# SPACE POLICY & LAW COURSE 2017

16 TO 18 OCTOBER 2017

CHARLES CLORE HOUSE, RUSSELL SQUARE, LONDON

## Questions, Answers & Discussions

This report is intended to document questions, answers and discussions arising during the Space Policy and Law Course 2017. They are grouped by day and topic rather than in order of presentation, and we have included further information in footnotes. Please refer to the case study solutions handed out during the course for discussions specific to them,[1] and to our list of material for further reading for more in-depth information.[2]

**DAY 1, SESSIONS 1 - 4:**

1. What is a Launching State, and what is transfer of liability?

A Launching State is one that launches or procures a launch, or from whose territory or facility a launch is made.

A Launching State will always remain liable for damage caused by the launched space object, and cannot transfer that liability to another State. However, it is possible for a State to seek indemnity from a State that subsequently acquires the space object. In practice, the Launching State is indemnified by the acquiring State for any damages.

2. Where do launches typically originate?

A launch can originate anywhere, but some locations have benefits over others in terms of the energy needed to reach orbit and the desired orbital inclination. For example, for launches to geostationary orbit (altitude = 36000 km, inclination = 0 degrees), a launch from the equator is desirable, and the direction west to east. Launching close to the equator will remove the need to perform an inclination change. Launching to the east ensures you can use the rotation of the Earth to help reach orbital velocity.

There are also safety concerns, especially with launch over populated areas. Cape Canaveral Air Force Station (CCAFS) on the East Coast of the US is only used for low and medium inclination orbits and avoids Central and South America, the US and Canada.

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[1] Many thanks to Andrew Ratcliffe of the UK Space Agency for providing notes of the discussions. Errors and omissions are ISPL's.

[2] http://www.space-institute.org/app/uploads/1509729834_2017_ISPL_SPLC_Recommended_reading_ver_4.docx

Vandenberg, on the west coast of the US, supports high inclination uses such as polar launches over the Pacific Ocean.

3. What dictates the type of launch vehicle and its intended destination?

Choice of launch vehicle depends on its capability and performance.

One consideration is the maximum mass of the satellite that can be delivered to a specific orbit. Typically the larger the launch vehicle, the higher the mass it can deliver to orbit, and thus the higher its price.

Another consideration will be cost. For example, Ariane 5 is used for GEO launches, and can deliver 10 tonnes to Geostationary Transfer Orbit (GTO). VEGA can only deliver 1.5 tonnes to LEO, and cannot to deliver a useful payload to GEO.

The volume of the fairing[3] will be considered, the environment experienced by the satellite (mechanical or thermal loading, etc.) and whether the launch slot can be shared with other satellite owners (e.g. Ariane 5 dual-launch of GEO satellites).

4. Why are some GEO slots empty over certain latitudes?

There are limited populations directly beneath the slot, so the benefits of placing satellites there would be limited.

5. Can a satellite be moved from one orbit to another?

Yes, but a move may require a significant amount of fuel, depending on the intended destination. A number of satellites perform manoeuvres during the initial stages, or at the end of life for decommissioning purposes. Typically these manoeuvres involve changes in satellite altitude to alter the orbital height or to reposition in an orbit. Satellites rarely perform inclination changes, as these are usually prohibitively expensive in terms of energy.

6. Can you give an update on air-breathing propulsion?

One of the biggest limitations to rocket performance is the need to carry both fuel and oxidiser. Air-breathing engines, e.g. jet engines, carry fuel and use atmospheric oxygen as the oxidiser for the combustion. A combined-cycle engine uses air-breathing and classic rocket technology. For the early phases of a mission, at lower velocities, the engine uses oxygen from the atmosphere. As the velocity increases, the air gets hotter. Air-breathing propulsion systems remove this heat and add it to the fuel for combustion. The heat exchanger needed to perform this is very advanced technology. The current leader in this technology is Reaction Engines, developing Skylon and the SABRE engine.

7. Do launch propellants affect the environment?

There is an impact, and is assumed to be low[4] but there has been no formal assessment to date.[5] Launch vehicles use a range of propulsion systems from liquid based systems such

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[3] The space inside the nose cone available to house the satellite during launch

[4] But see http://www.aerospace.org/crosslinkmag/summer2011/rocket-soot-emissions-and-climate-change/

[5] https://www.scientificamerican.com/article/how-much-air-pollution-is-produced-by-rockets/

as liquid oxygen and kerosene, to solid propulsion systems that use a binder and energetic particles. Each produces some level of pollution. In 2016 there were 85 launches of civil, commercial and military payloads. Launch sites perform extensive environmental assessments of local conditions, e.g. effects on wildlife.

8. Does space law address waste and pollution?

There continues to be debate as to whether international environmental law applies to space. Debris is one significant aspect of this debate.[6] The OST includes provisions relating to contamination of the Earth and space environments [OST Art IX] and the UN General Assembly endorsed the Space Debris Mitigation Guidelines [Resolution 62/217].[7]

9. What is the difference between Public and Private International Law?

Public International Law concerns relationships between countries. Private International Law (also referred to as Conflict of Laws) covers relationships between private individuals and entities, in an international setting. The latter is of particular relevance in legal disputes involving parties in different jurisdictions.

Principles of conflict of laws provide guidelines to determine whether a Court will apply its law or the laws of another interested jurisdiction to a dispute. For example, if a French agent of a Portuguese company contracts with someone in Germany to supply something to Spain, and the Portuguese company disputes quality, whose laws apply? The answer to the question will be determined by conflict of laws principles.

10. What is the difference between a Treaty, an Agreement and a Convention?

These are generally used synonymously, and each will have same force.

11. Are there any countries that have not ratified OST?

Of the 195 states recognised by the UN, 105, including all space-active countries, have ratified the OST. There are a few countries that have ratified but not implemented or completely implemented the laws. Countries with light or no national laws may become attractive as bases for space operations, e.g. Belgium, where the application fee and insurance requirements are low.

12. Are commercial companies subject to the rules of non-appropriation?

States are responsible for commercial companies within their jurisdictions, and must authorise and supervise them under the OST. The State must ensure that private entities observe the OST.

13. What is overflight?

Overflight takes place when a craft passes over an area. In civil aviation through airspace,[8] permission is required for overflight. By contrast, satellites can pass over any

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[6] https://www.space.com/12860-photos-space-debris-images-cleanup-concepts.html; http://www.unoosa.org/oosa/en/ourwork/topics/space-debris/index.html

[7] http://www.un.org/en/events/tenstories/08/spacedebris.shtml

[8] The accepted definition of useable airspace is up to at approximately 50km, but for a discussion of history and different interpretations, see https://publicapps.caa.co.uk/docs/33/CAP_1498_V2_APR17.pdf

part of the world without permission. They are not in airspace, but in outer space, so are beyond individual countries' jurisdictions. However, when launching or returning through airspace, the permission of a country through whose airspace the craft travels is required.

14. What is State Responsibility in the context of space activity?

Under the OST, a country that has ratified the Treaty is responsible for its national space activities. The OST requires the State to authorise and supervise such activity. A non-ratifying country doesn't have to enforce a licensing regime.

Responsibility is not the same as liability. Liability is the obligation to pay damages, and attaches to the launching state. 'Launching State' is a term of art defined in the Liability Convention.

15. What is Registration?

Under the Registration Convention anything launched into space must be recorded on a national register, and the UN must be notified for the purposes of its register. [9]

16. The Registration Convention is said to be the least observed of the space treaties. What is the impact of that, and is the Register publically available?

Yes, the registry is public. The key impact of lack of registration is that it the States responsible and liable are not always easily identifiable.

17. It was stated that a large number of satellites are not registered, but the UN website says 92% are registered. What is the position?

The UN does not know the number of objects on orbit. Some operators and regulators see registration as unnecessary. There is no penalty or enforcement mechanism for non-compliance. In particular, many military and security satellites are not registered. The UN does not have infrastructure or capability to detect launches.

18. What is the difference between jurisdiction and arbitration?

Jurisdiction is power, right or authority to interpret and apply the law. In relation to a dispute, the parties can only take legal action in a court that has jurisdiction over the matter. For example, a contract between English and German companies would normally stipulate which country's laws would govern the contract and whose court would have jurisdiction.

Parties to a contract can agree to have disputes resolved in arbitration (the hearing and determination of a disputed case by an arbiter). Some space contracts have an arbitration clause. The arbitrators are generally chosen according to rules set out in the contract.

19. Are military activities permitted in space?

Military activities are not prohibited *per se*. The OST specifies that space shall be used for peaceful purposes. There is debate about the interpretation of this phrase. Only certain

[9] In order…"to make provision for a mechanism that provided States with a means to assist in the identification of space objects, the Registration Convention expanded the scope of the United Nations Register of Objects Launched into Outer Space that had been established by resolution 1721B (XVI) of December 1961 and addressed issues relating to States Parties responsibilities concerning their space objects." Source: UNOOSA.

activities are expressly prohibited, i.e. placement of weapons of mass destruction in space. Military manoeuvres on celestial bodies are prohibited.

20. What is the difference between the terms 'province' and 'common heritage'?

'Province of mankind' is an expression of the availability of an area for exploration by all States, i.e. the right to roam rather than the right to own.

The Moon Agreement uses the expression 'heritage of all mankind'. 'Heritage' may arguably imply an element of ownership.[10] "Heritage" is also used in the Convention on the Law of the Sea, under which the Seabed Authority was established.[11]

21. Are the UN treaties enforceable? Is OST a special case?

Under international law every State is sovereign, and cannot be forced to act in a specific way. Treaties are based on consensus building and self-interest. There are mechanisms to encourage parties to keep to their commitments. This has been seen to work in some areas, for instance on the environment (Montreal agreement). OST is not different from other treaties in this regard.

22. Have there been any rulings in the international law of space?

No. This may change as countries take measures that are driven by commercial interests. The International Court of Justice could be the arbiter.

23. Has any country been taken to court over a space-related issue?

No. Kosmos 954 crashed into Canadian territory, with resulting radiation pollution, but the parties settled. The Kosmos 2251-Irridium 33 collision was never pursued in court. Equatorial countries claimed sovereignty over the geostationary orbit above their territories in the Bogota Declaration of 1976, but the claim as never been tested in court, and is largely abandoned.

24. What is the WTO?

The World Trade Organisation provides for general agreement and tariffs on trade.

25. Can you comment on investment from China and India into space activity?

China has made significant investment in space activities, particularly in government programmes such as human spaceflight and launchers.

India has a burgeoning Space industry with a number of new participants. One area of focus is launch, where they have been able to offer their PSLV launch vehicle at very competitive prices. ISRO hopes to commercialise these launch activities and increase customer base.

Russian design standards are different from those of the rest of the world. (European and US standards were developed in cooperation).

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[10] The Moon Agreement has only been ratified by 17 States, none of them major spacefaring nations. They recognise that outer space is the heritage of all mankind.

[11] The Authority manages the exploitation and distribution of the benefits derived from seabed resources.

**DAY 2, SESSIONS 5 - 8**

26. What is the difference between remote sensing and Earth observation?

    Often the terms are used interchangeably. Early techniques were photographic, but not all remote sensing is visual. Remote sensing may be non-optical, for instance radar technology, or non-electromagnetic, for example the Gravity Recovery and Climate Experiment (GRACE) system that used microwaves to measure variations in the Earth's gravitational field and distribution of mass. GRACE was useful in a wide range of areas including studying ocean currents and aquifers.[12]

27. What are the Remote Sensing Principles?

    These are contained in a UN General Assembly Resolution.[13] Principle III, for instance, stipulates that activities are carried out in accordance with International Law. Although non-binding, they are generally adhered to.

28. What is a Graveyard transfer?

    At the end of life, geostationary satellites licences require manoeuvres to move them from the useful GEO slot to a graveyard orbit, sufficiently above GEO so they will not interact with operational satellites. There are on-orbit services that provide graveyard transfer that does not rely on the spacecraft's own propellant.

    A satellite that can be manoeuvred out of graveyard orbit could subsequently be used to temporarily satisfy ITU frequency assignment requirements. For this reason the US Air Force is developing refuelling systems for satellites near the end of their useful lives.

29. Are graveyard definitions set by the ITU?

    No. These are guidelines set by the Inter-Agency Debris Coordination Committee (IADC), an international governmental forum that includes various space agencies. These are not enforceable.

30. What is solar electric propulsion?

    This is a system that makes use of solar electric power to accelerate a satellite propellant. To provide thrust you need to expel mass. You can use solar energy to facilitate this. A number of satellites use solar electric propulsion systems to reduce the total mass of the propulsion system and therefore facilitate smaller satellites.

31. What is the definition of sub-orbital?

    'Suborbital' relates to the type of flight, not a specific altitude. In such a flight the vehicle reaches space but does not have the much greater speed required to enter orbit. It is an up and down flight. By one definition, a sub-orbital spaceflight is one that reaches an altitude higher than the Karman line at 100 km, designated because it is roughly the point where a vehicle flying fast enough to support itself with aerodynamic lift from the Earth's atmosphere would be flying faster than orbital speed.

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[12] https://earthobservatory.nasa.gov/Features/RemoteSensing/

[13] http://www.unoosa.org/oosa/en/ourwork/spacelaw/principles/remote-sensing-principles.html

32. Compare the ITU and COPOUS

The ITU allocates and manages resources. COPOUS is a political forum to discuss the use of outer space including the OST.

UNISPACE is a conference periodically organised by COPOUS, discussing changes to space regulations and principles for use.

33. What is the separation between GEO satellites?

The ITU has allocated a planned-band under which each of the 195 States is guaranteed one orbital slot to service its national territory. In the much larger non-planned band, the rule is first come, first served.

Typically, satellites are separated by about 3 degrees. In practice operators can share a slot. There are a number of options such as splitting the frequency bands, or transmitting at opposite polarities.

34. Are the radio regulations updated every three to four years by World Radio-communication Conference (WRC)?

This is not in the ITU Constitution, but generally it is done every four years. It is based on consensus, and can be modified depending on developments in the industry.

35. How do national laws relate to satellite licensing?

Licences are granted under national laws, and their conditions can be changed and monitored by the regulator. In France, the duration of the satellite licence is its design life. To extend the licence, the regulator must be satisfied as to capability and functionality. In UK, the licence applies until service ceases.

36. Are there US limitations on EO applications?

There are limitations on resolution, and under US law, earth observation of Israel is illegal. Some US companies have sought to be licensed in the UK where the licence does not impose these restrictions.

37. Under EU and UK law, a waiver of liability for death or personal injury is unenforceable. Does this apply elsewhere?

Yes, this can be the case elsewhere. For example, some US states have legislated waiver or limitation of liability.

38. After the introduction of recent laws by the US and Luxembourg in relation to space resources, was there any international pressure not to enact them?

There was no publicly expressed pressure, but that does not mean that other countries did not have objections. There have been other areas where national legislation has been in conflict with international obligations, for example in environmental law.

There is no universal view about whether extracting resources from space is legal or desirable. A number of lawyers in the field who advocated the legality of exploitation of space resources appear to be changing their minds, but what is clear is that there needs to be a much broader debate.

An aggrieved country might take the US to the ICJ for breach of the OST. The US as Respondent State could not argue that the OST limitation does not apply to commercial operators, as the Government still needs to authorise and supervise the activities.

The Moon Agreement does provide for resource exploitation when it becomes feasible, but it provides that a regime would have to be established to manage the extraction and its benefits. This might be designed along lines similar to the Seabed Authority. Neither the UK nor the US has ratified the Moon Agreement.

**DAY 3, SESSIONS 9 - 12**

39. What is the difference between a comet and an asteroid?

Asteroids are primarily made up of metals and rocky material, while comets are primarily composed of ice, dust and rocky material.[14] Comets will tend to vaporise near the Sun, while asteroids will tend to remain solid.

40. In the Tungusta event in 1908, how large was the debris?

A large, probably rocky body exploded in the atmosphere over Siberia and left no crater, so we are not sure about its size. The huge explosion left no impact crater or measurable debris.[15]

41. What technology is available to observe and track asteroids?

There are no dedicated systems. Most of the capabilities piggyback on existing systems. A mission called STEREO looks at interaction between Sun and Earth, and has picked up a number of objects. There is also a network of amateur observers that provide information to the IAF, using very advanced technology.

42. Compared to the infamous 4-minute warning period for a nuclear attack, what would the warning period be like for an asteroid impact?

It would depend on the nature of the asteroid, but would likely be a number of years.

43. How close are we to having a system that could deal with the problem of asteroid deflection?

It is not getting a lot of political attention, although there is lobbying. High net worth individuals are now becoming interested due to the legacy aspect. The protocols are still being developed.

44. What are Active Debris Removal missions?

These aim to target and remove debris from orbit. One technology being tested is SSTL's RemoveDEBRIS[16] that would carry its own target "artificial debris", which it would then attempt to capture.

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[14] https://www.universetoday.com/33006/what-is-the-difference-between-asteroids-and-comets/

[15] https://www.nasa.gov/topics/solarsystem/features/tunguska-20080627.html

[16] https://www.youtube.com/watch?v=7CEH9V9psKY

Key debris targets are priority rated by mass and the probability of collision. The critical limitations in developing these systems are currently not technological, but relate to policy, legal and funding issues.

45. Why is the operation of a gravity tractor like a Lagrange point?

Lagrange points are positions in an orbital configuration of two large bodies where a small object affected only by gravity can maintain a stable position relative to them. These are typically relevant to science missions. The point of equilibrium between an asteroid and a gravity tractor intended to move the object's direction would be dynamically changing.[17]

45. How is the UN responding to changes in technology?

These are matters for national regulation rather than treaty matters. Technology (and some would say commerce) moves faster than the UN's forums are able to respond to. For example, in EO with high-resolution images of certain areas, regimes are not in place to react to commercial agreements.

[17] For example, see http://www.esa.int/gsp/ACT/doc/MAD/ACT-RPR-MAD-2010-GravityTractorOCP.pdf; https://www.nasa.gov/sites/default/files/files/03-2013-NASA-AIIS-Summary-Deflection-Final.pdf