advice in criminal proceedings. He expressed some criticism about the use of thermal cameras and questions their legality. Since use of the

EO information can be subject to the Act.[37] WetBob applies to certain investigative methods, and requires the prior consent of the Board of Prosecutors General before the information is used or admitted into evidence.

The Special Powers of Investigation Act came into effect 1 February 2000, and relates to an amendment to the Dutch Code of Criminal Procedure. It is a direct result of the parliamentary inquiry into criminal investigation methods that underlined the fact that there seemed to be a number of investigative processes that were unknown to many parties. It regulates methods of this nature, with a key aim of open investigations with the scope for monitoring the methods used.

Broadly, the methods falling within the Act are those that are relatively unknown to the public, with the aim to provide a statutory basis for methods of investigation that could seriously impact the integrity of an investigation or ability to monitor it, or could infringe civil rights.

Wet BOB provides for three under-cover powers: covert investigation (infiltration), pseudo purchase or services, and systematically obtaining intelligence about suspects through under-cover investigations. These powers involve situations in which an investigating officer is active in the milieu of the suspected persons without his identity as investigating officer being known. In addition, the Wet BOB covers all types of surveillance, or entering and 'looking into' premises and recording of confidential communications.

Surveillance is defined as 'systematically following a person or systematically observing their whereabouts'.[38] Systematically following or observing a person is only permitted in the case of a suspected crime, and at the order of the public prosecutor. Surveillance is systematic if it enables a more or less complete picture to be gained of certain aspects of a person's life such as their financial activities or structural personal contacts with specific individuals. Systematic surveillance can include observing a person over a number of days using an observation team or following someone using a scanning device.

Ordinary or incidental observation of a number of actions or events is treated differently, unless technical aids are used which register signals of the person. This is similar to systematically following or observing the individual.

Surveillance of private homes is not permitted. Other locked premises such as office buildings or warehouses and storage buildings may be placed under surveillance, but only in the case of serious crimes. These locations may be entered without the owner's permission in order to place recording equipment or to perform other activities to enable the surveillance. Entering locked premises without the owner's permission is 'looking in'. It might provide an opportunity for the placement of technical aids (such as a scanner) in a vehicle in a garage. Opening cupboards and cabinets and breaking down doors is not permitted. In order to take samples, packaging can be opened, even if kept inside a container. 'Looking in' also includes the examination of a location using technical equipment such as a robot, a rod or an infrared camera.

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thermal camera could be regarded as a special means of detection, it might fall under the Act. See http://www.andrebeckers.nl/html/index.php.
(For a very rough translation of the website material, see:
http://translate.google.co.uk/translate?hl=en&sl=nl&u=http://www.andrebeckers.nl/&ei=nVCdT5zYBsjk8QPLq5GBDw&sa=X&oi=translate&ct=result&resnum=1&ved=0CDkQ7gEwAA&prev=/search%3Fq%3Dbeckers%2Bbergmans%2Badvocaten%26hl%3Den%26prmd%3Dimvns).

37 See www.om.nl/vast_menu_blok/english/special_powers_of/

38 For a factsheet on WetBOB, see www.om.nl/publish/pages/99114/specialpowersofinvestigationactbob.pdf.

Pro-active investigation into offences not yet committed is allowed, but only when it concerns organised crime. For less serious forms of crime, special powers of investigation can only be used to investigate offences that have already been committed. 'Exploratory investigation' preparatory to an investigation of certain serious crimes, comprising collection, combination and analysis of data from police and other records. Exploratory investigation is not a type of investigation to which powers of investigation may be applied.

5.2 POTENTIAL LIMITATION OF USE OF EO INFORMATION UNDER WETBOB

It has been argued that this Act may have certain consequences for the admissibility of EO information in criminal proceedings. In an advocate's report about a case concerning the growing of cannabis contrary to the Opium Act, it is reported that the Magistrate had rejected the thermal imagery offered by the prosecutor. It was rejected because it had been obtained without the prior consent of the Board of Prosecutors General under the Special Powers of Investigation Act.

However, the Prosecutor appealed the acquittal.[39] The Court of Appeal in Arnhem ruled that prior consent from the Board of Prosecutors General was not required for the use of thermal imagery. There was also no breach of privacy. The Court overturned the decision of the Magistrate and convicted the accused.

In addition, the advocate reports that The Court of Justice at the Hague (ICJ) also ruled 13 Dec 2002 that thermal imagery records only heat radiation and is not an infringement of privacy. Use of thermal imagery under the Opium Act without prior permission is therefore lawful and its use by the police is permissible.

6. USE OF AERIAL OPTICAL IMAGERY BY POLICE

Aerial optical pictures can be considered analogous to satellite-derived EO for the purposes of evidence.

Aerial optical pictures are often used for detection by the police in the Netherlands.[40] Aerial optical pictures are valuable in detection of illegal crop, and can help to obtain authorisation to enter a premises. This authorisation cannot rely on a single anonymous report. Cases involving illegal cannabis plantations often start with an anonymous tip, which may be verified by looking, listening, smelling, measuring the electricity consumption or the use of a thermal camera. If indications are found that confirm the tip, an authorisation to enter the premises will be sought. Thermal images may provide further corroboration in the chain of evidence, but may not be sufficient on their own. As time passes between the anonymous tip and the investigation, the judge is less likely to grant authorisation to enter the premises on its basis.

The use of aerial optical images from airplanes or helicopters may be preferred by the police, rather than the 'Cannabis-helicopter', a small, unmanned vehicle. Although it is equipped with a thermal camera and odour sensor, it is very expensive to use.[41] There may be a lack of knowledge about EO technology and its capacities which, if overcome, may lead to its wider use. Price may again be an issue.[42]

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39 Mr Drs André Beckers. See http://www.andrebeckers.nl/html/downloads/2003-04-beckers.doc.

40 Communication from Narcotics Sergeant Mr. Hunsche, *Politie Korps Kennemerland te Overveen*.

41 €15,000 per day, according to Ecoflight. See Section 7: Use of Aerial Optical Imagery for Planning.

42 Communication from Mr. Hunsche.

7. USE OF AERIAL OPTICAL IMAGERY FOR PLANNING

A company specialising in spatial planning by means of aerial optical pictures[43] was approached for a commercial insight into use of EO information for evidence. It. Spatial planning concerns the distribution of people and activities, and includes urban, regional, environmental and national planning. The company employs aerial photography techniques including infrared, thermal, radioactivity and radar technologies.

The company does not use satellite-derived EO images.[44] It indicated the following reasons:[45]

- Images may not be readily available, as satellites do not provide 24h coverage;
- The buying of the data may take time;
- When it is cloudy, EO images are not clear enough; and
- Satellite images are not detailed enough.

They do acknowledge two advantages of satellite-derived EO information: large-scale coverage and high quality after radiometric correction.

8. USE OF EO INFORMATION IN WATER MANAGEMENT: TWEEDE MAASVLAKTE

In the 1970s, the port of Rotterdam was extended at the south side of the mouth of the Nieuwe Waterweg by completion of the Maasvlakte (Meuse-plain), a large area of reclaimed land. The project was called Europoort (Gate to Europe). Subsequently new plans have been developed to extend Europoort further, with the Tweede Maasvlakte, or Maasvlakte 2 (Second Meuse-plain).[46] The expansion is intended to maintain the Port of Rotterdam's importance and efficiency, especially for large container vessels.[47]

In the Netherlands, it is necessary to submit an extensive environmental impact report to obtain a permit for a new project that may have an impact on spatial planning. The report will include potentially adverse effects that spatial planning decisions could have on the environment in great detail.

The use of EO information is expanding in this field. The Tweede Maasvlakte project in the Port of Rotterdam is a notable example. The environmental impact report for the second expansion comprises some 6500 pages, includes EO images in place of traditional measurements at sea.[48]

The Port of Rotterdam Authority in the Maasvlakte 2 project requires a permit from the competent authority, the Directorate General for Public Works and Water Management.[49]

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43 See http://www.vb-ecoflight.nl/. Its licence is issued by the Military Intelligence and Security Service (MIVD) after verification that no sensitive information is disclosed. *Militaire Inlichtingen en Veiligheidsdienst*, http://www.defensie.nl/mivd.

44 According to their website.

45 Personal communication from a company representative.

46 For a discussion of the project, *see* www.hull.ac.uk/hhcro/pdf/Rotterdam.pdf.

47 See http://royalhaskoning.ddg24.tamtam.nl/Royal_Haskoning/Strategie/nl-NL/Opdrachten/Draagvlak+voor+Tweede+Maasvlakte.htm?ref=1

48 Havenbedrijf Rotterdam N.V., see http://www.portofrotterdam.com.

49 *Rijkswaterstaat*, the executive agency of the Ministry of Transport, Public Works and Water Management. See http://www.rijkswaterstaat.nl/.

Before the permit is issued and during the environmental impact reporting process, various parties such as Friends of the Earth Netherlands[50] are given the opportunity to express their views. The Directorate will issue the permit if the Port of Rotterdam Authority complies with the legal framework and conditions imposed by it. In order to verify that it does so, EO information is used.

The Port Authority did not use EO images,[51] but they were utilised by Deltares,[52] a hydrological laboratory, and the Institute for Environmental Studies of the University of Amsterdam[53] in connection with the project. Deltares and the Institute for Environmental Studies interpret the EO data for Port of Rotterdam Authority. On the basis of these EO data the Port of Rotterdam Authority would then set up a mathematical model to allow them to reduce the need for measurements at sea.

9. USE OF EO INFORMATION BY WATER BOARDS

In the Netherlands a water board is responsible for control and management of water.[54] It is not responsible for the supply of water, as is the case in other countries. Like municipalities and provinces, water boards are decentralised government entities.

The role of the water board includes assessment of planning where flooding may be a risk, for instance where a municipality proposes to build houses. A water board may object if the risk is considered significant, and may use EO and topographic images to support its case.

10. USE OF EO INFORMATION BY THE INTERNATIONAL COURT OF JUSTICE

The Netherlands is home to the International Court of Justice in the Hague (ICJ). Parties regularly put forward EO information to support their claims before the Court, especially in boundary disputes.[55]

An example was the Maritime Delimitation in the Black Sea case between Romania and the Ukraine.[56] In this case, Romania used Google Earth images of Serpents' Island, an area in dispute.

Geoserve, an authorized distributor of satellite and EO images from commercial satellites such as WorldView-2, GeoEye, RapidEye, Spot-5 and Radarsat-2,[57] indicated that they regularly sell EO data to parties before the ICJ.

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50 Friends of the Earth Netherlands (Milieudefensie) is a non-governmental (NGO) environmental organisation with more than 90.000 members and supporters and eighty local groups, conducting campaigns on climate change, globalisation, traffic, agriculture and conservation of the countryside. See http://www.milieudefensie.nl/english/.

51 Communication from Mr. W. Borst of the Port of Rotterdam Authority

52 Deltares is an independent, institute for applied research in the field of water, subsurface and infrastructure. See http://www.deltares.nl/en.

53 IVM, Vrije Universiteit Amsterdam, http://www.ivm.vu.nl/en.

54 W*aterschap* or *hoogheemraadschap*.

55 Communication from H.E. Judge Peter Tomka of the International Court of Justice in The Hague (ICJ).

56 See for a summary of the judgment of 3 Feb. 2009, http://www.icj-cij.org/docket/files/132/14989.pdf. In the framework of this Report it has not been possible to examine the Parties' written and oral submissions, but these records are public and the details of this cases as well as other examples are at http://www.icj-cij.org.

57 http://www.geoserve.nl.

For a discussion of the use of EO information in international courts, see the Water Annex and the Humanitarian Crime Annexes of this Study.[58] The Netherlands Court of Audit also makes extensive use of EO information to verify use of funds, particularly in cases of foreign aid.[59]

11. CONCLUSIONS AND RECOMMENDATIONS

While a certain number of conditions must be fulfilled for EO information to be admitted in administrative or criminal proceedings in The Netherlands, EO information or analogous information, such as aerial optical images, are generally used and admissible in administrative and criminal proceedings. Over the past 12 years, EO information has been involved in 145 court cases,[60] mainly on detection control and enforcement of European regulations.

In administrative proceedings the Court obtains independent professional advice about the interpretation of EO information.

In relation to water management, EO information is extensively used in environmental impact reporting, to demonstrate that proposed projects comply with legal requirements. Water boards also use EO information.

In criminal proceedings, the Police are interested in using EO images, especially for larger areas, in order to detect illegal cannabis plants.

As far as international courts located in the Netherlands are concerned, parties regularly use EO information to support their arguments before the ICJ, and the ICJ accepts this use. Like the national courts, the ICJ does not acquire such information independently but relies on material the parties bring to its attention.

In general, the legal community in The Netherlands is reasonably informed about EO information and its potential uses. There is however no abundance of published cases, perhaps partly because the matter of the admissibility as such was not at stake. A better understanding by those involved, especially judges and police forces, will most likely increase the use of EO information in courts and administrative tribunals.

Finally, there appears to be some misunderstanding about some issues, like accessibility, technical capabilities and cost. Increased awareness about the range of products, prices and providers may also increase the use of EO information.

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58 Annexes 9 and 10.

59 See ISPL Workshop Report, *Evidence from Space*, Document ESA-ISPL/EO-55.

60 A search of the following: http://jure.nl and www.rechtspraak.nl for the terms 'satellietbeelden' (satellite-images) and 'satelliet' (satellite).

APPENDIX: CASES, EU REGULATIONS AND PUBLICATIONS

Cases:

Farm Subsidy Case (1):
LJN: AD9994, College van Beroep voor het bedrijfsleven, AWB 01/550 (01 maart 2002) (http://jure.nl/ad9994)

Illegal Cannibis Plantation Case:
LJN: AU0703, Centrale Raad van Beroep, 03/5257 NABW + 03/5259 NABW (22 februari 2005) (http://jure.nl/as7893)

Farm Subsidy Case (2):
LJN: BI4304, College van Beroep voor het bedrijfsleven, AWB 07/442 (28 April 2009) (http://jure.nl/bi4304)

EU Regulations:

Council Regulation (EEC) No 3508/92 of 27 November 1992 establishing an integrated administration and control system for certain Community aid schemes (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992R3508:EN:HTML)

Corrigendum to Council Regulation (EC) No 1036/1999 of 17 May 1999 amending Regulation (EEC) No 3508/92 establishing an integrated administration and control system for certain Community aid schemes as regards the deadlines for lodging applications for compensatory payments under the aid scheme for rice producers (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31999R1036R(01):EN:HTML)

Publications:

Ballegooij, van, *e.a.*, *Bestuursrecht in het Awb-tijdperk*, Deventer: Kluwer 2004.

Beckers, A., *Het gebruik van thermische camera's* (*The Use of Thermal Imaging Cameras*), www.andrebeckers.nl/html/downloads/2003-04-beckers.doc (For a very rough translation, see http://translate.google.co.uk/translate?hl=en&sl=nl&u=http://www.andrebeckers.nl/html/downloads/2003-04-beckers.doc&ei=CledT-LZEcqO8gOq6fX0Dg&sa=X&oi=translate&ct=result&resnum=1&ved=0CD0Q7gEwAA&prev=/search%3Fq%3DHet%2Bgebruik%2Bvan%2Bthermische%2Bcamera%26hl%3Den%26prmd%3Dimvns).

Jorna, F., *De Autobureaucratie*, Delft: Eburon 2009.

Mayence, J.F., *The big eye in the sky – The satellite's testimony: The use of satellite data for law enforcement purpose in judicial and extra-judicial procedures*, ECSL Summer Course on Space Law and Policy, Lisbon, September 2009 (published on CD-rom).

Mejía-Kaiser, M., *Verification of European Farm subsidies by satellite*, in Proceedings of the Colloquium on the Law of Outer Space, Jerusalem 1994, AIAA 1995, p. 257.

Moody, R., *Mapping power – Geographical Information Systems, Agenda-Setting and Policy Design*, PhD thesis, Erasmus University Rotterdam, 2010.

ANNEX 7.5

USE OF EO INFORMATION AS EVIDENCE IN THE UK

TABLE OF CONTENTS

1. RULES OF EVIDENCE

The United Kingdom comprises three jurisdictions, those of England and Wales, Scotland and Northern Ireland. In many areas, particularly under statute, the laws in these jurisdictions are the same or very similar. Here the law is stated as it is under those of England and Wales (English Law).

Satellite EO data is automatically generated and recorded by machines, without human intervention, save in devising the relevant technical capabilities. In many ways it is analogous to photographs generated by traffic speed cameras, regarded as real evidence.[1] Data generated by machines are statements that are not hearsay. However, EO information is the result of the data being processed through a number of steps to generate intelligible information as evidence. Such information offered as evidence will be regarded as *hearsay*.[2]

The rule against hearsay in civil proceedings was largely abolished in 1995,[3] and in criminal proceedings in 2003.[4] There were, and to the extent that the common law rules still apply, continue to be, exceptions to the rule. As observed in our document *Rules of Evidence*,[5] the result is that hearsay evidence *can* be admissible in court, thereby joining statements produced by machines that are *not* based on human input.[6] What becomes relevant and

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1 In *Statue of Liberty Owners of Motorship Sappord Maru v Owners of Steam Tanker Statue of Liberty*, [1968] 2 All ER 195, [1968] 1 WLR 739, a record made mechanically without human intervention, by radar on shore, of the echoes of two ships involved in a collision, is in the nature of real evidence and admissible as evidence of a collision. The same principle applies to other types of real recordings; Gbenga Oduntan, *The Evidentiary Issues Arising from the Proposed Use of the Satellite Based Vehicle Monitoring System and Electronic Logbooks in the FishCAM Project Within the European Union*, IJL&IT 2004 12 (74).

2 Data stored or processed by computer with human intervention, depending on human truthfulness and accuracy, may be hearsay: *R v Wood* (1982) 76 Cr App Rep 23, CA; see Criminal Justice Act 2003 s 129(1).

3 Civil Evidence Act 1995, (CPA 1995), s 1(1), renders hearsay admissible in civil proceedings. However, s 2 requires a party relying on hearsay to give notice of that intention and of the hearsay evidence. Failure to give notice does not necessarily render the evidence inadmissible but may have adverse costs consequences and reduce the weight given to the evidence (s 2(4)). However, the 1995 Act has not changed the general rule that where possible proof be by oral evidence (see CPR 32.2). Although admissible, the court is required to weigh the reliability hearsay evidence having regard to the circumstances, one being whether it would have been "reasonable and practicable" to call the maker of the original statement (s 4 of the 1995 Act); *Jafari-Fini v Skillglass Ltd (In Administration)* [2007] EWCA Civ 261, [2007] All ER (D) 504 (Mar).

4 Criminal Justice Act 2003, (CJA 2003), s 114. Statement not made in oral testimony in criminal proceedings is admissible as evidence of any matter stated only if: (1) any statutory provision makes it admissible; (2) it is admissible under a common law rule that has been expressly preserved under the Criminal Justice Act 2003, s 114(b); (3) all parties to the proceedings agree to it being admissible; or (4) the court is satisfied that it is in the interests of justice for it to be admissible; Halsbury's Laws, Vol 11(3) [2006 Reissue], Para 1520.

5 ESA-ISPL/EO 25.

6 A document produced by computer without human intervention does not contain information 'supplied by a person' with 'personal knowledge' (*Pettigrew* (1980) 71 Cr App R 39). Such a document is unlikely to constitute hearsay evidence, and the conditions of the exception need not be satisfied (see *R v Wood* (1982) 76 Cr App R 23); Blackstone's Criminal Practice 2010.

Business documents, automatically generated by computers and other devices, are admissible in evidence; Civil Procedure Act 1995, s 1. Computer generated and similar documents are subject to appropriate notice and weight provisions applying to oral hearsay; CPA 1995, ss 2, 4 and 9. The exception applicable to public documents is preserved by the CPA 1995, s 7. The US position is slightly different. Under Federal Rules of Evidence, the rule against hearsay remains (Rule 802), and exceptions do not extend to *all* machine generated information (Rule 902). http://www.law.cornell.edu/rules/fre/rules.htm. Compare California Vehicle Code, S. 21455.5, Traffic Signal Automated Enforcement: Photographic Records, http://www.dmv.ca.gov/pubs/vctop/d11/vc21455_5.htm. However, EO data is admitted under the public records exception (Rule 803(8)). Such records need to be authenticated by complying with certain rules as to their collection and custody (Rule 901(b)), or meet the requirements for self-certification (Rule 902(12)). See also *Daubert v Morrell Dow Pharmaceuticals*, 507 (1993); *Frye v United States*, 293 F 1013 (DC Cir 1923); Ronald J Rychlack, Joanne Irene Gabrynowicz, Rick Crowsey *Legal Certification of Digital Data: The Earth Resources Observation and Science Center Project*, 33 J Space L, 195 (2007).

important is the reliability of the evidence adduced and its probative value.[7] It is, therefore, necessary to show that the evidence relates to the fact being proved, has been in safe and traceable custody without interference or inappropriate manipulation.

2. DIGITAL DATA

2.1 AUTOMATIC GENERATION AND PROCESSING

An important evidential aspect of space-derived information is its digital nature and the need to process that digital data to create intelligible information. It is the processed information that is offered as evidence. This characteristic of space-derived information is analogous to other digital data generated by computers, speed cameras and closed circuit television, CCTV, or security cameras. Guidelines have been established for the capture and processing of digital images.[8]

It has rightly been observed that "the UK judiciary has a general openness towards new technologies, and satellite photography could be easily assimilated with similar forms of evidence derived from digital security, speed cameras and digital facial mapping".[9] One may go further to extend this attitude to all forms of digitally processed information.

The potential use of EO information is recognised in legislation implementing European Commission Regulations. In particular, the Fisheries Regulations[10] have been implemented in the United Kingdom.[11] The use of computer-generated evidence is now admitted and used in criminal proceedings, following the repeal of the special conditions that had to be satisfied to qualify such evidence for admission.[12] As noted above, such evidence is also admissible in civil proceedings.[13]

Other automatically generated evidence widely used includes that from speed cameras and number recognition devices. These are used as evidence in the prosecution of speeding offences and use of vehicles without current excise tax certificates and other driving offences.[14]

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7 CJA 2003, ss. 117 and 121. The latter section applies to multiple hearsay. In *Maher v DPP* (2006) 170 JP 441 a note which had been made (and lost) of a car number plate could not be adduced as second-hand evidence under s. 117 because a relevant passer-on of information had not received it in the course of trade etc. The evidence was, however, admitted under s. 121(1)(c) as multiple hearsay, on the ground that the value of the evidence, taking into account its apparent reliability, was so high that the interests of justice required admissibility; Blackstone's Criminal Practice 2010.

8 Home Office Scientific Development Branch, *Digital Imaging Procedure*, Publication 58/07, Version 2.0 November 2007; Forensic Science Regulator, *Codes of Practice and Conduct for Forensic Science Providers and Practitioners in the Criminal Justice System*, Second Consultation Draft July 2010.

9 Ray Purdy, Richard Macrory, *Satellite Photographs: 21st Century Evidence?*, (2003) 153 NLJ 337.

10 Council Regulation (EC) No 1966/2006 and Commission Regulation (EC) No 1077/2008.

11 Fishing Boats (Electronic Transmission of Fishing Activities Data) (England) Scheme 2010.

12 Youth Justice and Criminal Evidence Act 1999, Sec 60, repealing Sec 69 of the Police and Criminal Evidence Act 1984.

13 CPA 1995, ss 2, 4 and 9.

14 Road Traffic Offenders Act 1988, Sec 20; Statutory Instruments under the Act. See Halsbury's Laws, Vol 40(1), Para 1042.

2.2 STANDARDS

Standards have been developed to address the admissibility of digital data.[15] To ensure admissibility, the information needs to be managed by a secure system throughout its lifetime, which can be for many years.

There is a British Standard based on the specification of requirements for planning, implementing, operating, monitoring and improving an organization's information management systems. It specifies the requirements for the implementation and operation of electronic information management systems, and the electronic transfer of information from one computer system to another, addressing issues relating to the authenticity and integrity of the electronic information. These issues are important where the electronic information could be used as evidence.

The Standard covers:

1. Management of electronic information over long periods, including through technology changes, where information integrity is vital;
2. Management of risks associated with electronic information;
3. Method to demonstrate the authenticity of electronic information;
4. Management of quality issues related to document scanning processes;
5. Provision of a full life history of an electronic object throughout its life;
6. Electronic transfer of information from one computer system to another; and
7. Policies, security issues, procedures, technology requirements and electronic document management systems (EDMS).

By complying with BS 10008, it is anticipated that the evidential weight of electronic information transferred to, or managed by, any person will be maximised, ensuring its trustworthiness and reliability.[16]

3. CASES IN WHICH EO INFORMATION WAS ACCEPTED IN EVIDENCE

There are no reported English cases directly dealing with EO information being used as evidence. The following are not all English cases, but establish principles or provide guidance relevant to the use of EO information under English law.

3.1 ASSOCIATED BRITISH PORTS V HYDRO SOIL SERVICES NV [17]

This was a building contract case involving the strengthening of a quay wall in a port. A Netsurvey system[18] was used to determine the exact positions of wharf piles driven into the seabed. It plotted profiles of the piles above the seabed by measuring the distance from a boat to the piles, with corrections for the movement and angle of the boat.

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15 See BS 10008: 2008 - *Evidential Weight and Legal Admissibility of Electronic Information*.

16 BS 10008 formalises the Codes of Practice BIP 0008-1 to -3. The Standard and CoP are referenced in Section 46 of the Freedom of Information Act 2000: Code of Practice on Records Management. See also BSI.

17 (2006) EWHC 1187(TCC), (2006) All ER (D) 269 (Jun).

18 Netsurvey is a multi-beam system of measurement using global positioning satellite.

Two measurements were offered, one taken in 2004 and another in 2005. No point appears to have been taken on admissibility. The 2004 reading was relied on as the parties agreed it was reliable.

3.2 ADMINISTRATIVE DECISION

Another decision of relevance is that of the Administrative Court of the City of Regensburg, Germany,[19] which concerned allowable quota of milk production and use of agricultural land. The court relied, *inter alia*, on a written expert opinion based on a Landsat Thematic Mapper (TM) satellite image that was evaluated by a satellite imagery expert. The image that was supported by collateral evidence was considered to be visual evidence.

The case has been referred to in an article[20] that considered whether satellite images were comparable to photographs or electronically stored data. Since steps were necessary to generate images from raw remote sensing data, they could not be compared with ordinary photographs but rather with electronic media or electronically stored data.

3.3 THE IKARIAN REEFER

National Justice Compania Naviera SA v Prudential Assurance Co. Ltd (The Ikarian Reefer)[21] was a civil case concerning an insurance claim for the loss of a ship. The English court accepted the reliability of satellite tracking systems fixing the location of ships. The primary issues in the case were the use of expert witnesses rather than the underlying EO information.

3.4 ENVIRONMENT AGENCY V ARROW CAR SPARES

The UK Environment Agency used EO information in the form of images to assess and bring a prosecution for an offence relating to an illegal landfill site.[22] Satellite images showed the illegal burning of wastes. Imagery archives of earlier years showed evidence of such burning, which, if known to the prosecuting authorities, could have been used to press for a harsher sentence.

3.5 EUROPEAN COMMISSION V UNITED KINGDOM

EO information has been the subject of a European Commission action against the United Kingdom before the European Court of Justice, ECJ. In *European Commission v United Kingdom (Portugal intervening)*,[23] the Commission claimed the United Kingdom was in breach of its obligations concerning urban waste water treatment. The Commission relied on satellite images to show high concentrations of algae in the Humber estuary. The United Kingdom attacked the introduction of such images on grounds of reliability.

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19 VG Regensburg (Administrative Court of the City of Regensburg, Germany) Final Decision of 25/4/1996 (RO 7 K 94.1846 at p 7), unpublished.

20 Clemens Arzt, *Use of Satellite Imagery in Legal Proceedings*, Air & Space Law, Vol XXIV, No 4/5, p 195, 1999.

21 [1993] 2 Lloyd's Rep 68 (CA). This case is authority on expert evidence; see Claire Brown, *What to Expect from the Expert*, http://tltt.strath.ac.uk/media/alias/bulletins/Forms/AllItems.aspx.

22 See *Environment Agency v Arrow Car Spares*, 2006 prosecution for illegal burning of waste; See Ray Purdy, *Using Earth Observation Technologies for Better Regulatory Compliance and Enforcement of Environmental Laws*, J Environmental Law, 22:1 (2010), 59-87 at 68.

23 C-390/07; [2009] All ER (D) 224 (Dec).

However, the Court dismissed the objection. It held that:

> [C]ontrary to what the United Kingdom asserts, the capture of images by remote sensing cannot, as such, be regarded as unreliable, the United Kingdom itself indeed having recourse to such images to support certain of its arguments concerning other areas at issue, and it therefore constitutes a means capable of revealing the existence of accelerated growth of algae and higher forms of plant life.[24]

4. AVAILABLE EO INFORMATION NOT USED AS EVIDENCE

EO information is frequently used to detect or monitor conditions and activity. Although monitoring is mentioned in this Report, it is not the main focus of the Study. The Study is concerned with the more rigorous applications of EO information as evidence.

4.1 EARLIER STUDIES

A report by the British National Space Centre (BNSC)[25] and a University College London (UCL) study[26] describe many situations in which satellite monitoring is used for monitoring or detection. The monitoring exercise often leads to gathering of evidence by other means and enforcement actions based on that evidence.[27]

An example of this was a prosecution at Cullompton Magistrates Court on 18 November 1997. Satellite imagery was used to provide advance notification to the authorities of non-compliance by farmers with agricultural set-aside schemes. However, direct evidence based on visual inspection (ground truth requirements) was used as the evidential basis for the successful prosecution.[28]

4.2 AGRICULTURAL SUBSIDIES

European law provides for fraud detection under the Common Agricultural Policy (CAP) subsidy schemes using EO information. However, in the UK, and in other jurisdictions, the evidence is supplemented with aerial and ground gathered evidence.[29]

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24 Paragraph 87.

25 BNSC Sector Studies Programme, *The Applications of Earth Observation to the Legal Sector: Final Report*, Prepared by NPA in partnership with British Institute for International and Comparative Law, with support from D J Freeman and UCL, August 2001.

26 UCL AHRC Project, *Satellite Monitoring as a Compliance Tool in the Environment Sector*, 2005-2008, http://www.ucl.ac.uk/laws/environment/satellites/index.shtml?ahrc_home.

27 In a written Answer to a Parliamentary Question on 29 April 2010, the Minister for Agriculture, Fisheries and Food stated that his Department in "delivering the Direct Payment Schemes, is required to carry out on-the-spot inspections on a number of farms covering such issues as eligibility under the Scheme, compliance with EU legislation in the areas of the environment, food safety, animal health and welfare and plant health and ensuring that the farm is maintained in good agricultural and environmental condition. A minimum of 5% of Scheme applicants are required to be inspected under the eligibility rule. These checks are carried out to verify that the actual area claimed in the application form corresponds to the area held by the farmer and to ensure there are no overlapping claims or duplicate claims. Up to two-thirds of these inspections are carried out without a farm visit and using the technique of remote sensing."

28 Richard Macrory, Ray Purdy, *The Use of Satellite Images as Evidence in Environmental Action in Great Britain*, Droit & Ville, No 51/2001, 69-88 at 73.

29 *Satellite Monitoring as a Legal Compliance Tool in the Environment Sector*, UCL AHRC Project: *Satellite Monitoring as a Compliance Tool in the Environment Sector*, 2005-2008, http://www.ucl.ac.uk/laws/environment/satellites/index.shtml?ahrc_home.

5. CASES WHERE EO WAS NOT USED

As indicated, there is a paucity of English decisions on the use, or lack of use, of EO information as evidence. Any comment on the reasons for the lack of use of such evidence is merely speculative. There is no authority on which to base reasons for rejection of EO information.

6. SPECIFIC LEGISLATION RELATING TO THE USE OF EO EVIDENCE

6.1 EUROPEAN UNION LAW

The European Commission has made extensive provision for the use of remote sensing to monitor operation of the Common Agricultural Policy, including expenditure.[30] Earlier provisions empowered Member States to adopt such techniques in verification of applications for subsidies.[31]

A Regulation lays down detailed rules for applying the integrated administration and control system for certain Community aid schemes established by Council Regulation (EEC) No 3508/92. The United Kingdom applies these Regulations in monitoring and enforcing the CAP.[32]

EC legislation also gives Member States the option to use satellite remote sensing for monitoring fish catches (Council Regulation (EC) No 2371/2002 (20/12/ 2002) on the conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy OJ 2002 L358/59).

6.2 UNITED KINGDOM

Member States have the option of using remote sensing to monitor claims for CAP farm subsidies.[33]

In the UK, examples of the use of remote sensing laid down in legislation include the following enactments relating to fishing. The primary legislation for these enactments is the Fisheries Act, 1981:

(i) The Sea Fishing (Enforcement of Community Satellite Monitoring Measures) Amendment (Revocation) (England) Regulations 2004;

(ii) The Sea Fishing (Enforcement of Community Satellite Monitoring Measures) (Scotland) Revocation Regulations 2004;

(iii) The Fishing Boats (Satellite-Tracking Devices) (England) Scheme 2004;

(iv) Fishing Boats (Satellite-Tracking Devices) Scheme (Northern Ireland) 2004;

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30 Council Regulation (EC) No 78/2008 of 21 January 2008 on the measures to be undertaken by the Commission in 2008-2013 making use of the remote-sensing applications developed within the framework of the common agricultural policy, Official Journal L 025, 30/01/2008 P. 0001 – 0002.

31 Commission Regulation (EC) No 2419/2001 of 11 December 2001 laying down detailed rules for applying the integrated administration and control system for certain Community aid schemes established by Council Regulation (EEC) No 3508/92; Official Journal L 327, 12.12.2001, p.11. Regulation as amended by Regulation (EC) No 2550/2001 (OJ L 341, 22.12.2001, p. 105).

32 See note 24 above.

33 See note 24 above.

(v) The Sea Fishing (Enforcement of Community Satellite Monitoring Measures) Order 2004; and

(vi) The Sea Fishing (Enforcement of Community Satellite Monitoring Measures) (Scotland) Order 2004.

Satellite images have been used to monitor field crop data, supplementing other evidence in courts in the UK, other EU countries, and also in the US.[34]

7. CONCLUSION

In the United Kingdom, as elsewhere, many agencies rely on EO information to mount further investigation, often resulting in formal administrative or judicial proceedings.

As indicated here, the English rules of evidence do not preclude admission of EO information, and the Courts will admit such evidence if reliable and probative of facts in issue. The challenge is to devise rules that can ensure reliability and verification of the information.

[34] See also Dr. Gbenga Oduntan, *The Evidentiary Issues Arising from the Proposed Use of the Satellite Based Vehicle Monitoring System and Electronic Logbooks in the FishCAM Project Within the European Union*, International Journal of Law &Information Technology, Oxford Journals, 2004 12 (74).

ANNEX 7.6

THE USE OF EO INFORMATION AS EVIDENCE IN THE UNITED STATES

TABLE OF CONTENTS

1. RULES OF EVIDENCE

The United States comprises fifty-one jurisdictions, that of its fifty States and the Federal Jurisdiction. Certain areas of law have been reserved to the Federal government and courts.[1] The Federal system and all but one State legal system are based on common law. The exception is Louisiana, a former French colony.

One distinguishing feature of the US legal system is that it has a written constitution that is frequently invoked as a tool in legal challenges. Therefore, administrative and judicial proceedings meet objections not often found in other jurisdictions. These include the protection of privacy and limitations of the right to search and seize. They will be discussed in the context of the decided cases below.

1.1 Admissibility

The US procedural law distinguishes admissibility and weight of evidence.

a. Judge decides admissibility; jury determines weight, ie credibility; and

b. Admissibility requirements tend to be lower than under English law.

EO information is deemed scientific and technical evidence. Standards for admissibility of scientific evidence were set in the *Daubert v Merrell Dow Pharmaceuticals*[2] ruling of the Supreme Court in 1993. Most States use the *Daubert* ruling for evaluating scientific evidence.[3] The ruling, provides the following guidelines:

a. Whether the methodology has been peer reviewed;

b. Whether the methodology can be, and has been, tested;

c. What are the error metrics associated with the methodology; and

d. Whether the reasoning or methodology underlying the testimony is scientifically valid, and whether that reasoning or methodology can properly be applied to the facts in issue.

The last requirement, established in *Daubert,* supersedes that in *Frye*,[4] and is consistent with the more permissive tenor of the Federal Rules of Evidence (FRE).[5] *Daubert* relies on the scientific reliability of the reasoning and methodology employed.

The admissibility of EO information has not been specifically examined in any court proceedings in the United States. However, remote sensing by satellites has been in use for over 30 years, and the methodologies are well reported, so it seems that EO information could meet the *Daubert* criteria and those of *Frye*.[6]

1 US Constitution, Article III and 10th Amendment.

2 Daubert *v Merrell Dow Pharmaceuticals*, 509 U.S. 579 (1993).

3 Rick C Crowsey, *When Geography Goes to Court Will it Get to Testify?* The University of Southern Mississippi, Colloquium 15 October 2009.

4 *Frye* v. *United States*, 54 App. D.C. 46, 47, 293 F. 1013, 1014 (1923). The *Frye* test required that "the methodology [be] generally accepted by the pertinent scientific community.

5 FRE, Rule 702.

6 Ronald J Rychlack, Joanne Irene Gabrynowicz, Rick Crowsey *Legal Certification of Digital Data: The Earth Resources Observation and Science Center Project*, 33 J Space L, 195 (2007) at 202.

In addition, subsequent court decisions have considered whether a scientific technique has been widely employed by the scientific community in non-legal applications, before using it in court proceedings, and have explored the experience and expertise of an expert. The *Daubert* court stressed that experts must have followed a scientific method "as it is practised by (at least) a recognised minority of scientists in their field."[7]

FRE, Rule 702 puts the responsibility on the judge to act as gatekeeper and to determine the admissibility of scientific evidence. The Supreme Court held that (1) "general acceptance" is not a necessary precondition to admissibility of scientific evidence under Federal Rules of Evidence, and that (2) the Rules assign to the trial judge the task of ensuring that expert testimony both rests on reliable foundation and is relevant to the task at hand.

The *Daubert* ruling listed a few important tests for admission of scientific testimony beyond general acceptance, including falsifiability, known error rates and peer review.[8] Most States use the *Daubert* ruling for evaluating scientific evidence.[9]

1.2 Hearsay

The US hearsay rule is not very different from that in the UK, both tending to permit rather than exclude hearsay evidence that is reliable and probative. Under Federal Rules of Evidence, the rule against hearsay remains,[10] with exceptions that extend to some, but not *all* machine generated information.[11] However, satellite earth observation data may be admissible under the exception applicable to business records[12] or to public records.[13] Such records need to be authenticated by complying with certain rules as to their collection and custody,[14] or meet the requirements for self-certification.[15]

2. DIGITAL DATA

2.1 Automatic Generation and Processing

Space-derived information is generated from processing satellite digital raw data by means of appropriate computer software into intelligible information. This information forms the basis of the evidence presented to the relevant tribunal. In this respect, the collection and processing of space-derived information has similar characteristics to other computer-generated information from sensed data. An example is speed detection by automatic speed cameras.

The absence of a human observer, the complex processing by a machine and digital nature of the data present evidential challenges under US law as they do under English Law, namely that of the need for processing through a number of different stages and the ease with which

7 *Daubert v Merrell Dow Pharmaceuticals*, 509 U.S. 579 (1993), and 43 F.3d 1311 (1994).

8 Siegel, J. A. 2006. *Forensic Science: The Basics*. Boca Raton, FL: CRC Press.

9 Rick C Crowsey, *When Geography Goes to Court Will it Get to Testify?* The University of Southern Mississippi, Colloquium 15 October 2009.

10 FRE, Rule 802.

11 FRE, Rule 902. http://www.law.cornell.edu/rules/fre/rules.htm. *Cf.* California Vehicle Code, S. 21455.5, Traffic Signal Automated Enforcement: Photographic Records, http://www.dmv.ca.gov/pubs/vctop/d11/vc21455_5.htm.

12 FRE, Rule 803(6).

13 FRE, Rule 803(8).

14 FRE, Rule 901(b).

15 FRE, Rule 902(12)). See also *Daubert v Morrell Dow Pharmaceuticals*, 507 (1993); *Frye v United States*, 293 F 1013 (DC Cir 1923); Ronald J Rychlack, Joanne Irene Gabrynowicz, Rick Crowsey *Legal Certification of Digital Data: The Earth Resources Observation and Science Center Project*, 33 J Space L, 195 (2007).

digital data can be changed.[16] However, there are State laws that deal with such issues. A case in point is that of speed cameras in California.[17]

2.2 Guidelines and Standards

The US Geological Survey (USGS) at the Earth Resources Observation and Science Data Center (EROS) provides certified digital images for a variety of applications. USGS/EROS and the National Center for Remote Sensing, Air, and Space Law at the University of Mississippi (NCRSASL) undertook a study to determine whether exhibits prepared from digital data could be certified so that they would be admitted into evidence during legal proceedings, if proper procedures were followed.[18]

The NCRSASL study examined the practice of USGS for certification of digital information it now supplies in place of photographic images of the past. This certification assures the user of the data that it is the same as that contained in the USGS/EROS archive file. It does not certify the image produced using the data, as it may be manipulated after receipt from USGS. The party proffering the evidence generated from the data must provide evidence of its security and processing after receipt in order for it to be accepted as evidence.[19]

It is the "proper procedures" that are of particular interest here. To qualify as reliable evidence, the EO information must satisfy a number of requirements. These are summarised in the following sections.

2.3 Establishment of Foundation

Broadly, it must be shown that the evidence being offered is relevant and reliable. First, the witness offering the evidence must be shown to be qualified and competent.[20]

An expert will usually introduce EO information, and may also interpret the technical details of the information.[21] Alternatively, judicial notice can be taken of the underlying validity of EO evidence.[22]

In addition, it is necessary to show that the process and system used to produce the EO information generates accurate results.[23] There will be evidence of collection and handling of the information, as well as of the techniques used to produce the information from underlying data.

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16 See Annex 8.5: UK Report.

17 California Vehicle Code, S. 21455.5, Traffic Signal Automated Enforcement: Photographic Records, http://www.dmv.ca.gov/pubs/vctop/d11/vc21455_5.htm.

18 Ronald J Rychlack, Joanne Irene Gabrynowicz, Rick Crowsey *Legal Certification of Digital Data: The Earth Resources Observation and Science Center Project*, 33 J Space L, 195 (2007).

19 Ronald J Rychlack, Joanne Irene Gabrynowicz, Rick Crowsey *Legal Certification of Digital Data: The Earth Resources Observation and Science Center Project*, 33 J Space L, 195 (2007) at 215 and note 57.

20 FRE, Rule 702 *et seq*.

21 See also the requirements of *Daubert*.

22 FRE, Rule 102(b).

23 FRE, Rule 901(b)(9).

3. CHALLENGES TO ADMISSION

3.1 Trade Secrets and Intellectual Property

The leading case on several constitutional issues is *Dow Chemical Company v United States*,[24] decided by the Supreme Court in May 1986.

Dow operated a 2,000-acre chemical plant with many covered buildings, and outdoor manufacturing equipment and piping conduits between the buildings, visible from the air. The plant was secured at the perimeter, preventing ground-level public views of the area. Dow denied the Environmental Protection Agency ("EPA") permission to enter the plant for an on-site inspection. The EPA did not obtain an administrative search warrant, but instead employed a commercial aerial photographer to take photographs of the facility from various altitudes within lawful navigable airspace, using a standard precision aerial mapping camera.

On becoming aware of the aerial photography, Dow brought action claiming violation of the Fourth Amendment[25] by the EPA, and a search beyond its statutory investigative authority. The District Court granted summary judgment for Dow. But the Court of Appeals reversed the decision, holding that the EPA's aerial observation did not exceed its investigatory authority and that the aerial photography of the plant without a warrant was not a search prohibited by the Fourth Amendment.

The Court of Appeal held:

> The fact that state trade secrets law might bar aerial photography by Dow's competitors is irrelevant to the questions presented in this case. Governments do not generally seek to appropriate trade secrets of the private sector, and the right to be free of appropriation of trade secrets is protected by law. Moreover, state tort law governing unfair competition does not define the limits of the Fourth Amendment.

Note that this decision does not preclude the exclusion of EO information where it is obtained by a private party, which may disclose trade secrets protected under State or Federal law.

3.2 Search and Seizure

Although they are closely allied principles with shared underlying rationale, a distinction must be drawn between the constitutional right of protection against unwarranted search and seizure and the right to privacy. The Fourth Amendment to the Constitution expressly guarantees the first. The right to privacy, which is a broader concept, has its roots in the 1890 article of Louis Brandies and Samuel Warren.[26]

The *Dow* Court, addressing the Fourth Amendment claim, also held:

> The EPA's taking, without a warrant, of aerial photographs of the plant from an aircraft lawfully in public navigable airspace was not a search prohibited by the Fourth Amendment. The open areas of an industrial plant are not analogous to the "curtilage" of a dwelling, which is entitled to protection as a place where the

24 476 US 227 (1986).

25 US Constitution, Amendment 4: The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized.

26 Samuel D. Warren & Louis D. Brandeis, "The Right to Privacy," 4 Harv.L.Rev.193 (1890).

> occupants have a reasonable and legitimate expectation of privacy that society is prepared to accept.[27]

The Court concluded that for purposes of aerial surveillance, the open areas of an industrial complex are comparable to an "open field" in which an individual may not legitimately demand privacy.[28] It went on to observe that the EPA was employing a conventional, commercial camera commonly used in mapmaking and available to the public. The mere fact that human vision is enhanced somewhat, at least to the degree here, does not give rise to constitutional problems.

3.3 Privacy

The right to privacy has been raised as a potential barrier to the use of EO information. However, without a much greater resolution capability, satellite images are unlikely to reveal sufficient detail to become an intrusion on privacy. In addition, the necessity to have a clear line of sight may put these images beyond what may be regarded as private. One possible exception is where the detected spectrum is outside the visual range.[29]

However, with improving technology and changes in social attitudes, the concept of privacy may also change. In the early 19th Century *"I am afraid my inquiry has been impertinent, but I had not supposed any secrecy intended...."*[30] captured the essence of privacy. In today's environment where intimate details are posted on public Websites, expectation of privacy are reduced, at least where new technology is available to the public.

In *Kyllo v United States*,[31] on suspicion of marijuana being grown in a home, agents used a thermal imaging device to determine if the amount of heat emanating from the house was consistent with the high-intensity lamps typically used for indoor growth of marijuana. The scan showed that the garage roof and side-wall were relatively hot compared to the rest of the unit and substantially warmer than the neighbouring units.

Based in part on the thermal imaging, the agents obtained a warrant to search Kyllo's home, where they found marijuana growing. Kyllo unsuccessfully moved to exclude the evidence seized from his home and then entered a conditional guilty plea.

The Ninth Circuit ultimately upheld the thermal imaging on the ground that Kyllo had shown no subjective expectation of privacy because he had made no attempt to conceal the heat escaping from his home. Even if he had, ruled the court, there was no objectively reasonable expectation of privacy because the thermal imager did not expose any intimate details of Kyllo's life, only amorphous hot spots on his home's exterior.

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27 See California v. Ciraolo, 476 U. S. 207 (1986).

28 Oliver v. United States, 466 U. S. 170 (1984).

29 See Ronald J Rychlack, Joanne Irene Gabrynowicz, Rick Crowsey *Legal Certification of Digital Data: The Earth Resources Observation and Science Center Project*, 33 J Space L, 195 (2007) at 210. Compare also the European Convention on Human Rights, Art 8. See also *Colas Est SA v. France*, App. No. 37971/97, Eur. Ct. H.R. (Apr. 16, 2002); *Pretty v United Kingdom* (Application 2346/02), (2002) 35 EHRR 1, [2002] 2 FCR 97, 12 BHRC 149, 66 BMLR 147, [2002] ECHR 2346/02, [2002] All ER (D) 286 (Apr).

30 Jane Austen, *Sense and Sensibility*, 116 (1811); Kevin Werbach, *Sensors and Sensibilities*, SSRN, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=932927.

31 533 US 27 (2001).

On appeal to the Supreme Court, it was held:

> Where the Government uses a device that is not in general public use to explore details of a private home that would previously have been unknowable without physical intrusion, the surveillance is a Fourth Amendment "search," and is presumptively unreasonable without a warrant.

3.4 Security

Although not directly an admissibility issue, the level of resolution can constitute a barrier to the availability of EO information. Resolution better than half a metre is currently barred by under US munitions control regulations.[32]

If the Government relies on information generated using classified techniques or technology, the evidence will be inadmissible unless properly disclosed and open to challenge.[33]

4. CASES WHERE EO INFORMATION ACCEPTED IN EVIDENCE

Aerial and satellite Earth Observation information have been frequently used in the US courts, at both Federal and State level. The two main issues litigated have been constitutionality and reliability. A number of reported cases deal with Fourth Amendment rights, and the constitutionality of observation of emissions outside the visual spectrum. Others have focused on the qualifications of experts and the quality of the information.

Below are case summaries, divide into those dealing with EO information and those where aerial material is used.

4.1 EO Information

In *Chevron USA Inc v US Environmental Protection Agency*[34] satellite imagery was admitted as evidence of the size of an area of wilderness.

United States v Reserve Mining Co.[35] involved showing the extent of green water and widespread dispersion of taconite tailings into Lake Superior. Satellite imaging was admitted as evidence of these conditions.

Gasser v United States[36] was a Fifth Amendment claim for substantial reduction of water flow in the Colorado River, following construction of the Hoover and Glen Canyon Dam. Satellite and aerial imagery were allowed to show channel development after 1935.

Satellite images were used in *I & M Rail Link v Northstar Navigation* to determine whether a barge accident occurred in Illinois or Iowa waters, thus determining which court had jurisdiction.

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32 The US controls limit the resolution to 0.5m; See International Traffic in Arms Regulations, ITAR, Part 121 – United States Munitions List, Category VIII, remote-sensing satellites.

33 *U.S. v Kilgus*, 571 F.2d 508 (9th Cir. 1978): The Defendants were convicted of illegally importing and possessing marijuana with intent to distribute. On appeal, the Court of Appeals held that the forward-looking infrared system (FLIR) can be used for generic identification of objects. The Court found that evidence based on use of Forward Looking Infrared System was inadmissible where defence counsel were precluded from impeaching or rebutting the testimony because most of the necessary technical data were military secrets.

34 658 F.2d 271 (5th Cir. 1981).

35 380 F. Supp. 11 (D.C. Cir. 1974).

36 14 Cl Ct 476 (Cl. Ct. 1998).

4.2 Aerial Observation

In *Nutra Sweet Co. v. X-L Engineering Co.*[37] aerial photographs confirmed the dumping sequence in which Volatile Organic Compounds (VOCs) were dumped on X-L's land that migrated through the groundwater onto Nutra Sweet's land. Nutra Sweet used this evidence as well as other tests to prove that X-L Engineering was responsible for the dumping, and the court affirmed the decision for the plaintiff.

St. Martin v. Mobil Exploration & Producing U.S. Inc.,[38] concerned the admission of testimony by Charles Camp, plaintiff's surveyor witness, about the damage to the marsh between 1993 and 1997 as documented by two aerial photographs. At the trial, Camp described his methodology in making his estimate. He had done some scaling but mostly relied on the photographs' scale, and tabulated the increased damage based on the affected areas in the photographs, adjusted by the topography of the site.

Though Camp was not a trained photogrammetrist,[39] he testified to many years' experience working with aerial photographs as part of his surveying practice. The defendant had a full opportunity to cross-examine Camp, including attempted impeachment on his deposition testimony. Under the circumstances, it was within the court's discretion to credit Camp's figure as an estimate of marsh loss, which it was then free to discount for possible alternative causes of damage. The Court found the defendant responsible for the damage.

Pittson Co. V. Allianz Insurance Co.[40] centered on a general liability insurance and marine insurance issue. The plaintiff objected to an expert hydro geologist referring to aerial photos, on grounds that the expert was not qualified to interpret aerial photographs. The court allowed the testimony based in part on the expert's assertion that reliance on aerial photos was routine for members of his profession.

5. CONCLUSION

The courts in the United States frequently admit and rely on EO information. However, there is no major authority directly dealing with admissibility of such evidence. One area of concern is often the determination of time and date on which the information was gathered.[41]

The legal basis for such admission is reasonably well developed. The establishment of standards and means of certification of EO information will greatly aid its wider admission and use in judicial and administrative proceedings.

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37 227 F.3d 776 (7th Cir. 2000).

38 224 F.3d 402, (5th Cir. 2000).

39 One who uses photogrammetric technology to extract measurements, make maps and interpret data from images.

40 905 F. SUPP. 1279, (D.N. J. 1995).

41 Personal communication from Vermont Environmental Judge Merideth Wright, 12 August 2010.