Commercial Space Activities

Sam Adlen
Chief Strategy Officer

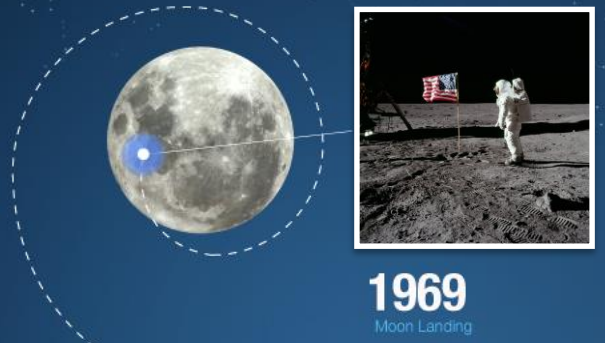
We work with
Innovate UK

CATAPULT
Satellite Applications

THREE WAVES OF INNOVATION

FIRST SPACE AGE

Cold War



1969
Moon Landing

SECOND SPACE AGE

Science & Exploration
Early Commercialisation

1964
INTELSAT
Envision. Connect. Transform.

1978
Navstar-1

1979
inmarsat

THIRD SPACE AGE

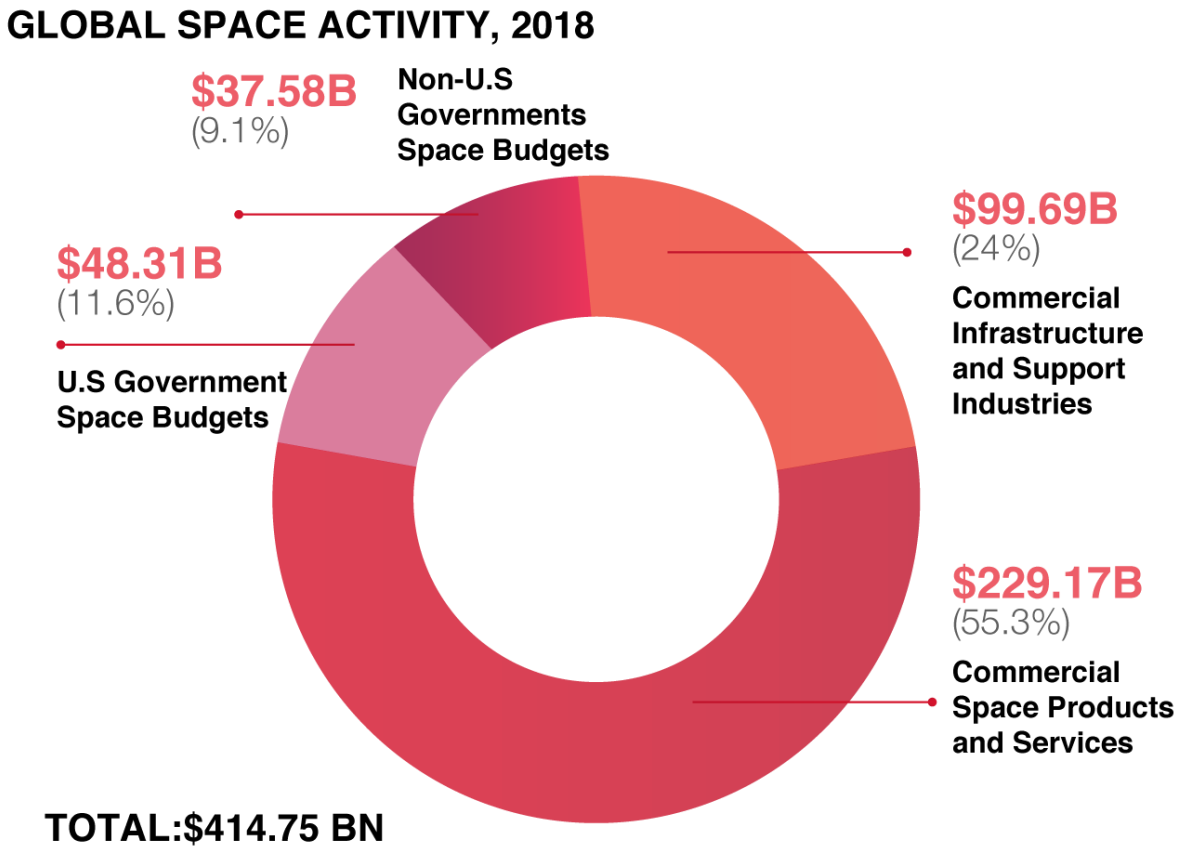
Democratisation

2004
- X-Prize Flight
- Commercial Space Launch Amendments Act

2007
Economic downturn

??

GLOBAL SPACE ACTIVITY



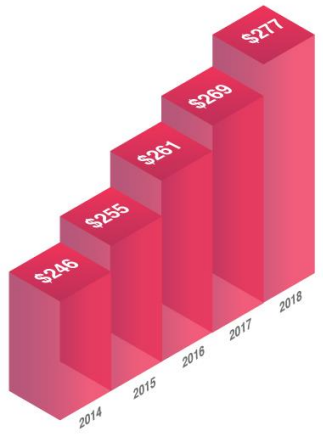
Source: The Space Report 2019

2019 STATE OF THE SATELLITE INDUSTRY

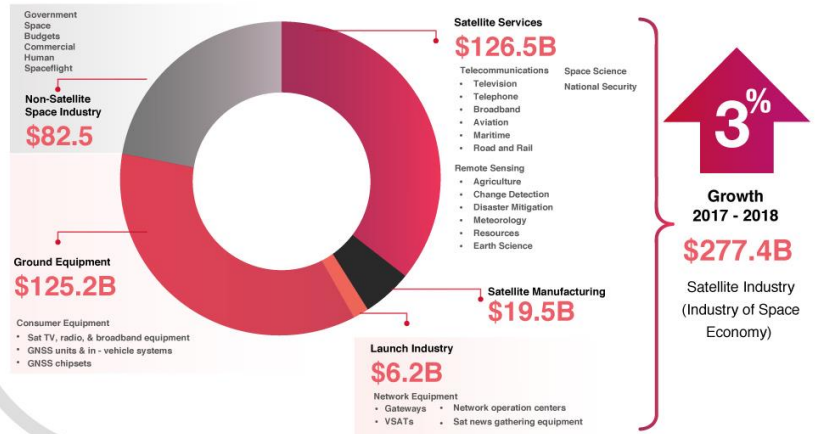
2018 Growth

Satellite manufacturing and launch Markets for value-added services across multiple segments

Global Satellite Industry Revenues
(billions of U.S. dollars)



The Satellite Industry in Context
(2018 revenues worldwide, in billions of U.S. dollars)



Satellite Services

1.7

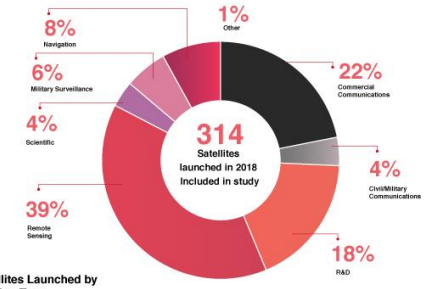
2018 Revenues
$126.5B

Television	$94.2B
Radio	$5.8B
Broadband	$2.4B
Fixed	$17.9B
Mobile	$4.1B
Remote Sensing	$2.1B

Satellite Manufacturing

26%

2018 Revenues
$19.5B $8B $11.5B

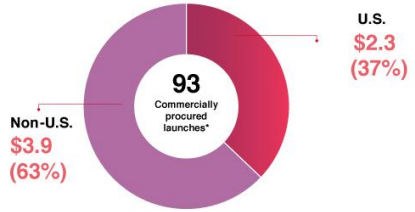


Satellites Launched by Mission Type

Launch Industry

34%

2018 Revenues
$6.2B



** There were 114 total orbital launches in 2018. Of these, 93 were commercially procured, 15 involved*

Commercial Launch Revenues by Region

Ground Equipment

5%

2018 Revenues
$125.2B

Consumer Equipment	$18.1B
GNSS Equipment	$93.3B
Network Equipment (VSATs, gateways, etc.)	$13.8B

TIMES OF TECHNOLOGICAL CHANGE

// Machine Learning and Automation

// New manufacturing processes

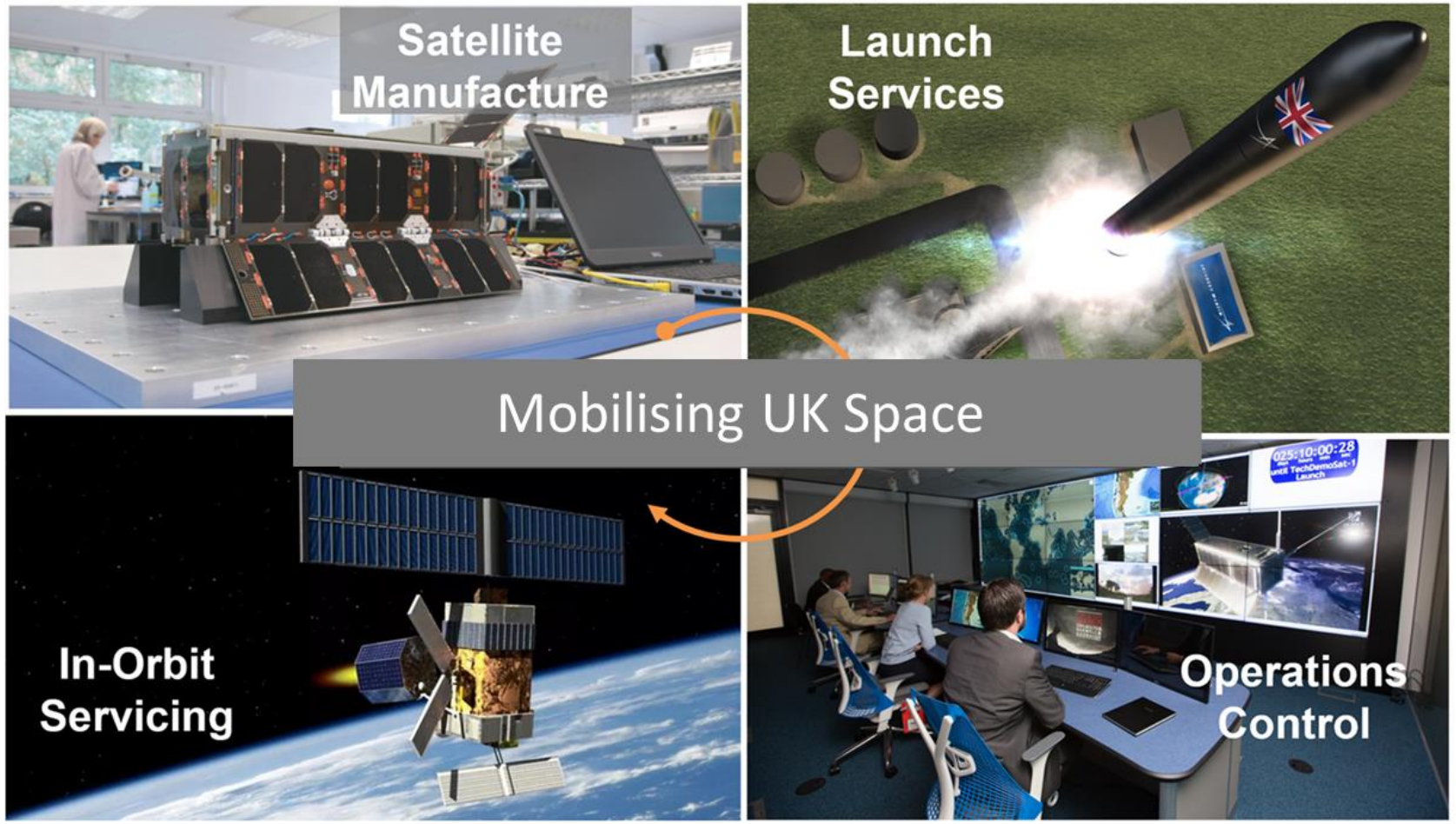
// Increasingly connected and informed world

CATAPULT
Satellite Applications

BIG AMBITIONS

WHAT THIS MEANS?

New entrants are challenging convention



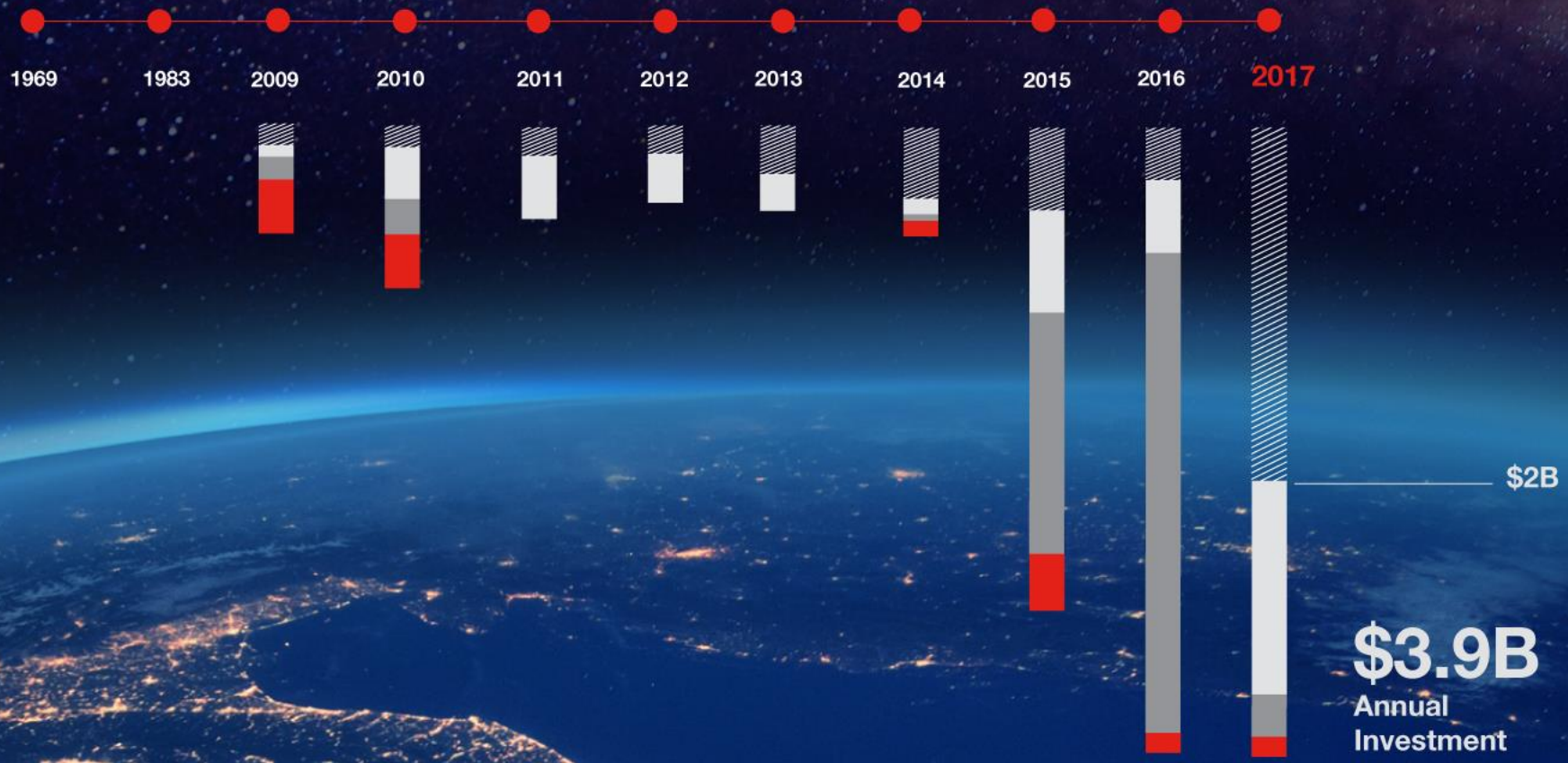
…Barriers to market are being lowered

DISRUPTION BEING LEAD BY VENTURE FUNDED START-UPS

Expensive (>$100m)	COST	Affordable ($5m)
Slow (3-5 yrs)	TIME TO MARKET	Fast (12 months)
Hardware centric	TECHNOLOGY	Software Centric
Delay Prone (2 yrs)	RELIABILITY	Disposable
Bespoke	SCALABILITY	Modular
High Risk	RISK	Lower Risk
Govt / Big Corp	ENTERPRISE	Start-up / SME

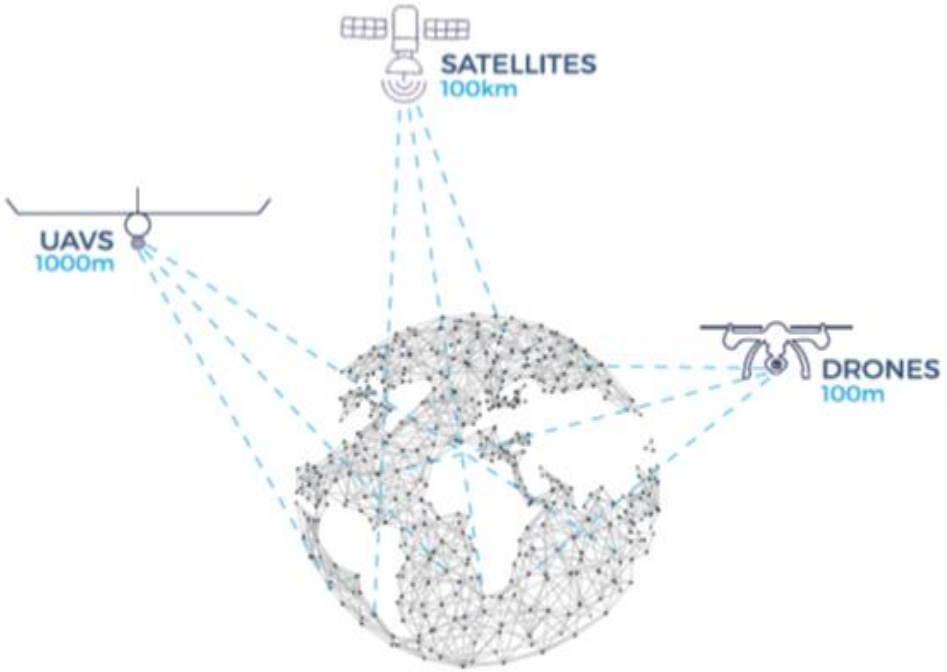
INVESTMENT IN THE SPACE SECTOR

SPACE ANGELS



SERAPHIM INVESTMENT FOCUS

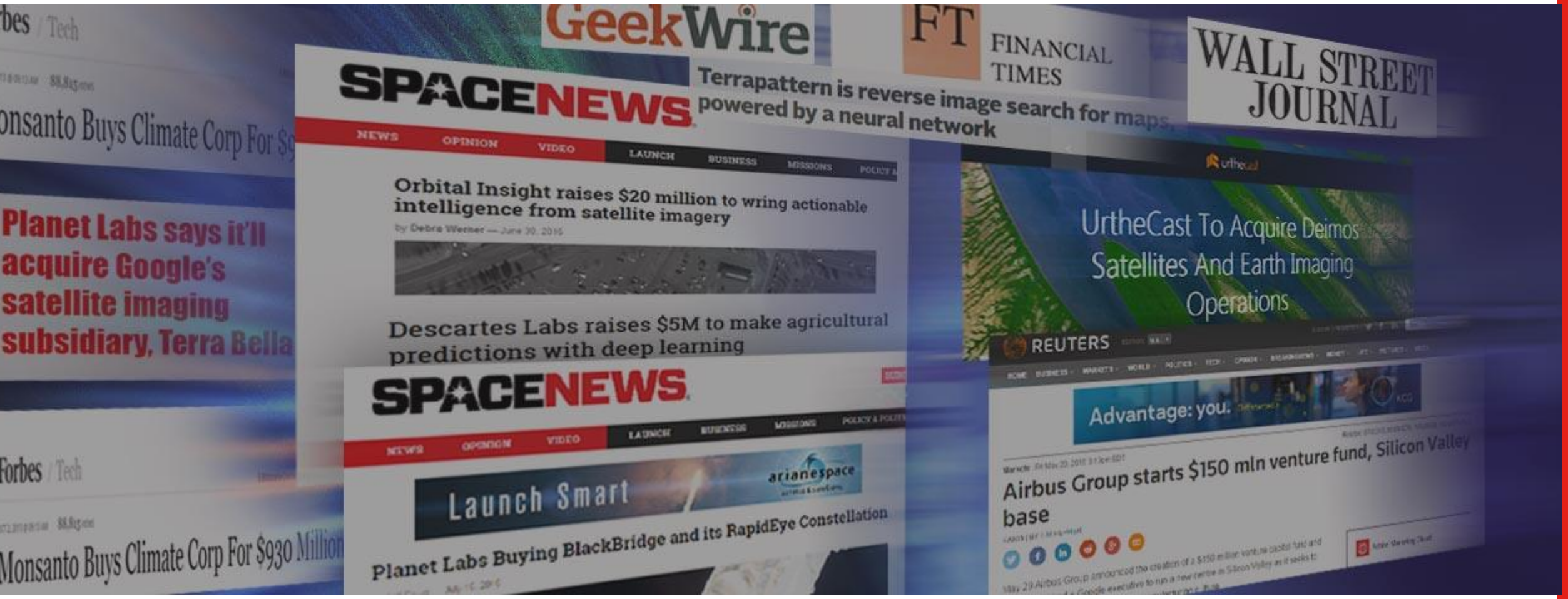
Space / Aerial Platforms Collecting & Communicating Data From Above….



…and the broader technologies that support the full spacetech ecosystem

Enabled Applications Tailored to Specific Verticals…

FUNDING AND CORPORATE ACQUISITIONS



PROGRESSIVE REGULATION OPENS UP SPACE TO BUSINESSES

Commercial Space Launch Amendments Act of 2004

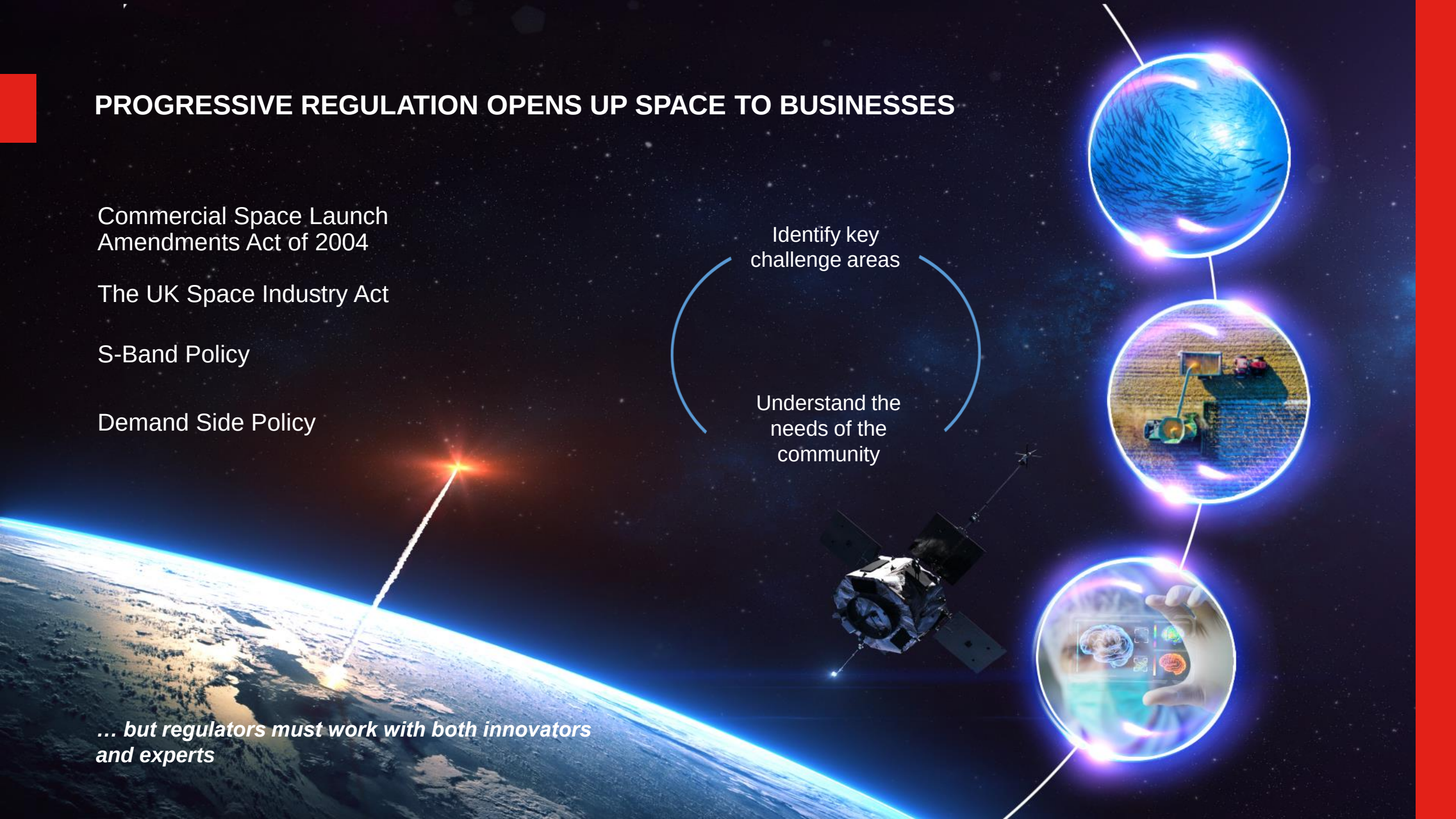
The UK Space Industry Act

S-Band Policy

Demand Side Policy

Identify key challenge areas

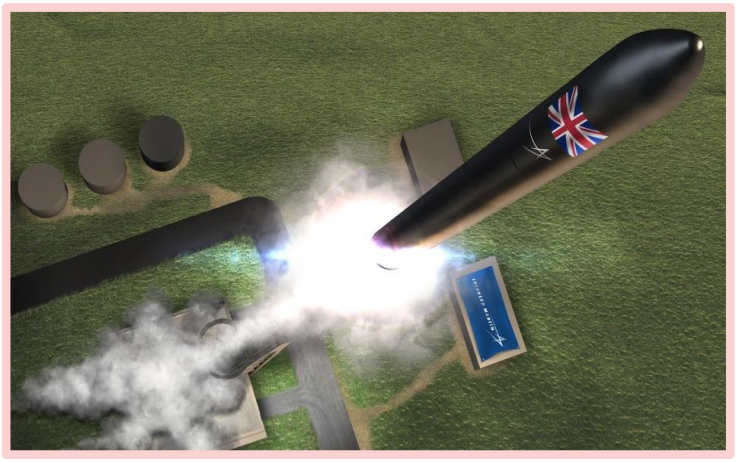
Understand the needs of the community



… but regulators must work with both innovators and experts

REGULATORY PRIORITY AREAS

DE-ORBITING REGULATIONS



LAUNCH RESPONSIBILITY

WHEN DAMAGE OCCURS

NON-FUNCTIONING ASSETS

… Keeping pace with innovation

OTHER TRENDS

INCREASING INVESTMENT BY END USER COMMUNITY

DISRUPTION OF TECH GIANTS

HORIZONTAL INTEGRATION

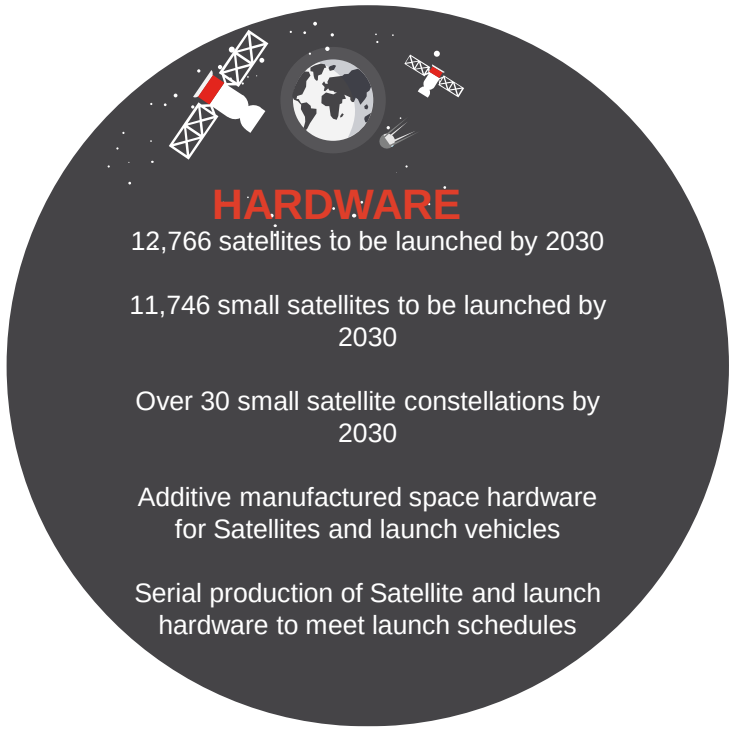
INDUSTRY CONSOLIDATION

Credit Frost & Sullivan

FUTURE OF SPACE - KEY DEVELOPMENTS

By 2030, over 12,500 Satellites will be launched. Space, will be busy like it never was.

TIMELINE 2016-2029



HARDWARE

12,766 satellites to be launched by 2030

11,746 small satellites to be launched by 2030

Over 30 small satellite constellations by 2030

Additive manufactured space hardware for Satellites and launch vehicles

Serial production of Satellite and launch hardware to meet launch schedules

APPLICATIONS

GNSS (and regional) systems delivering NAV services

Broadband services to remote locations via Satellite

On Orbit Servicing for life extension missions, manufacture and assembly, and active debris removal

High-throughput satellites (HTS) Global Connectivity / Internet of Things

LAUNCH

Over 40 small launch vehicles in development

More flexible and frequent launch capabilities

Spaceport-based business models (US and UK leading the game)

Air launched and other range-independent launch capabilities

2015-2020: TECHNOLOGY, SERVICE AND APPLICATIONS ENABLERS

Mega-constellations

Mega-Constellations

- Massive capacity & performance increase
- Low-cost mobile terminals
- Lower-latency ubiquitous services

GNSS augmentations

Enhanced positioning systems

- 4 GNSS systems;
- Low power devices, integrated inertial measurement
- Ubiquitous sub-10cm accuracy positioning

Advent of near-real-time EO

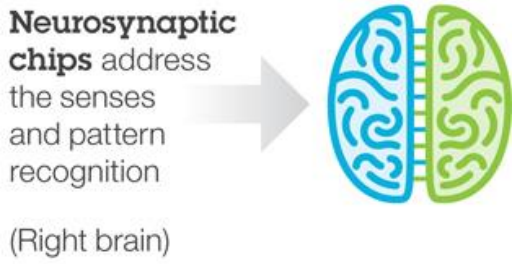
Near-Real-time EO services

- Technology miniaturisation
- Reduced-cost access to space
- Commercial satellite-based relay systems

2020 – 2025: TECHNOLOGY ENABLERS

Graphene

PV efficiency trends



Artificial intelligence

New Materials science

- Carbon nanotubes & graphene radically change power electronics capability
- Antenna embedded within structural materials

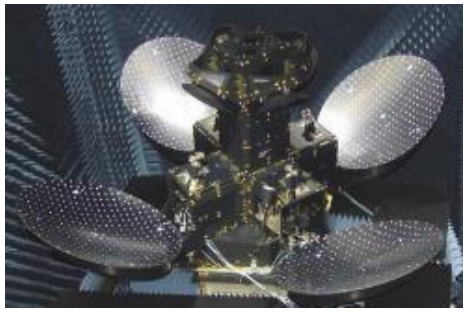
Energy generation and storage technologies

- Photovoltaic technology evolution → efficiency and lightweight
- Energy harvesting (wearables) & storage evolution
- Prevalence of contactless / induction charging systems

Artificial intelligence/ Neural processor technologies

- Advanced signal processing – image recognition
- Autonomous systems become a reality

2025-2030: TECHNOLOGY ENABLERS



Deployable structures

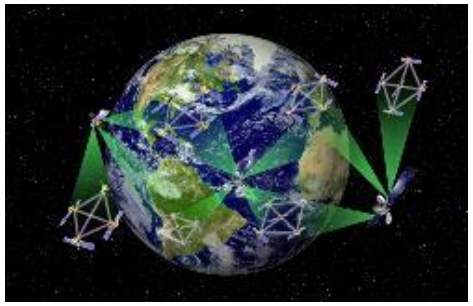
Hybridisation of robotics and new materials science

- Deployable and Reconfigurable structures
- Repairable/ replenishable / upgradeable space-craft
- Re-useable launch and orbit-transfer vehicles

HAPs

Stratellites/ city-satellites High altitude pseudo-satellites

- Exceptional duration flight times, 20km altitude
- Very stable observation and communications platforms
- Optical communications



Fractionated Spacecraft

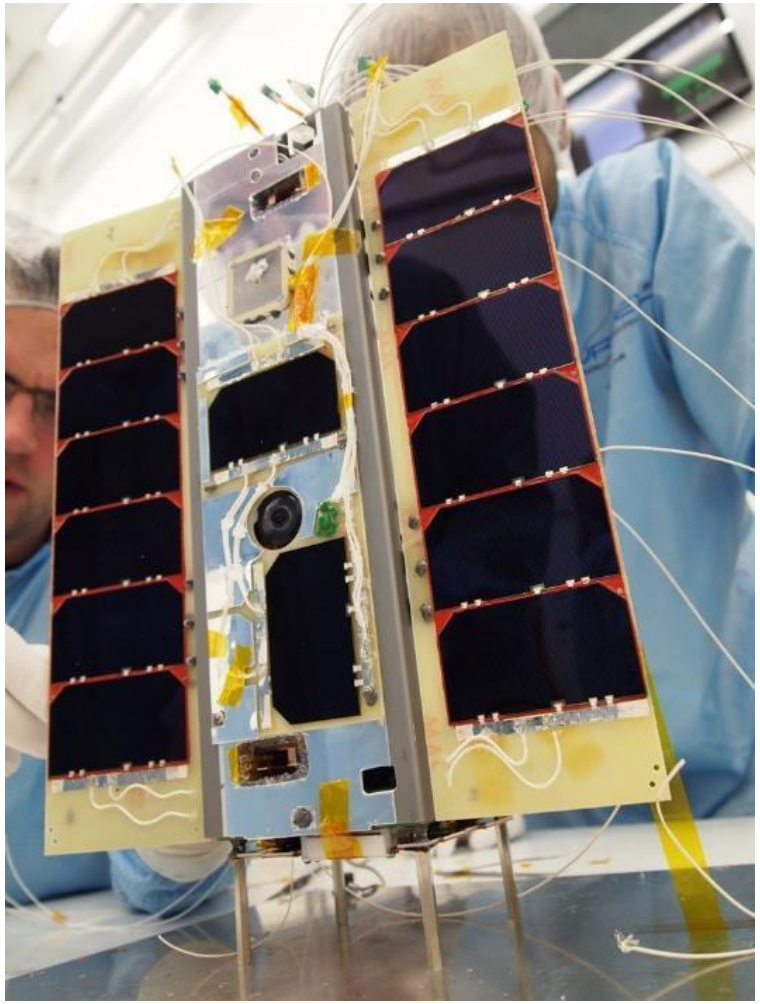
Fractionated and co-operative constellations

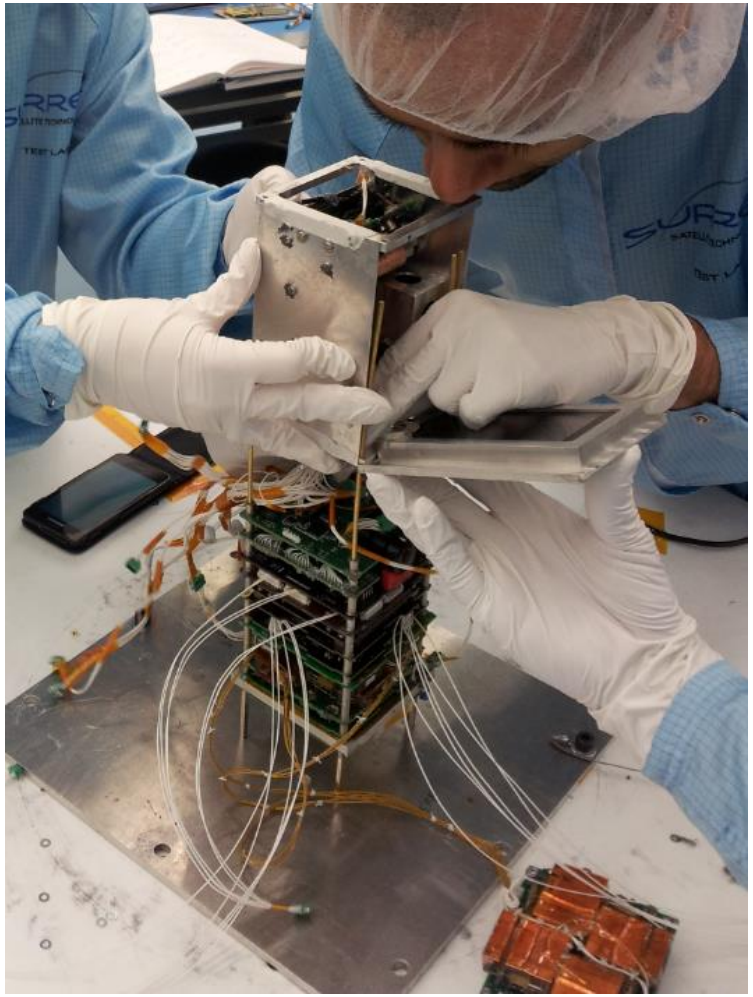
- Communications, distributed processing, precision positioning allow complex constellations of satellites to act in concert
- Ubiquitous high-performance communications and imaging

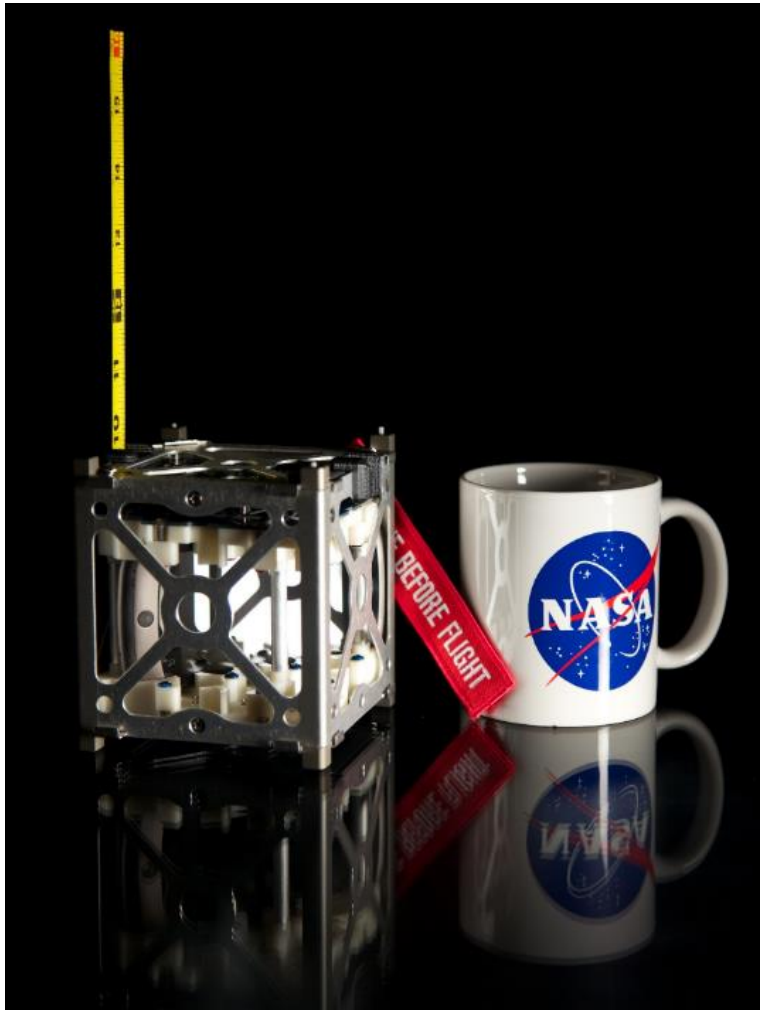
// Opportunity # 1:

Hardware

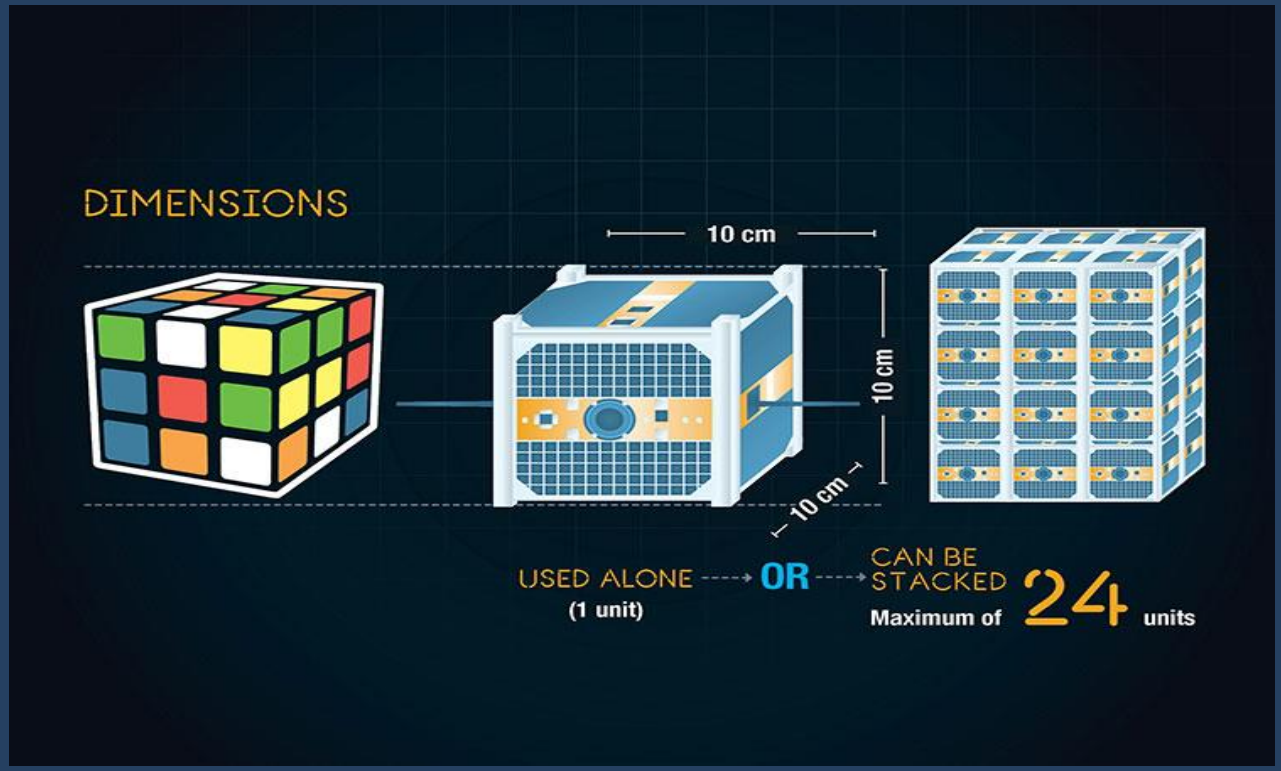
STRAND-1 AND PHONESAT: SMARTPHONES IN SPACE







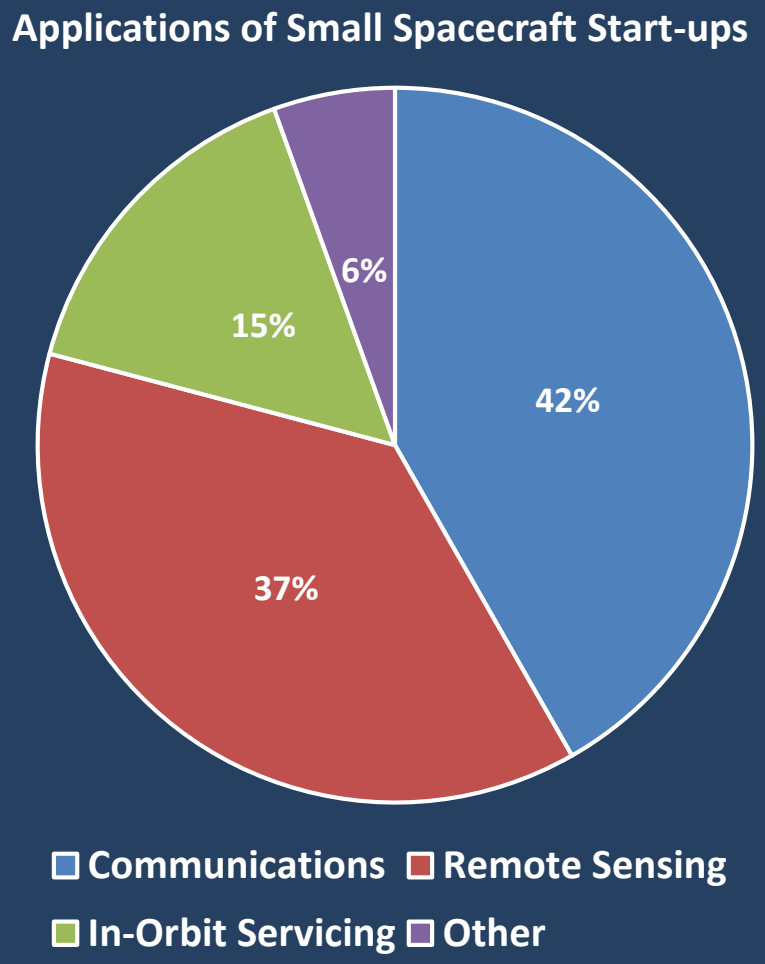
Small Satellites are part of the trend for the New Space evolution

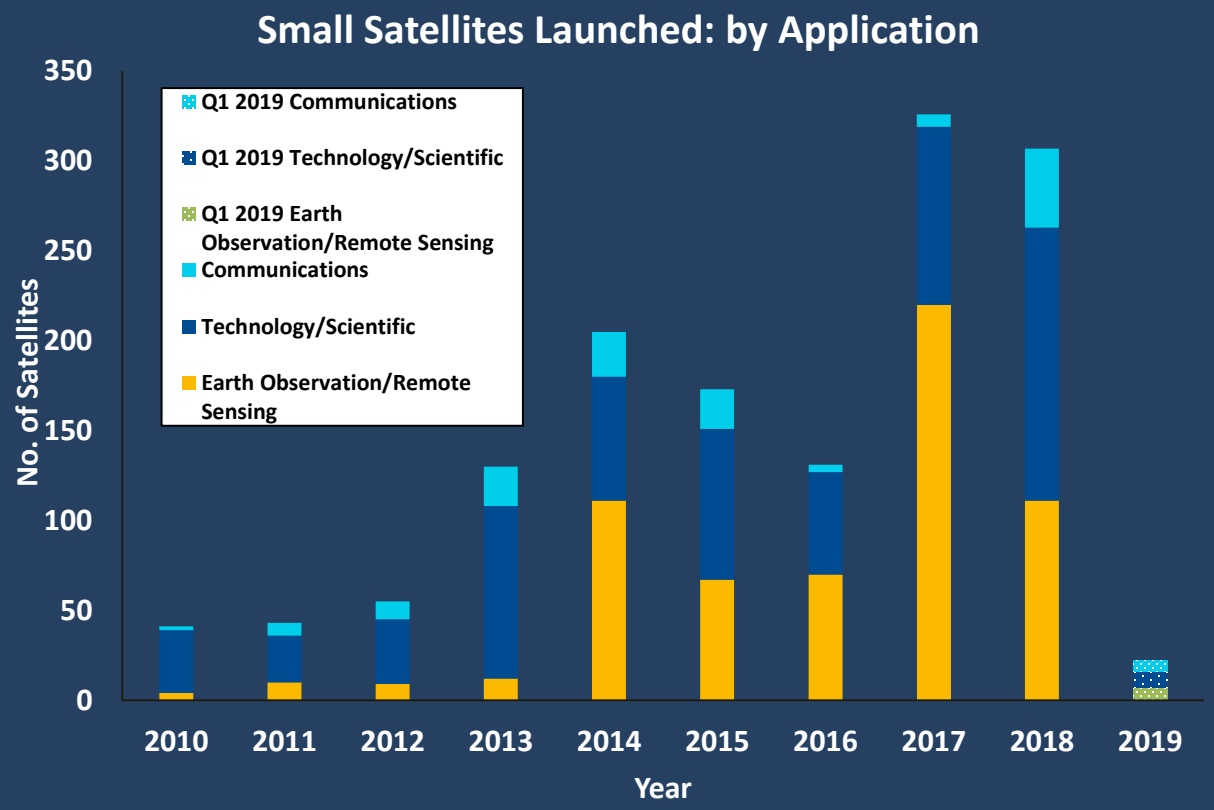


Source: Canadian Space Agency

CATAPULT Satellite Applications

Launches of Small Satellites are increasing as are the applications





OVER THE NEXT THREE YEARS

2300 Satellites will require a launch

Source: Small Satellite Quarterly Update, SA Catapult

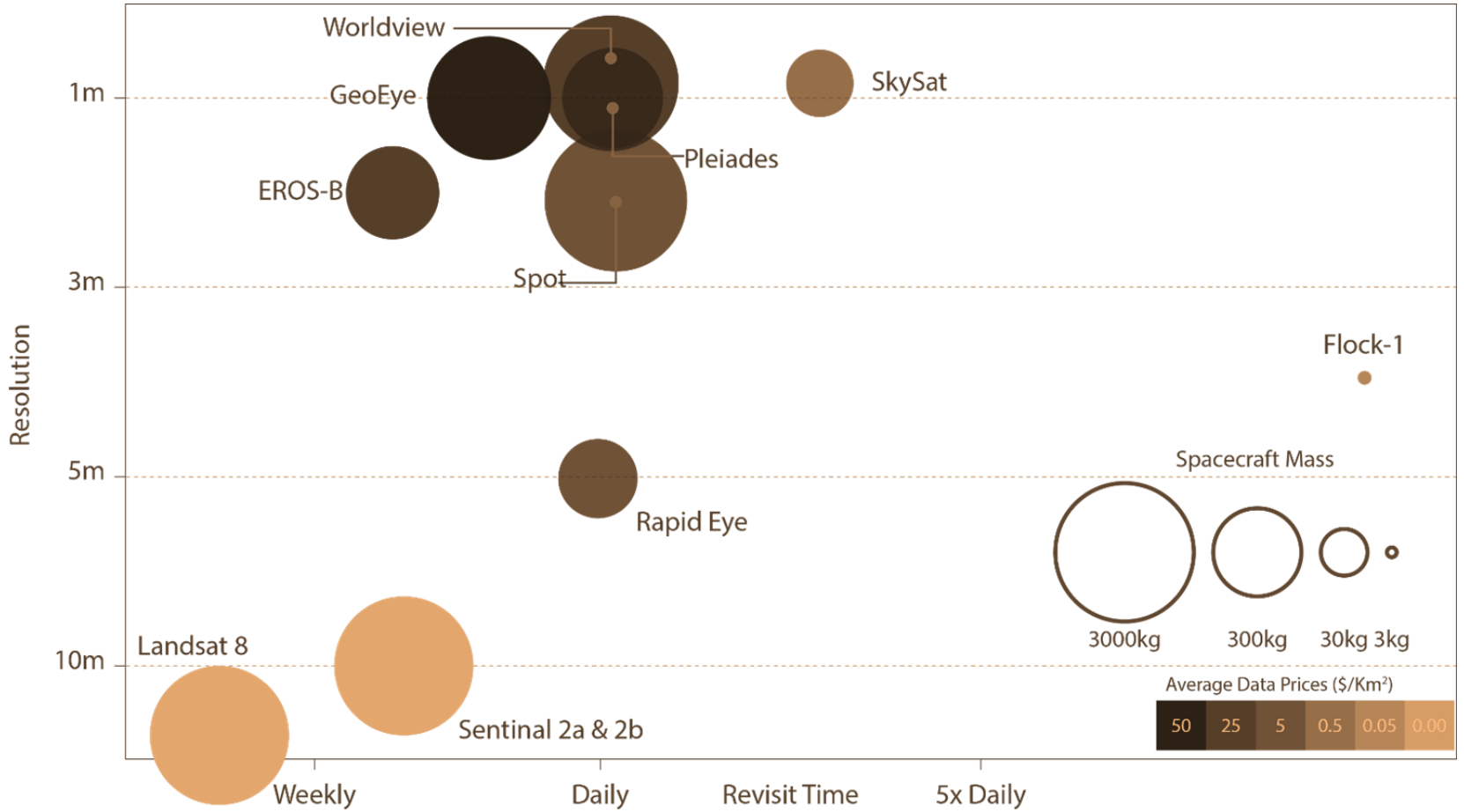
CATAPULT Satellite Applications

PLATFORMS

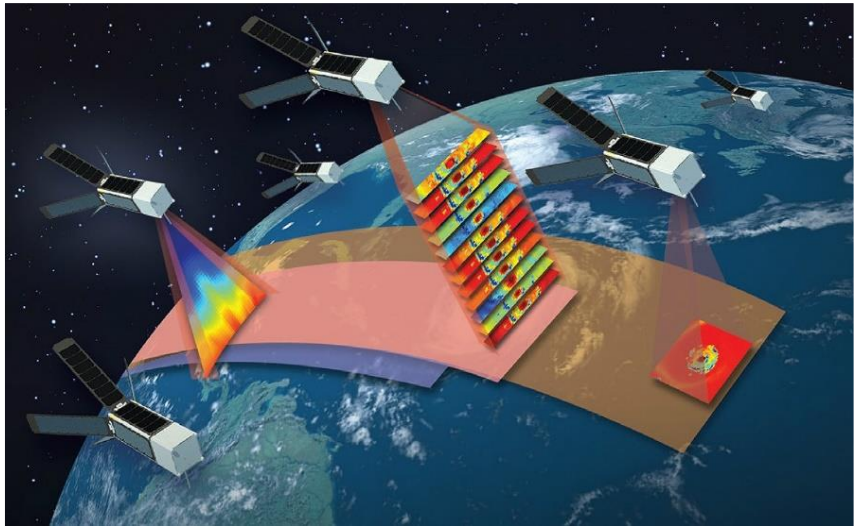
Free access to space

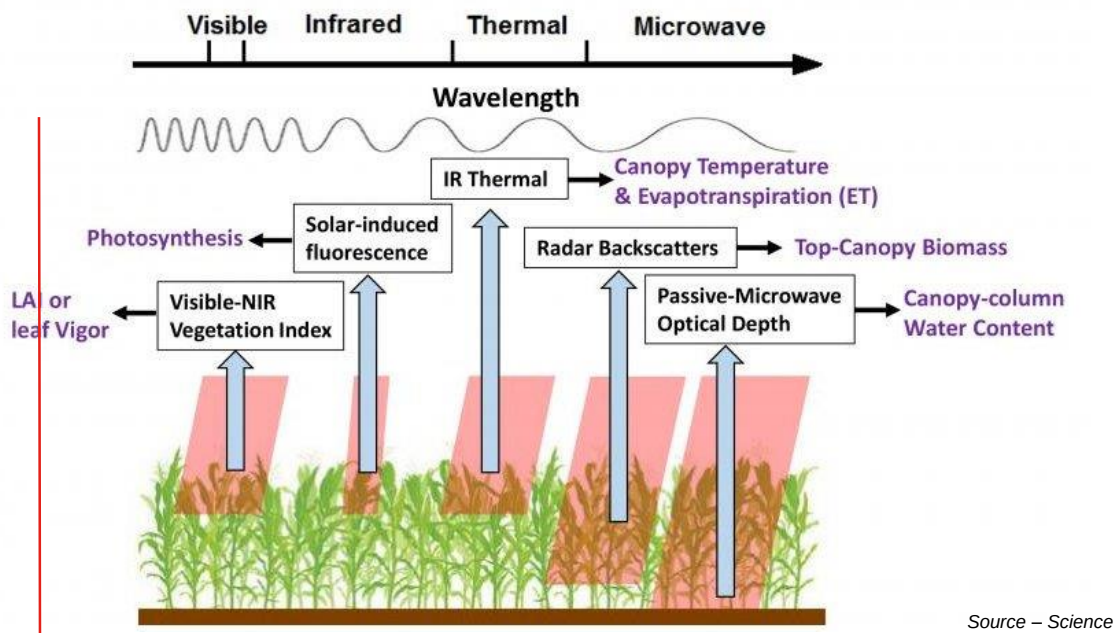
State of the art space

Commoditisation of space



SENSORS



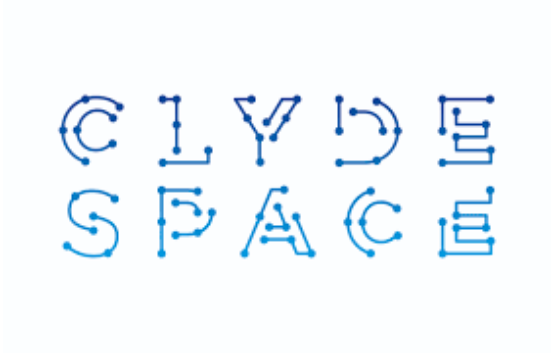


Source – Science Daily

- Increased spatial/ spectral detail
- New forms of sensing (e.g. Multi-frequency SAR)
- Configurable sensing
- Increased terrestrial sensing integration

- Increased sensitivity
- New biophysical and structural parameters
- Direct detection/ measurements

ONES TO WATCH



// Opportunity # 2:

Lower cost access to space

Launch Market Trends

LAUNCH MARKET TRENDS

Reduced launch costs, miniaturization of technology, and standardization are bringing the space sector within the reach of startups and entrepreneurs.

1980 $100,000/lb

2010 $10,000/lb

2030 $100/lb?

Shuttle

Falcon 9

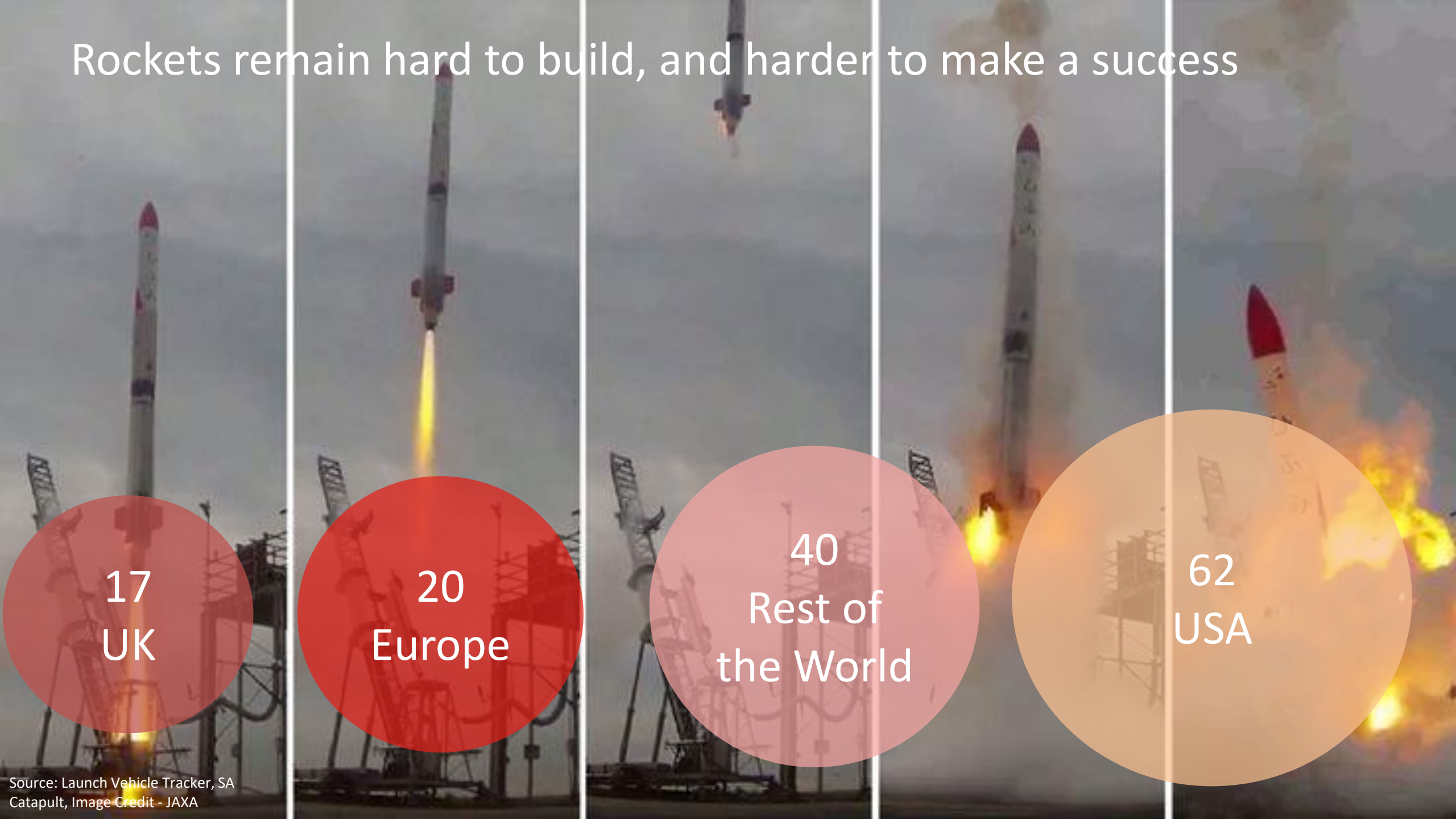
Delta IV

Falcon Heavy

Atlas V

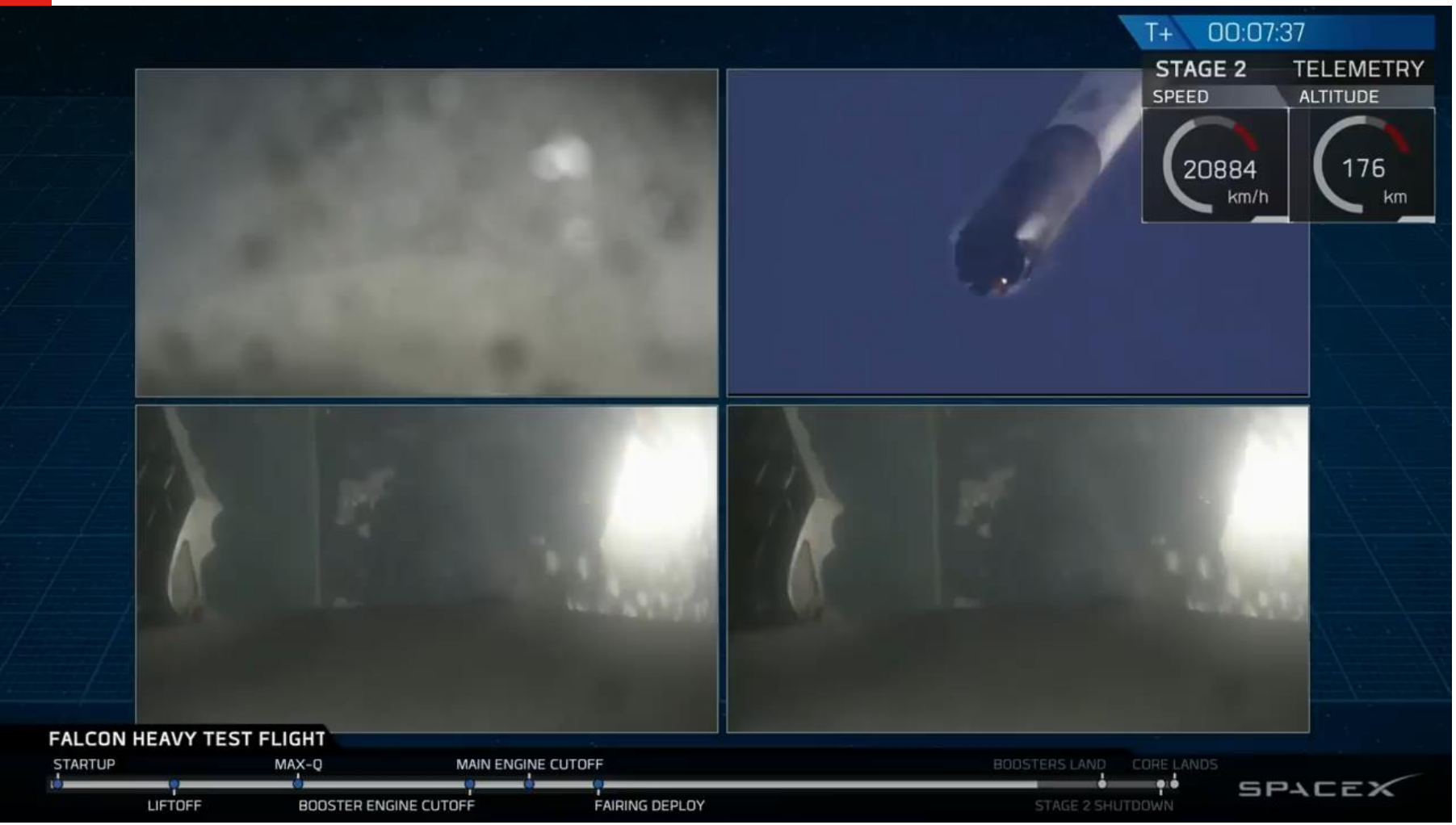
Re-usable and suborbital launch

Rockets remain hard to build, and harder to make a success

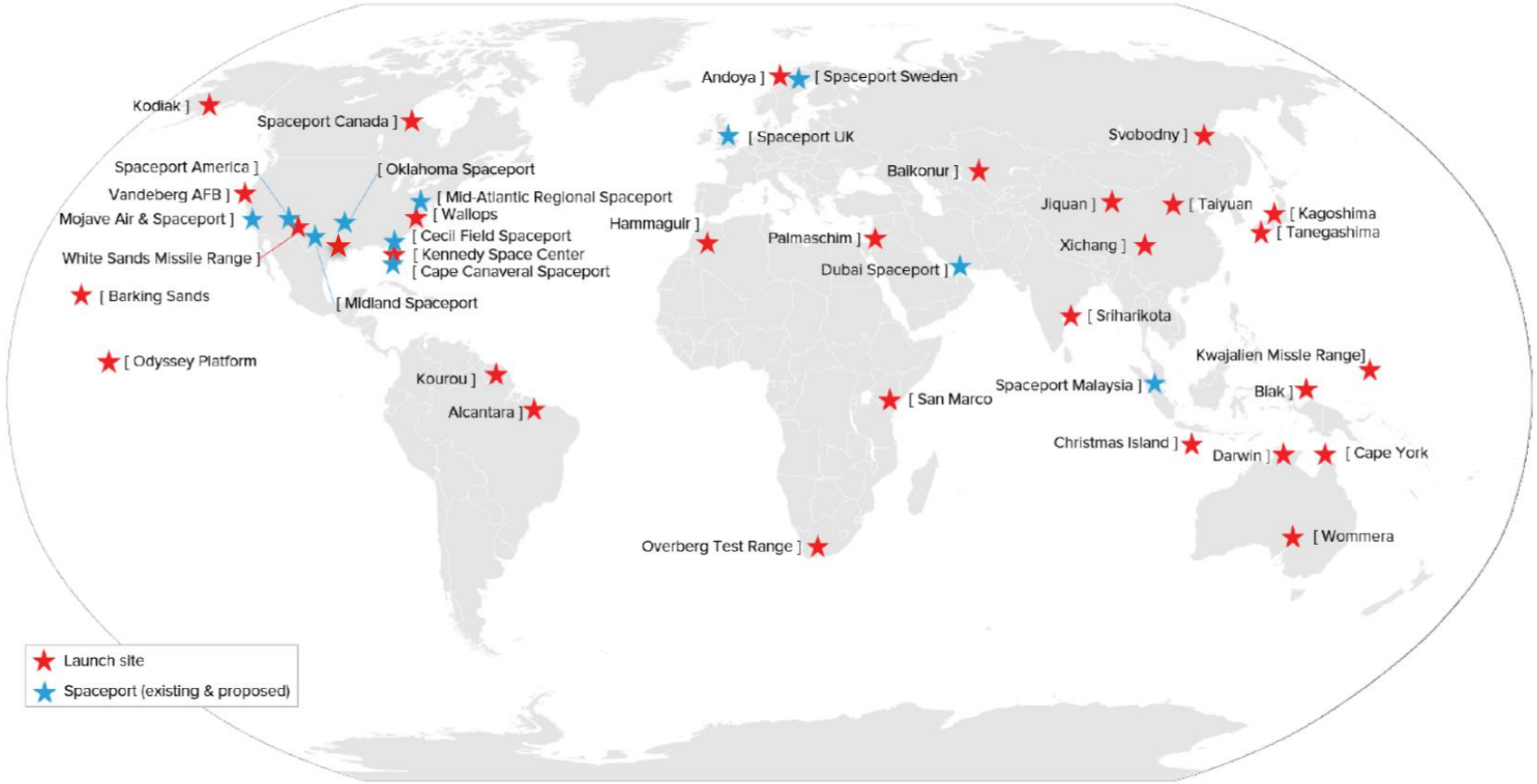


Source: Launch Vehicle Tracker, SA Catapult, Image Credit - JAXA

SPACE IS HARD



SPACEPORTS


Kodiak]
Spaceport Canada]
Spaceport America]
Vandeberg AFB]
Mojave Air & Spaceport]
White Sands Missile Range]
[Barking Sands
[Odyssey Platform
[Oklahoma Spaceport
[Mid-Atlantic Regional Spaceport
[Wallops
[Cecil Field Spaceport
[Kennedy Space Center
[Cape Canaveral Spaceport
[Midland Spaceport
Kourou]
Alcantara]
Andoya]
[Spaceport Sweden
[Spaceport UK
Hammaguir]
Palmaschim]
Dubai Spaceport]
Overberg Test Range]
Balkonur]
Svobodny]
Jiquan]
[Taiyuan
[Kagoshima
[Tanegashima
Xichang]
[Sriharikota
[San Marco
Spaceport Malaysia]
Kwajalien Missle Range]
Biak]
Christmas Island]
Darwin]
[Cape York
[Wommera
Launch site
Spaceport (existing & proposed)

A UK SPACE PORT

"We are committed to supporting a commercial market for access to space in the UK, and we will continue to engage with any company who seeks to operate here."
Graham Turnock, Chief Executive of the UK Space Agency

ONES TO WATCH

SPACEX

REACTION ENGINES

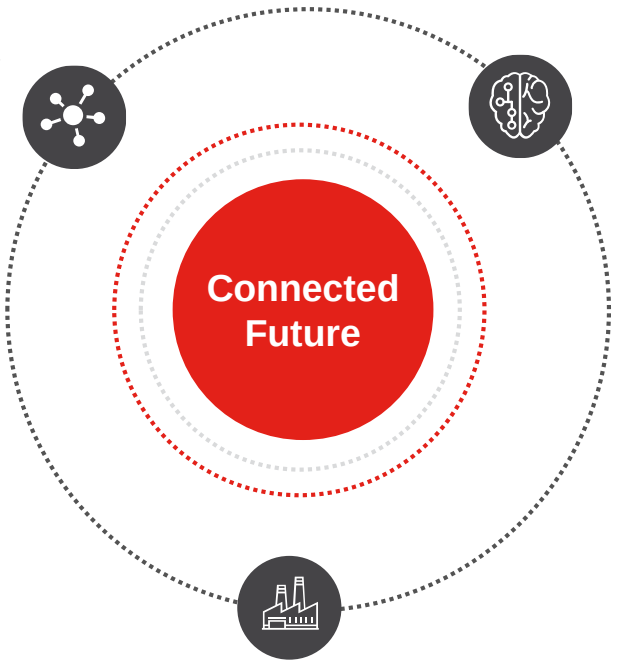
ROCKET LAB

ORBITAL ACCESS

// Opportunity # 3:

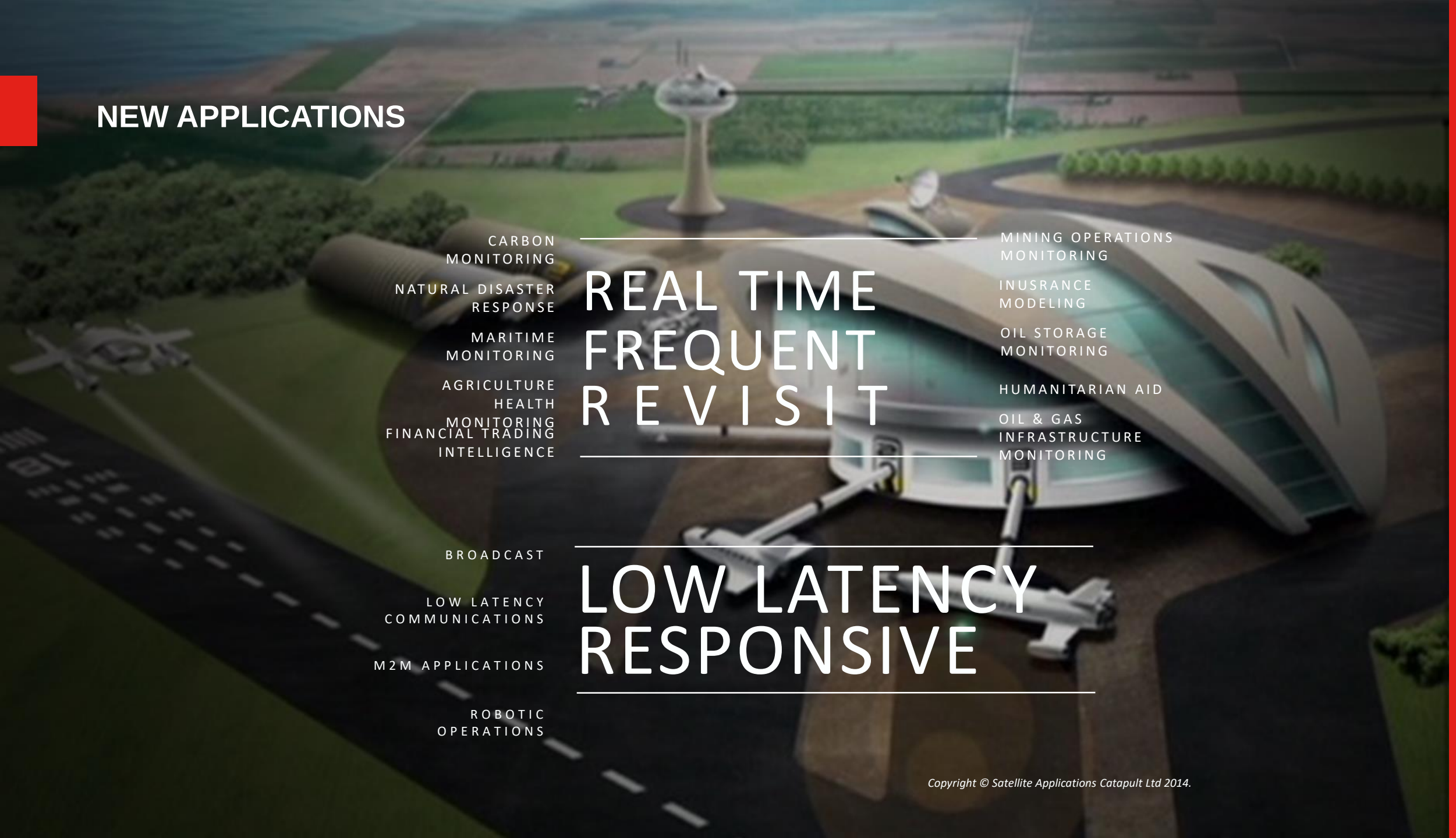
Applications

FUTURE OF SPACE



Credit Frost & Sullivan

NEW APPLICATIONS



CARBON MONITORING

NATURAL DISASTER RESPONSE

MARITIME MONITORING

AGRICULTURE HEALTH MONITORING

FINANCIAL TRADING INTELLIGENCE

REAL TIME FREQUENT REVISIT

MINING OPERATIONS MONITORING

INUSRANCE MODELING

OIL STORAGE MONITORING

HUMANITARIAN AID

OIL & GAS INFRASTRUCTURE MONITORING

BROADCAST

LOW LATENCY COMMUNICATIONS

M2M APPLICATIONS

ROBOTIC OPERATIONS

LOW LATENCY RESPONSIVE

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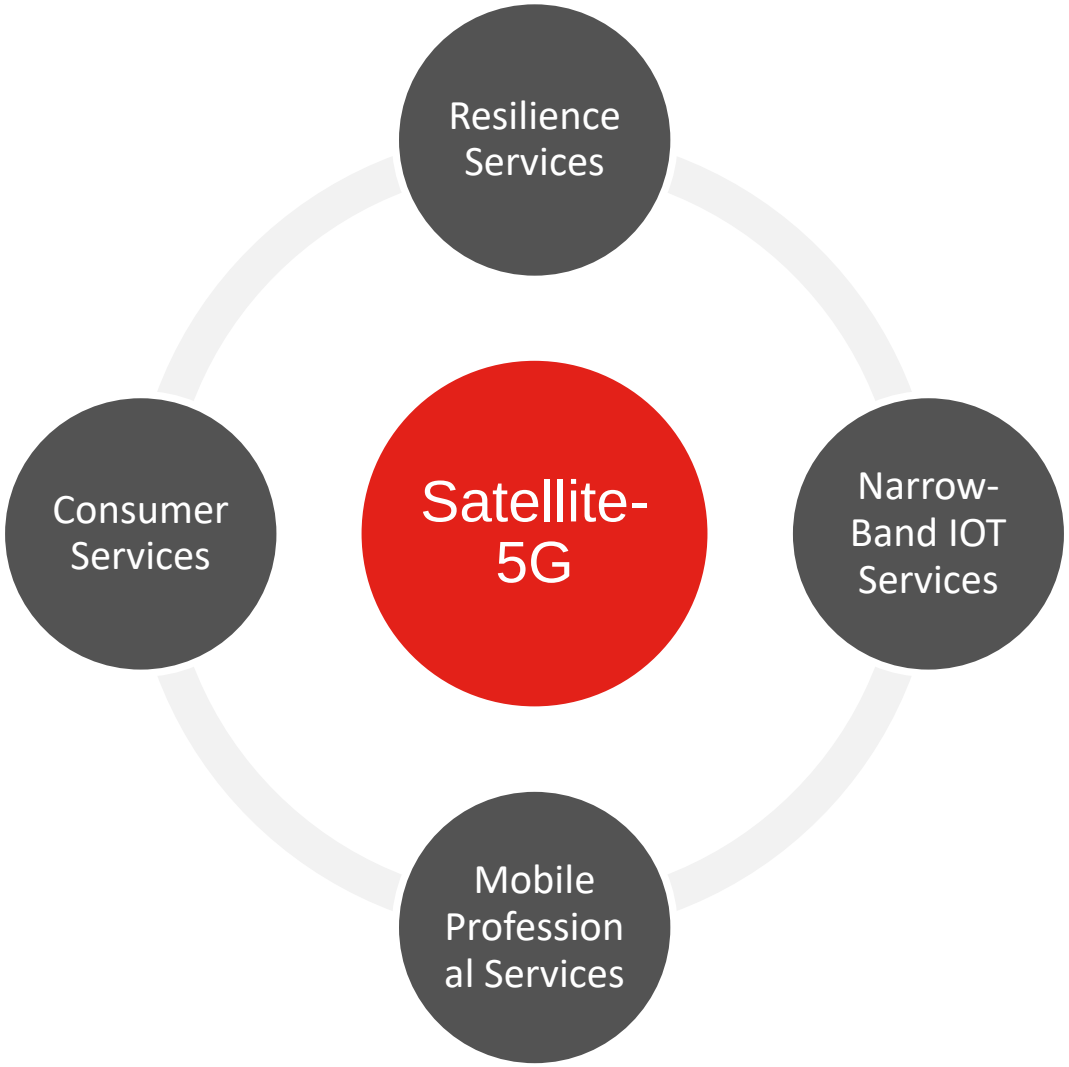
DOWN-STREAM GROWTH OPPORTUNITIES: MOBILE CONNECTIVITY – SATELLITE 5G



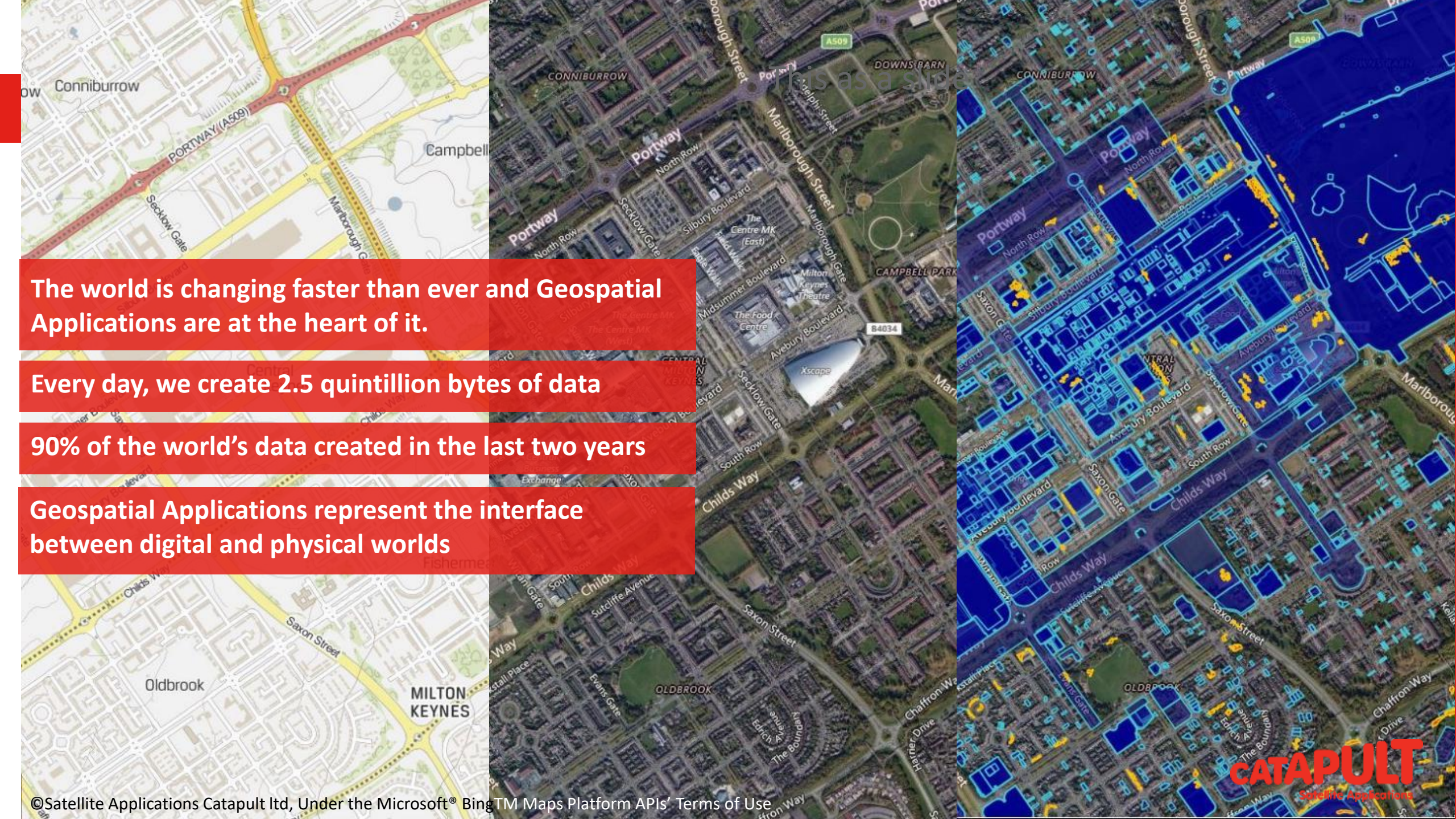
- We are reaching a point of convergence between satellite and terrestrial communications systems capabilities
- Opportunities exist for making satellite services integral to future mass-market communications systems

EXAMPLE FUTURE HARMONISED HYBRID NETWORK

CONNECTIVITY FOR AUTONOMOUS VEHICLES

The drive towards autonomy will create demand for ubiquitous and resilient connectivity across the entire road network, both for vehicle management, and in response to passenger service requirements

SATELLITE APPLICATIONS AND INTELLIGENT TRANSPORT



The world is changing faster than ever and Geospatial Applications are at the heart of it.

Every day, we create 2.5 quintillion bytes of data

90% of the world's data created in the last two years

Geospatial Applications represent the interface between digital and physical worlds

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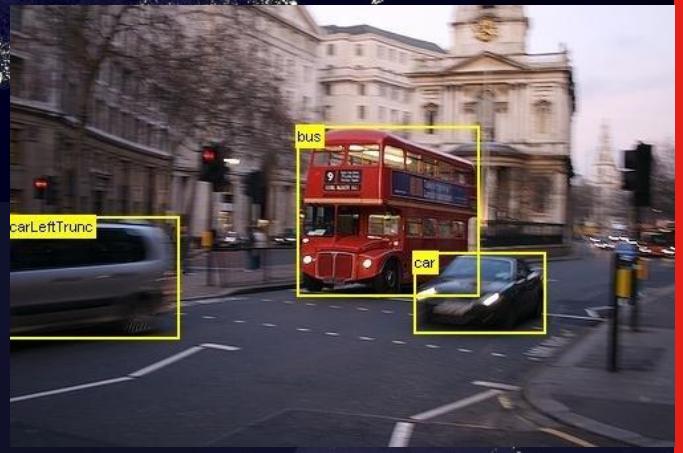
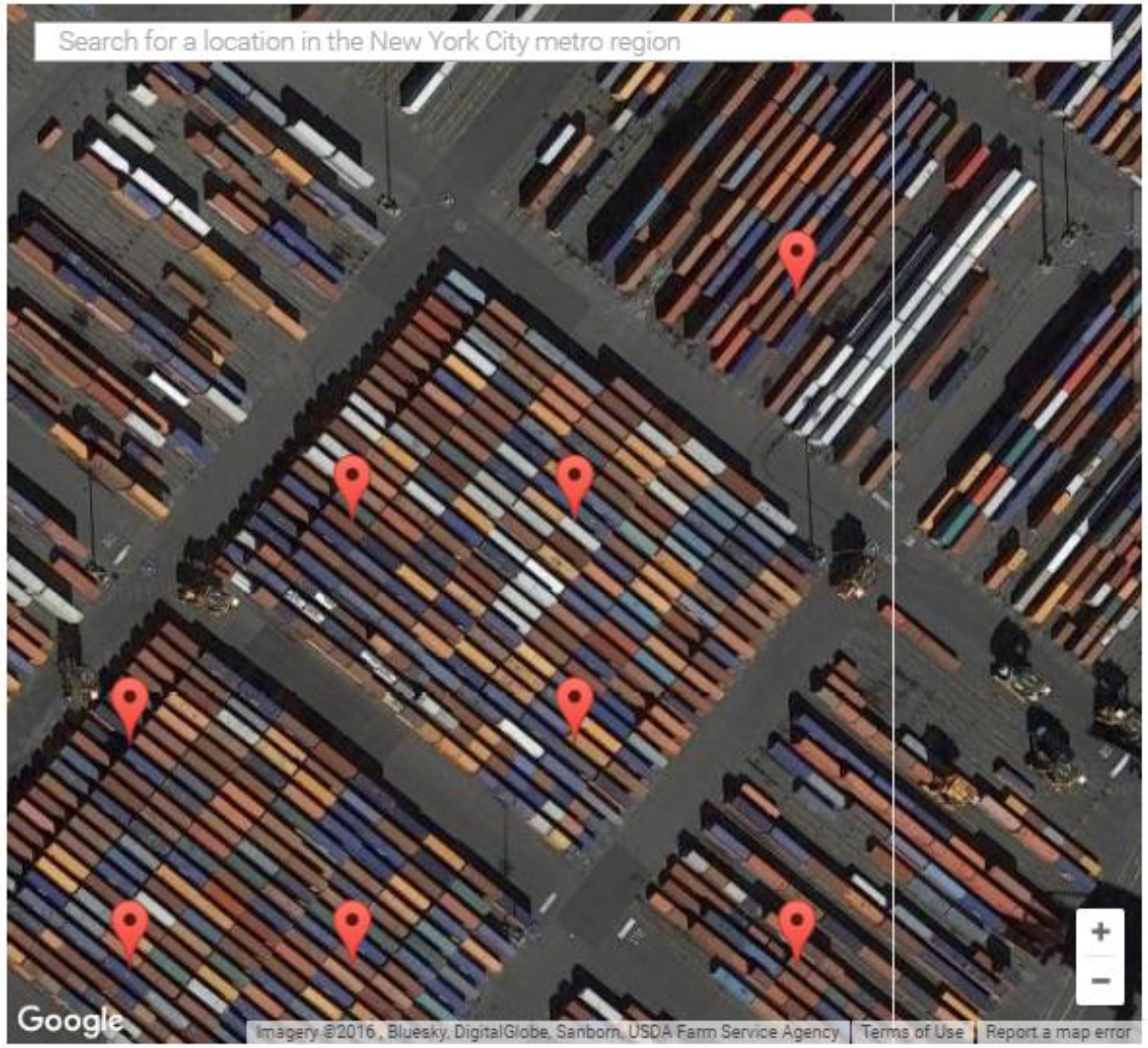
COMPUTER VISION & SCALABILITY



Advances in Computer Vision techniques allow for automated machine interrogation of imagery.

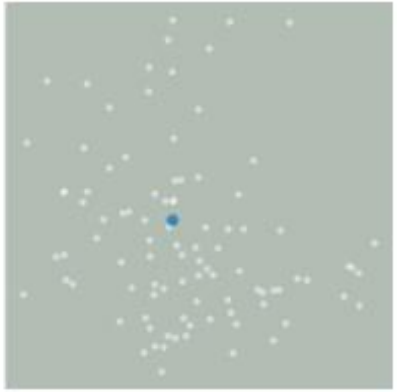
This allows for an unbiased analysis of huge amounts of imagery at unprecedented speed.

CONTAINERS – NEW YORK CITY

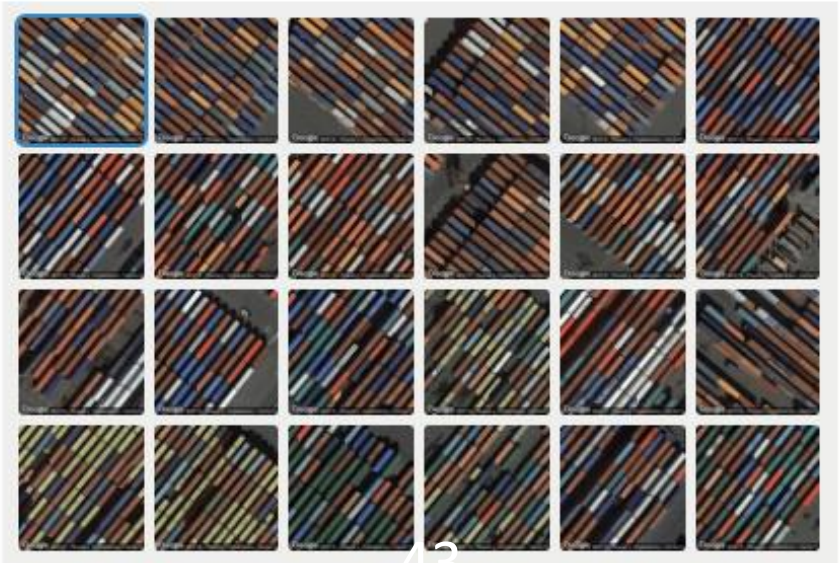


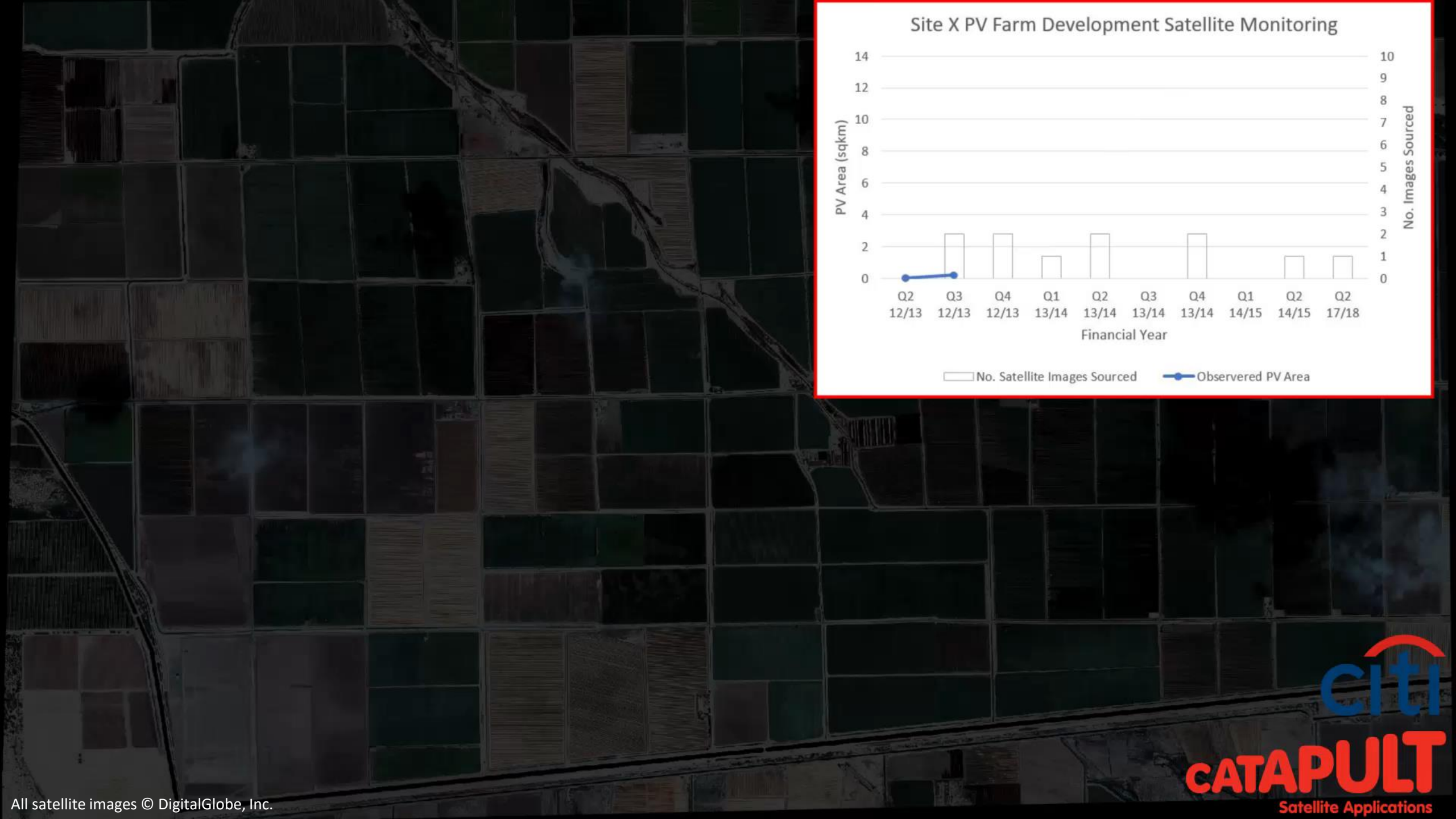
Geographical Plot

Similarity Plot



Search Results





All satellite images © DigitalGlobe, Inc.

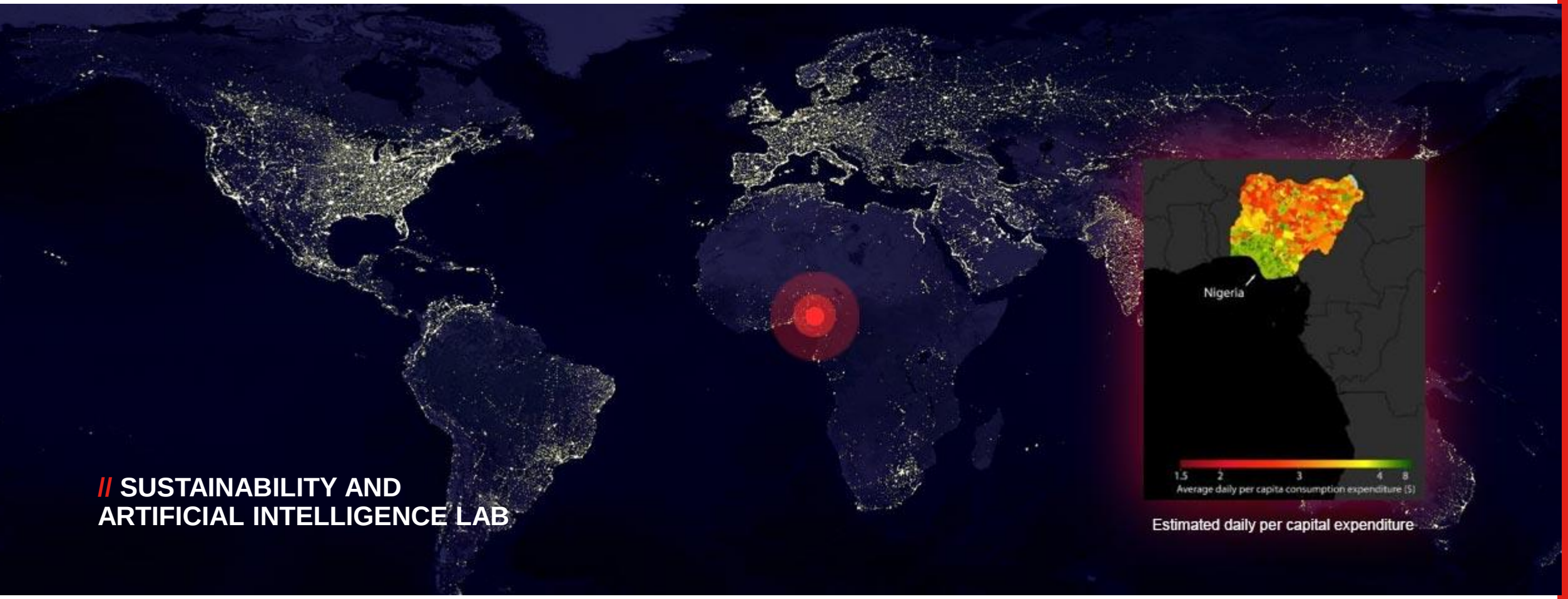
citi CATAPULT Satellite Applications


© EARTH-i, 2017
Simulated Satellite Video, 1m Res
EARTH

THE SUSTAINABLE DEVELOPMENT GOALS

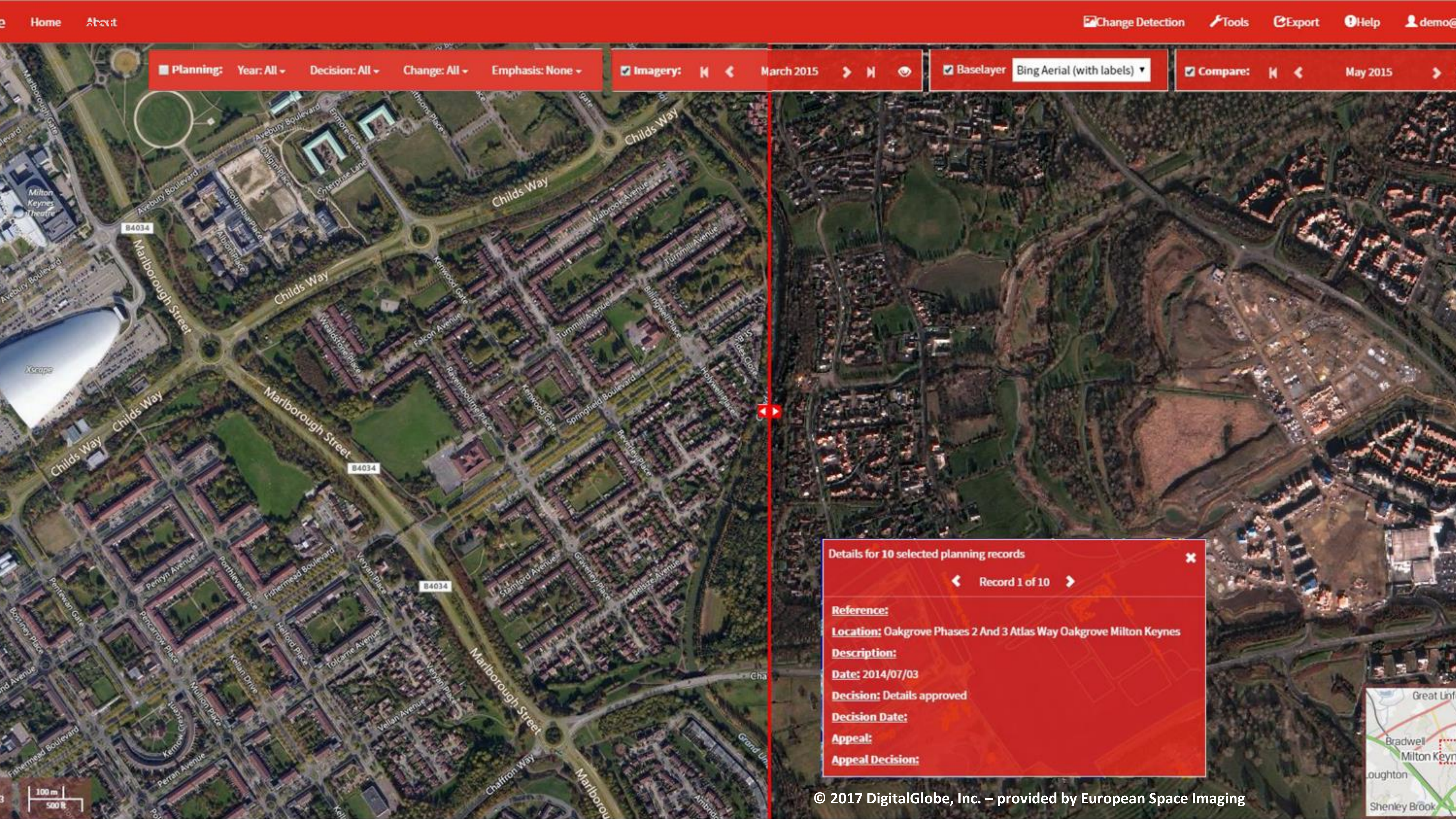
MAPPING POVERTY

Stanford



// SUSTAINABILITY AND ARTIFICIAL INTELLIGENCE LAB

Image credit: Neal Jean et al, Stanford University


Home
About
Change Detection
Tools
Export
Help
demo@
Planning:
Year: All
Decision: All
Change: All
Emphasis: None
Imagery:
March 2015
Baselayer
Bing Aerial (with labels)
Compare:
May 2015
Childs Way
Marlborough Street
B4034
Avebury Boulevard
Milton Keynes Theatre
Xscape
Details for 10 selected planning records
Record 1 of 10
Reference:
Location: Oakgrove Phases 2 And 3 Atlas Way Oakgrove Milton Keynes
Description:
Date: 2014/07/03
Decision: Details approved
Decision Date:
Appeal:
Appeal Decision:
100 m
500 ft
Bradwell
Milton Keyn
Loughton
Shenley Brook
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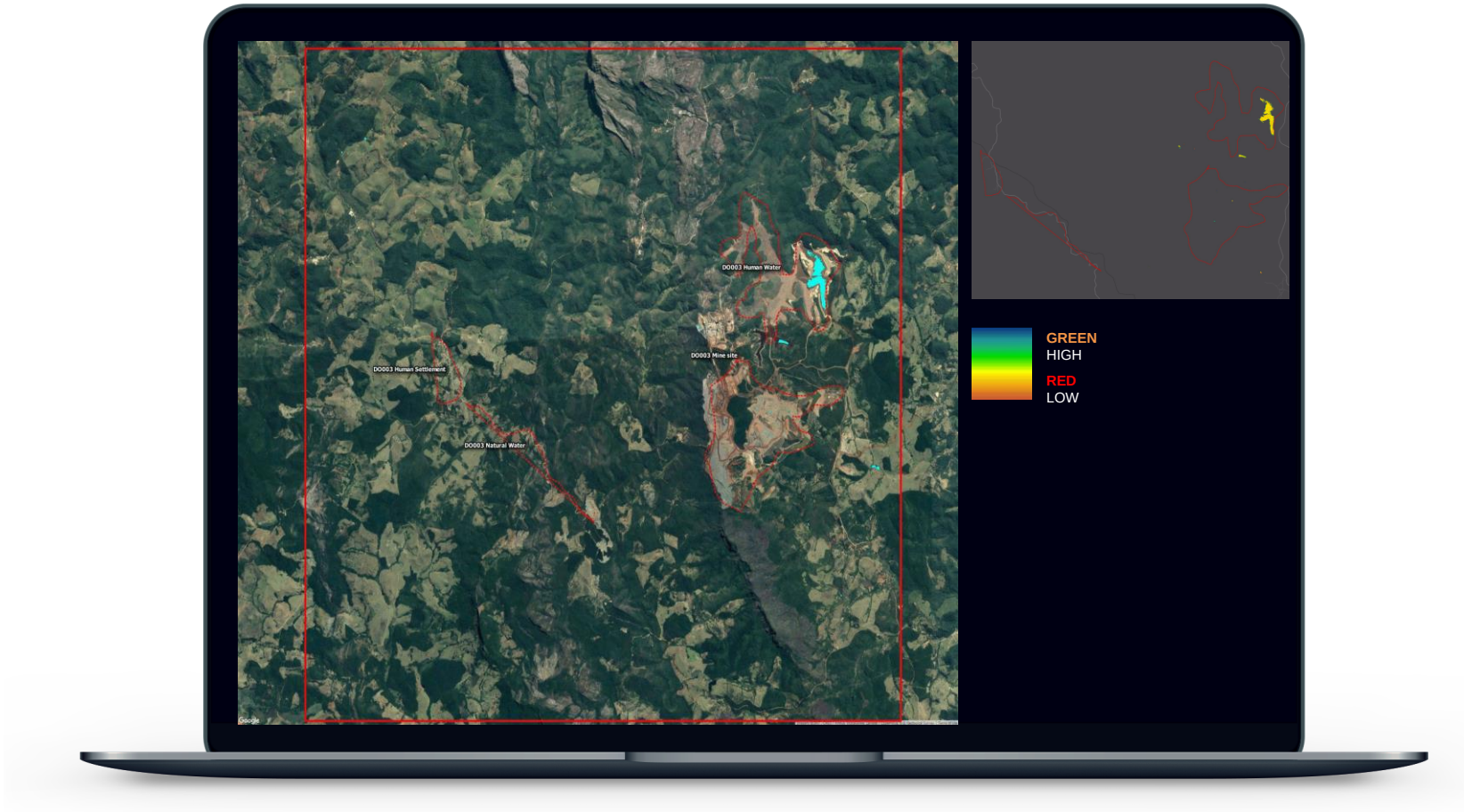
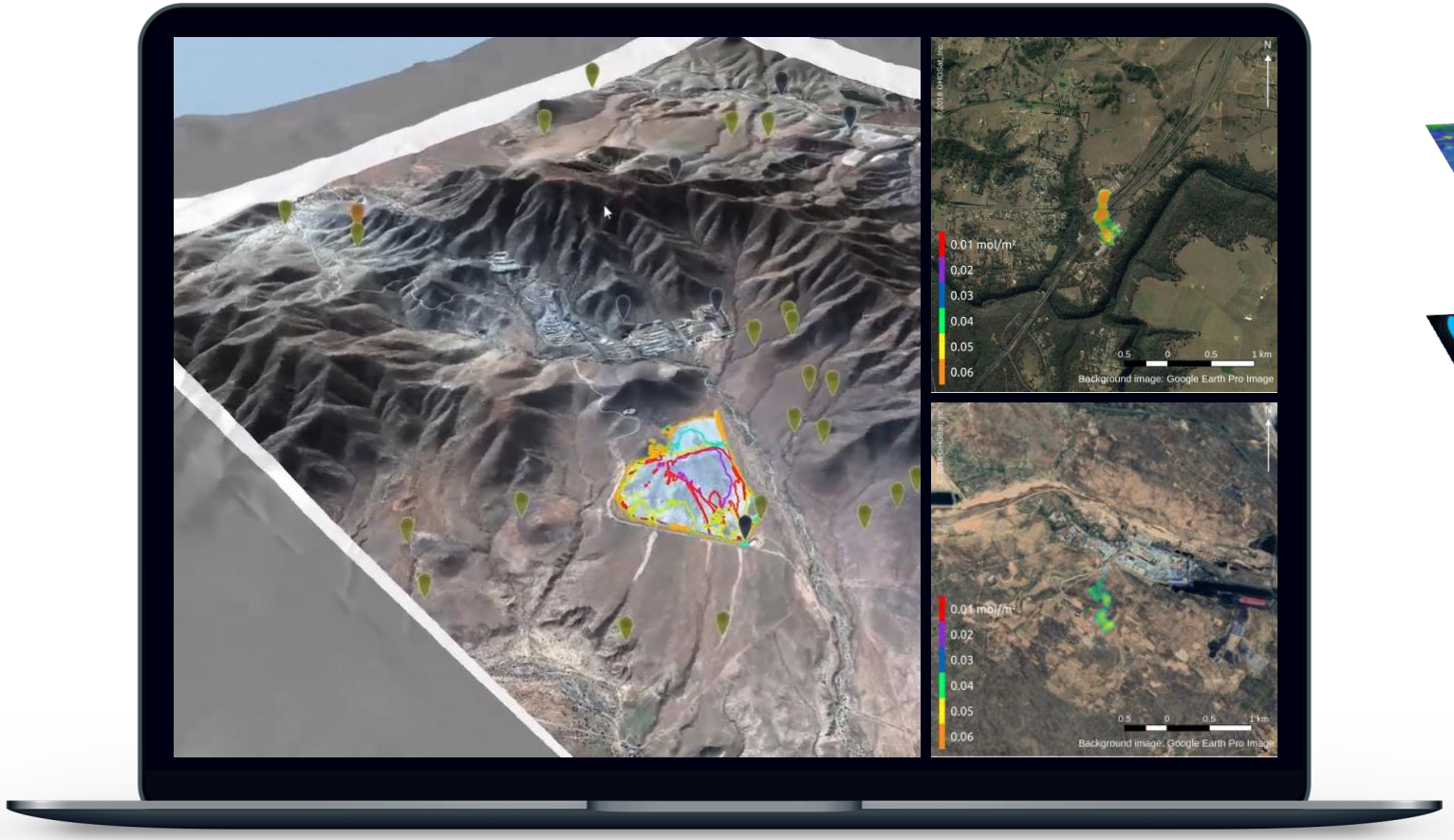
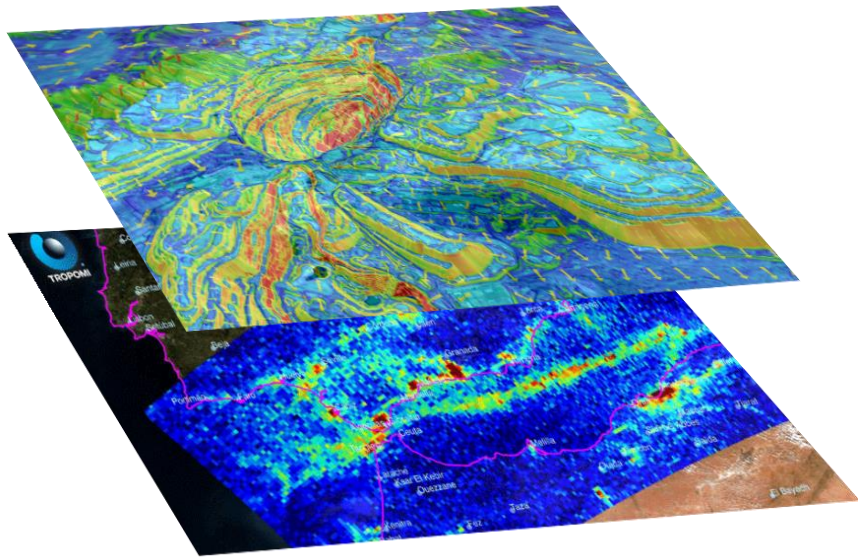
PHYSICAL RISK AND CLIMATE CHANGE



ENVIRONMENTAL AND EMISSIONS MONITORING





EARTH SENSE

GHGSat
GLOBAL EMISSIONS MONITORING

Copernicus
Europe's eyes on Earth

Bluefield


FOREST MIND
FOREST MIND
ZERO NET
DEFORESTATION
Image supplied by Earth-i Ltd
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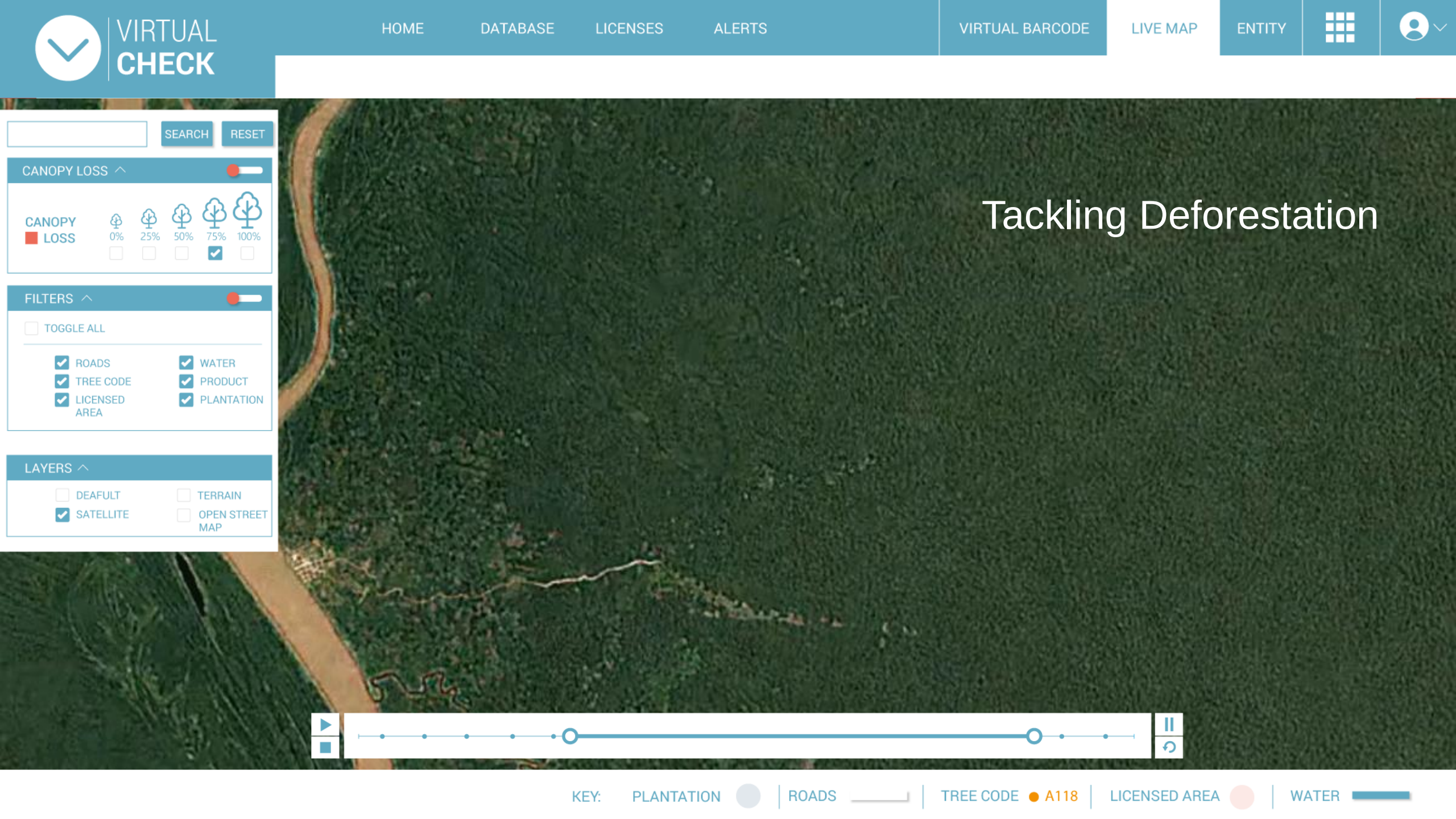
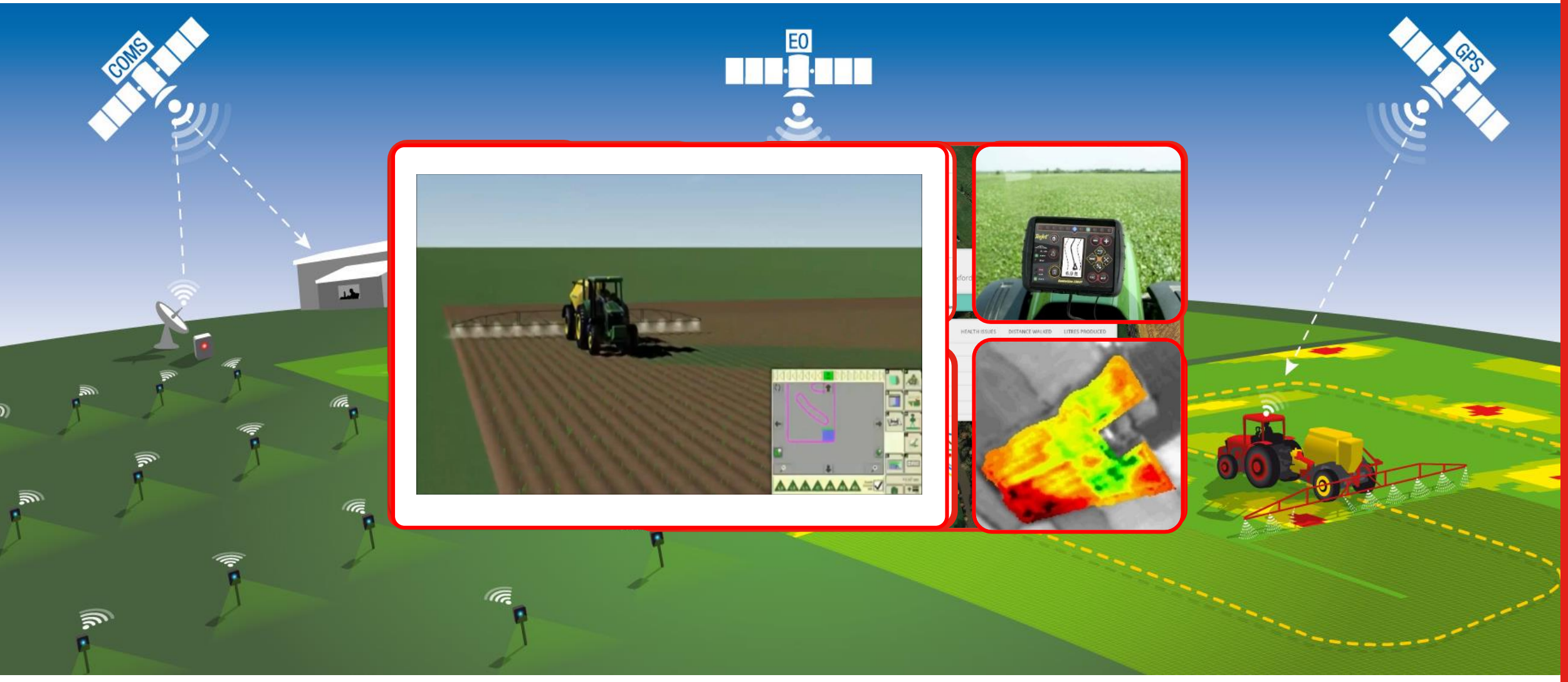
Created by Satellite Applications Catapult
Bellavista, Peru

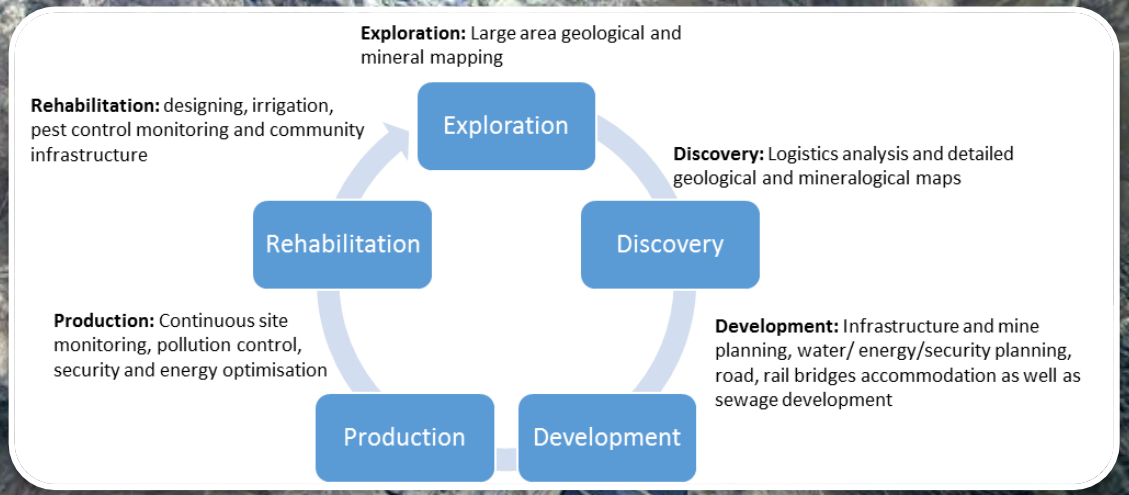

VIRTUAL CHECK
HOME
DATABASE
LICENSES
ALERTS
VIRTUAL BARCODE
LIVE MAP
ENTITY
SEARCH
RESET
CANOPY LOSS
CANOPY LOSS
0%
25%
50%
75%
100%
FILTERS
TOGGLE ALL
ROADS
TREE CODE
LICENSED AREA
WATER
PRODUCT
PLANTATION
LAYERS
DEAFULT
SATELLITE
TERRAIN
OPEN STREET MAP
Tackling Deforestation
KEY:
PLANTATION
ROADS
TREE CODE
A118
LICENSED AREA
WATER

AGRICULTURE



GEOLOGICAL SURVEYING & MONITORING

Normal RGB composite ASTER image 30x37km
Atacama Desert in Chile, Copper, Gold, Silver mine



ONE TO WATCH


Orbital Insight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Descartes
Labs


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INSIGHT

New Markets, New Manufacturing, New Worlds

SPACE 2030 VIDEO

Thank you

We work with Innovate UK

CATAPULT Satellite Applications