Satellite Applications

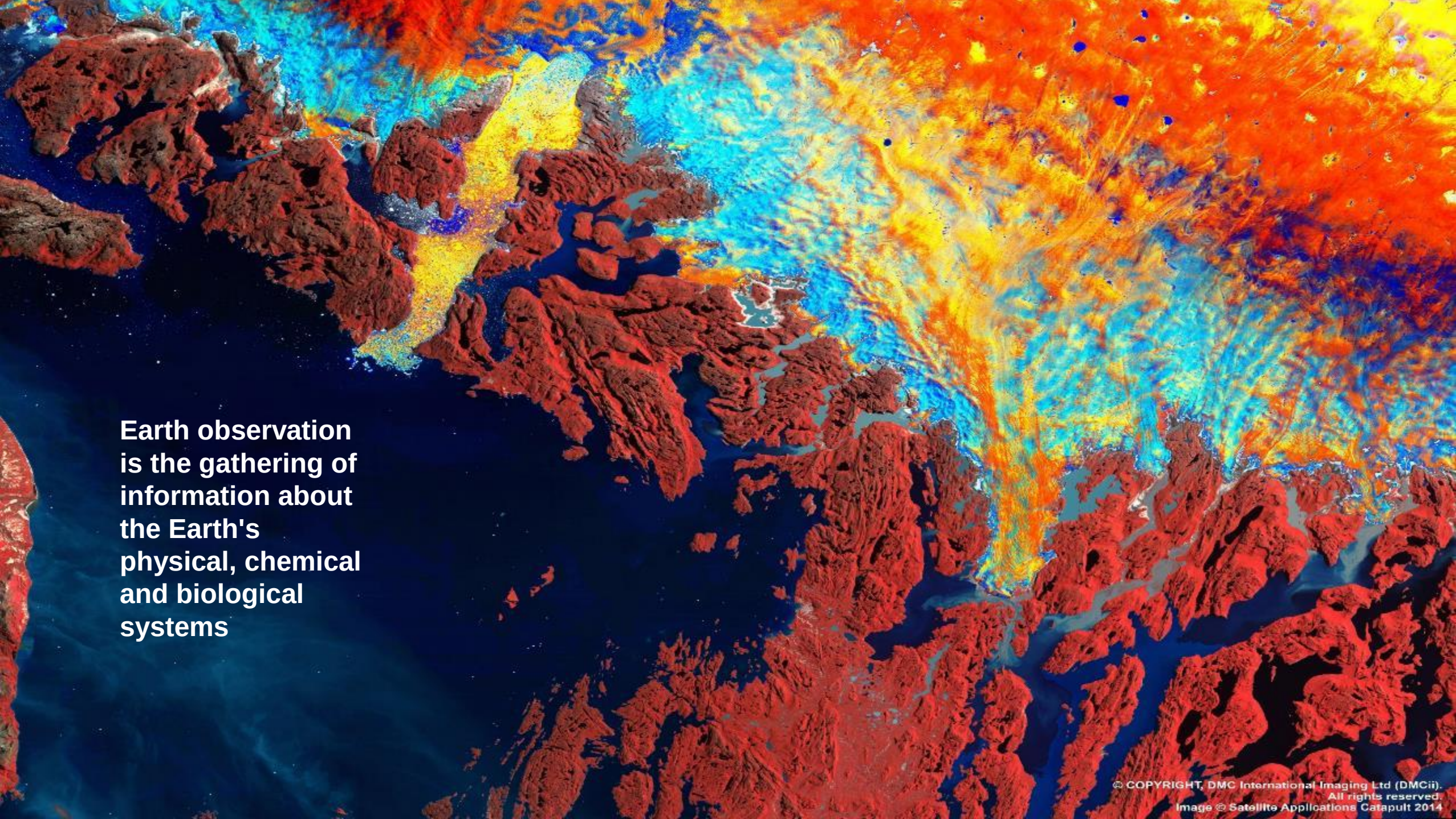
Earth Observation
Markets and applications

Nick Veck

27 July 2015

Innovate UK
Technology Strategy Board

CATAPULT




• Natural resource management
• Agriculture and Food security
• Risk assessment & Emergency response
• Environmental protection & Climate services
• Urban planning
• Insurance & Financial services
• Transportation & Communication
• Consumer, Retail & Tourism
• Defence
Data © USGS 2013
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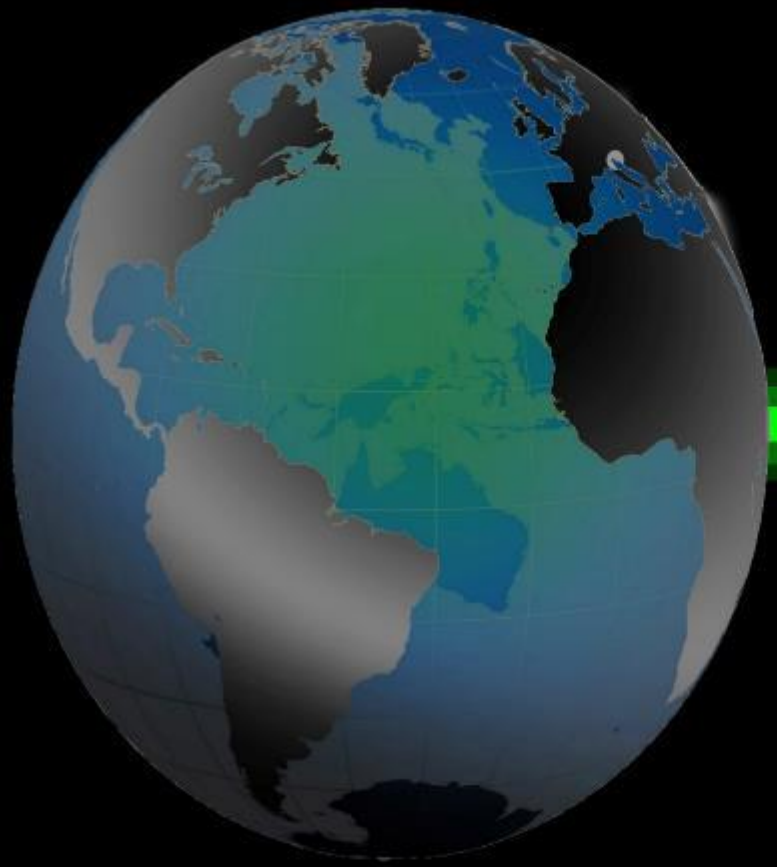
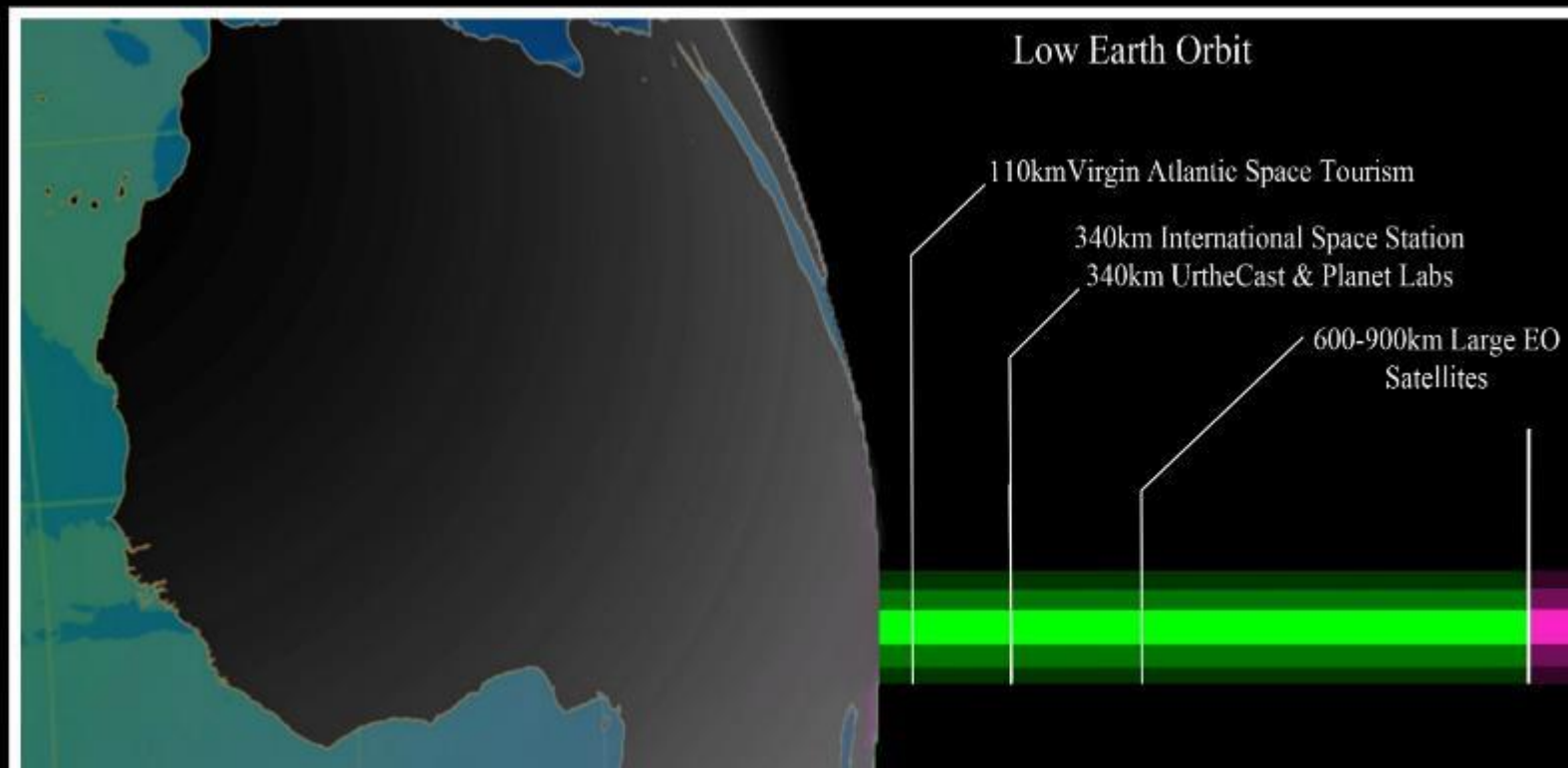
Where are the Satellites?

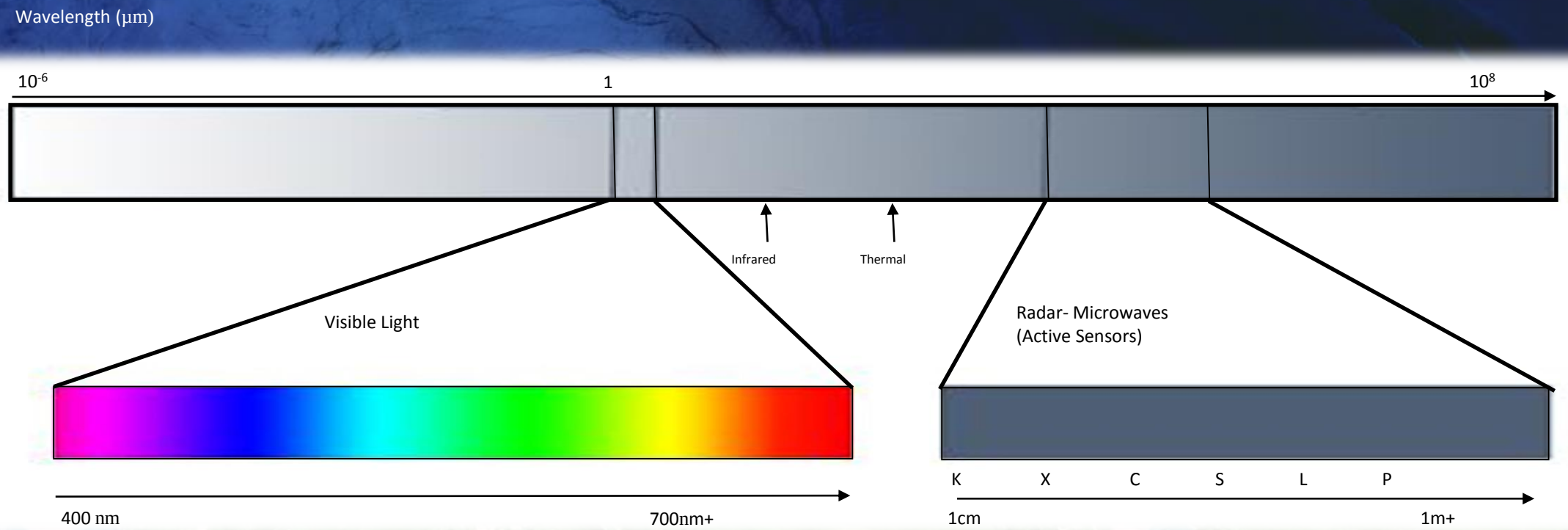




Remote Sensing

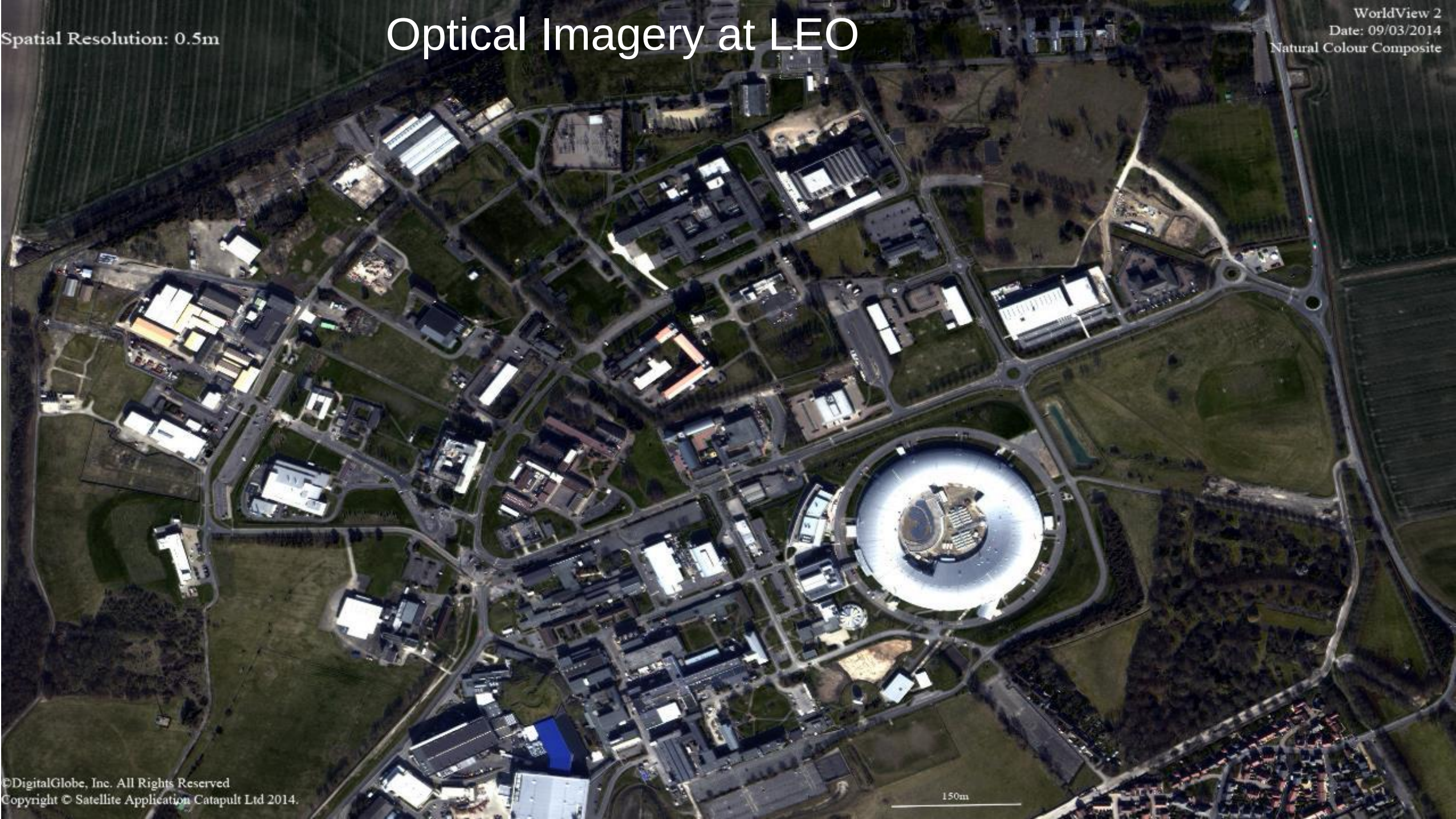
Remote sensing systems make use of the electromagnetic spectrum in two ways:

1. Collecting the radiation that is reflected, emitted or scattered by a target (**passive systems**)
2. Illuminating a target with a pulse or beam of radiation and collecting the signal that is reflected or refracted back to the sensor (**active systems**).

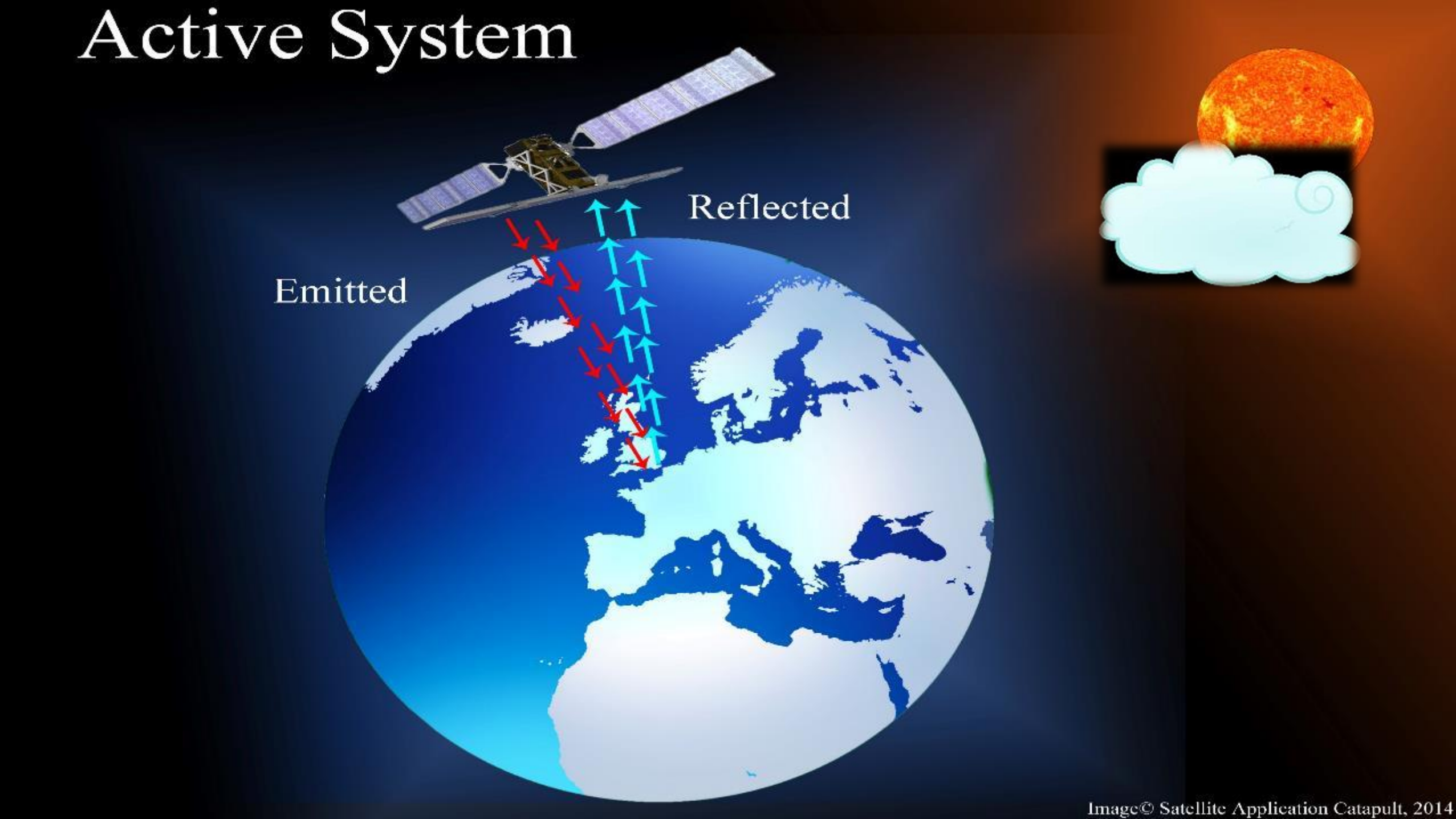


Passive System

Optical Imagery at LEO

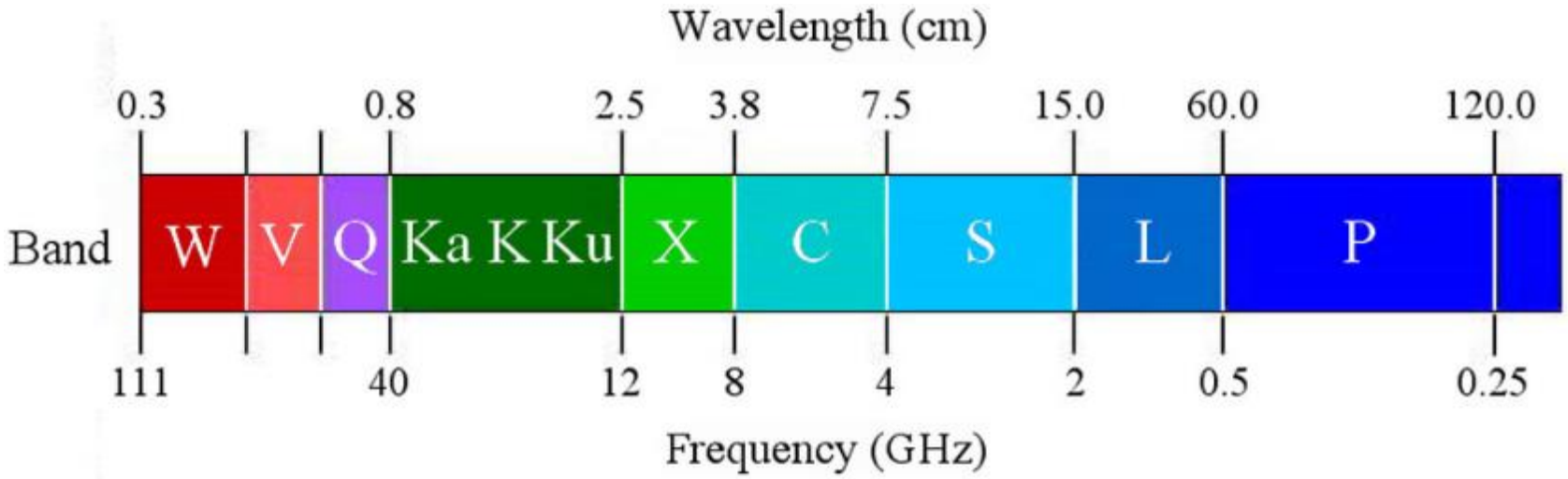


Active System



Radar Imagery

Microwave Spectrum



- Shorter frequencies penetrate deeper into a vegetation (forest or crop) canopy.

Where are the scatterers in a forest canopy?

Austrian pine

X band
λ= **3 cm**

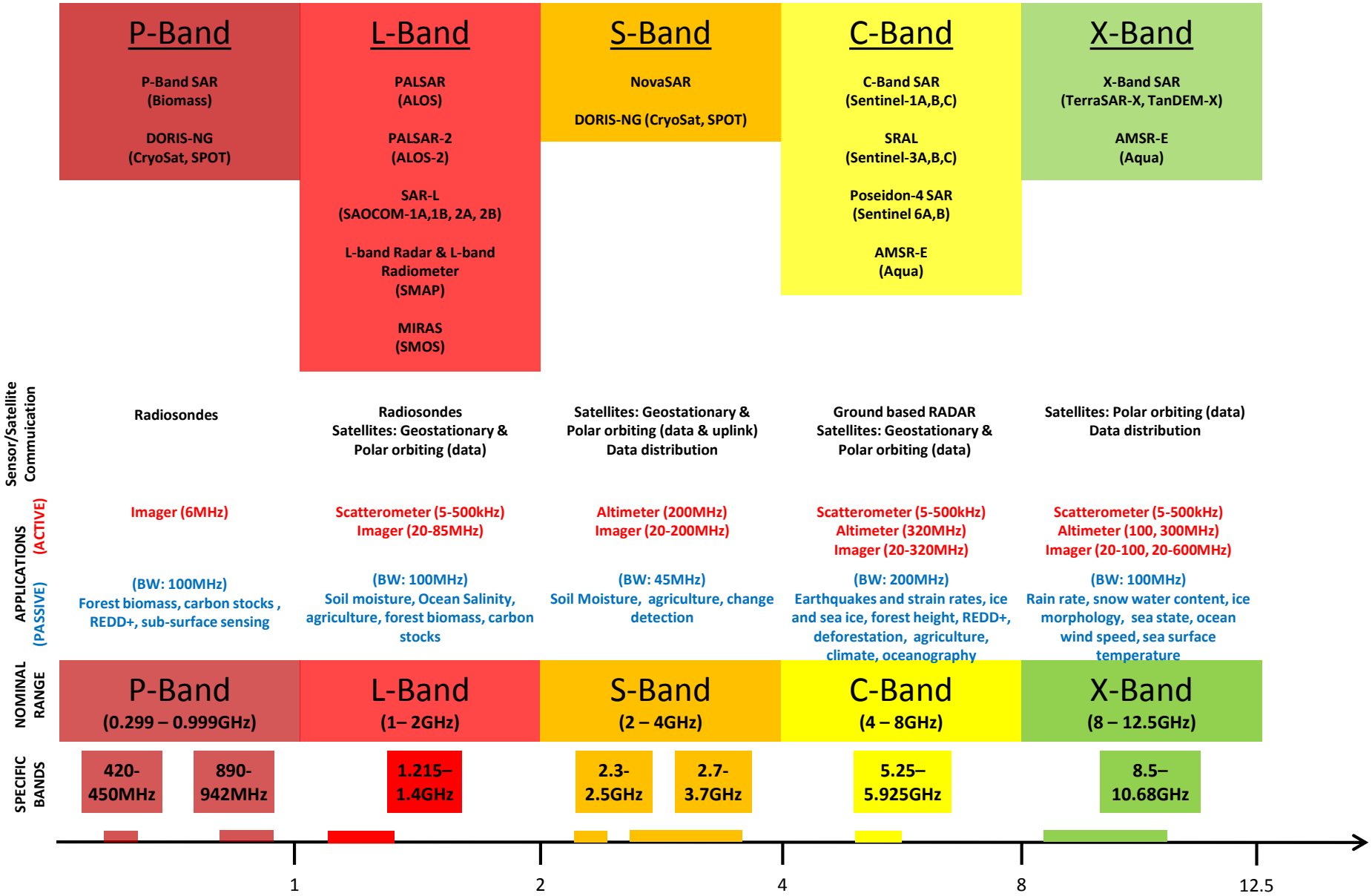
L band
λ= **24 cm**

P band
λ= **70 cm**

VHF
λ > **3 m**

The main *direct* backscatter comes from elements having dimension of the order of the wavelength.
This has strong implications for what radar intensity and coherence tell us about the forest.

UTILISATION OF THE ELECTROMAGNETIC SPECTRUM BY EARTH OBSERVATION SENSORS (1)

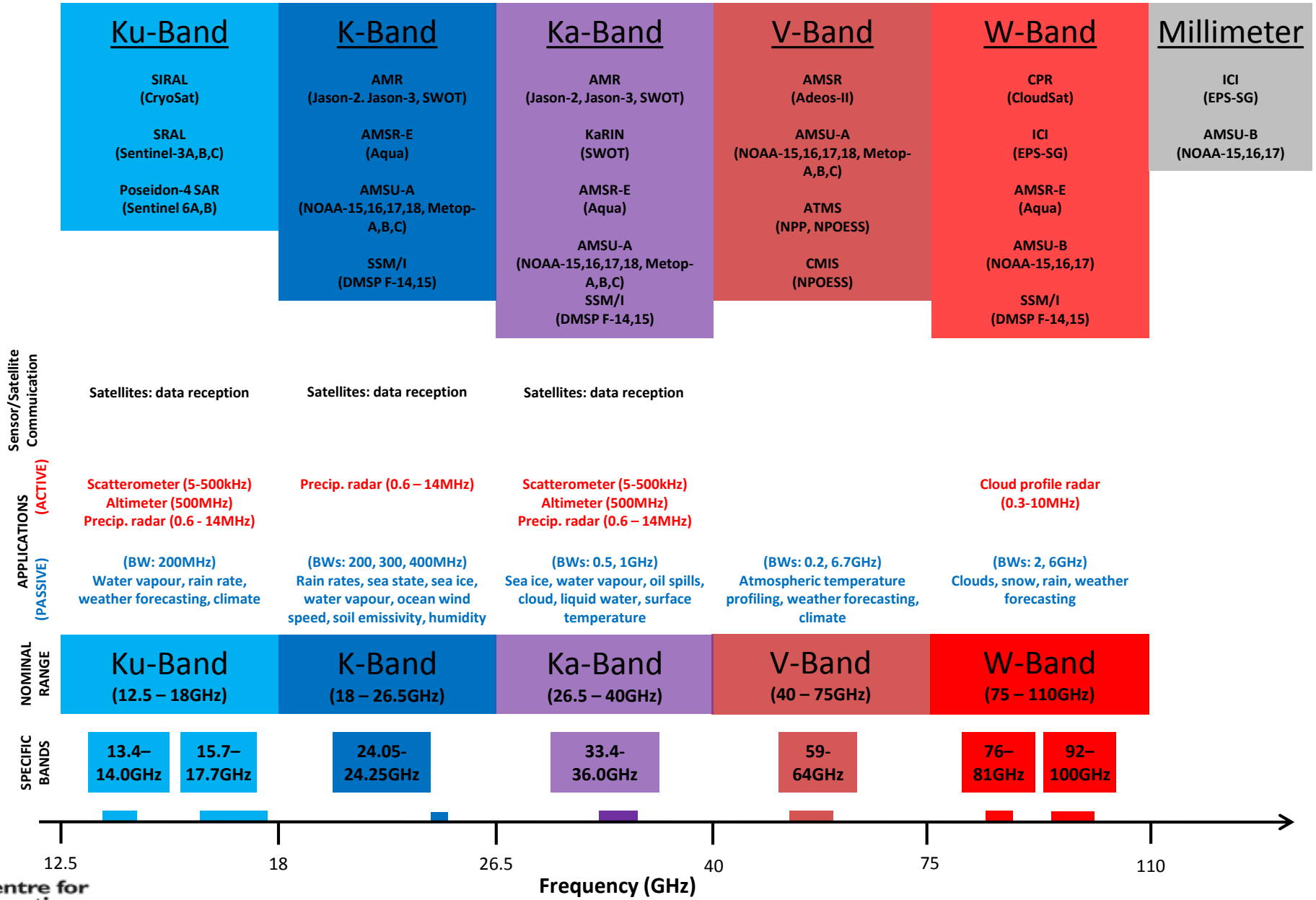


PRELIMINARY / DRAFT (JULY 2015)

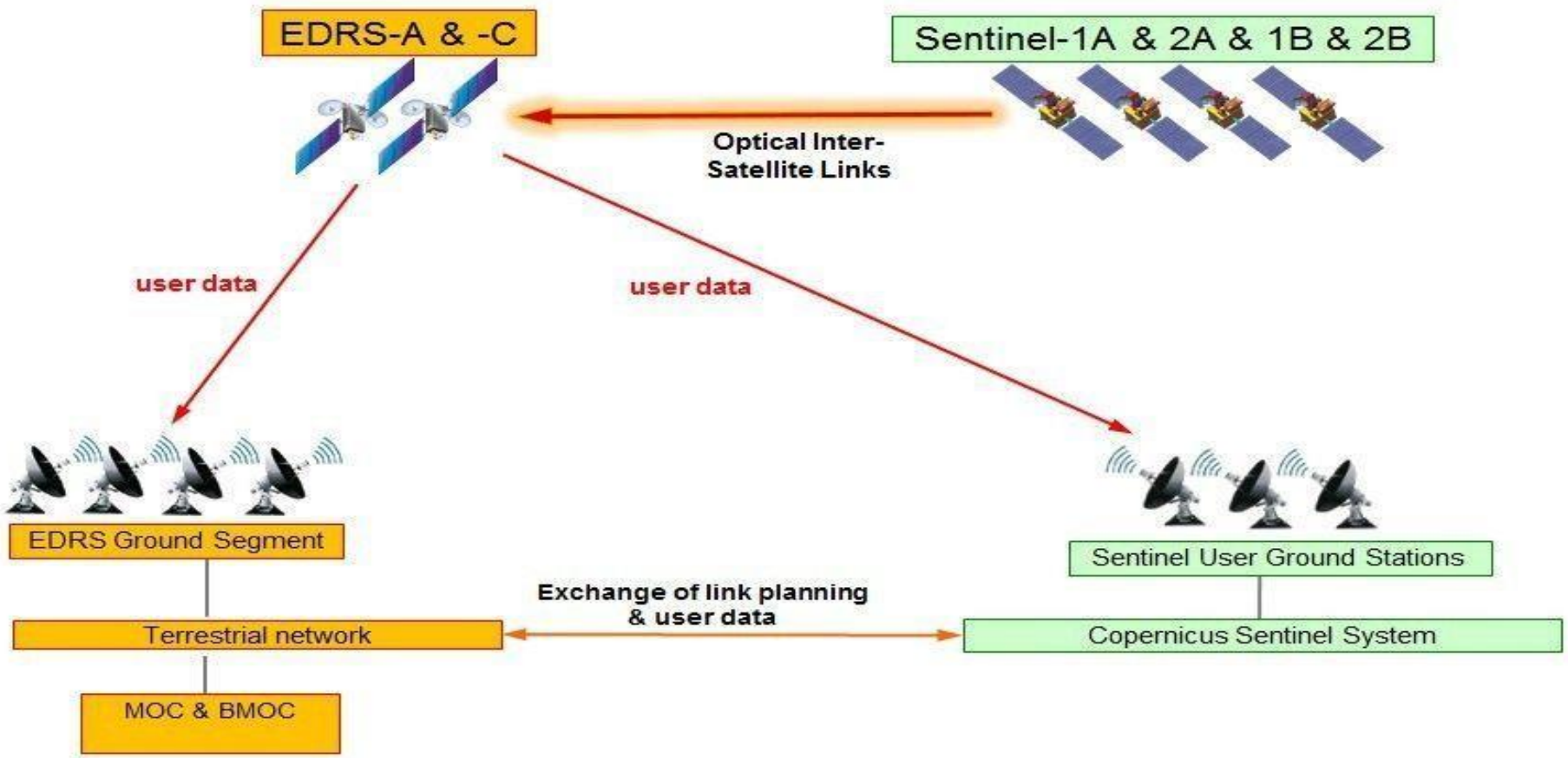
National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

Imperial College London

UTILISATION OF THE ELECTROMAGNETIC SPECTRUM BY EARTH OBSERVATION SENSORS (2)



ESA Sentinel Space Segment – use of EDRS



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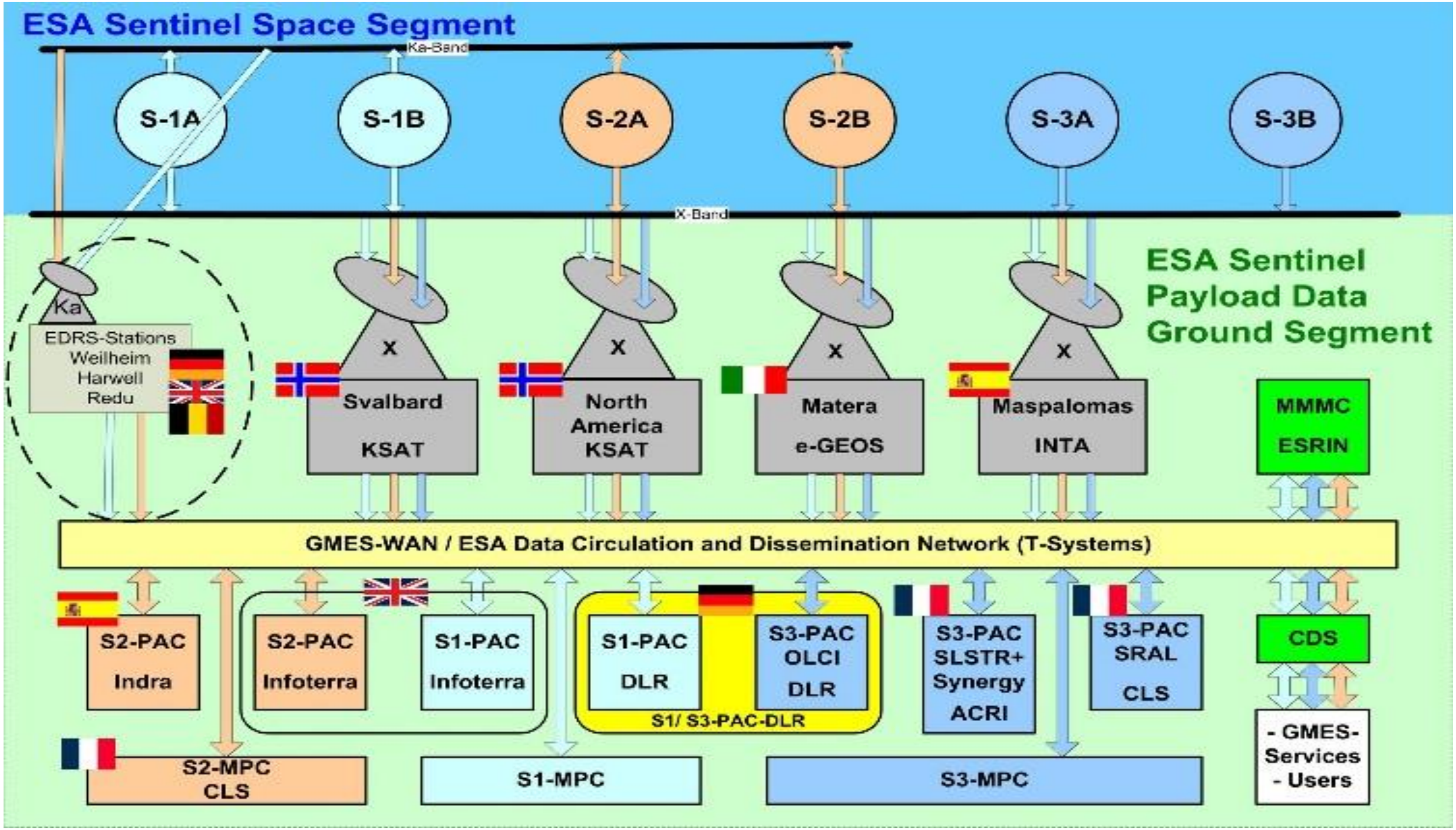
ESA Sentinel Space Segment
Ka-Band
S-1A
S-1B
S-2A
S-2B
S-3A
S-3B
X-Band
ESA Sentinel
Payload Data
Ground Segment
Ka
EDRS-Stations
Weilheim
Harwell
Redu
X
Svalbard
KSAT
North
America
KSAT
Matera
e-GEOS
Maspalomas
INTA
MMMC
ESRIN
GMES-WAN / ESA Data Circulation and Dissemination Network (T-Systems)
S2-PAC
Indra
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Infoterra
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Infoterra
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S3-PAC
OLCI
DLR
S1/ S3-PAC-DLR
S3-PAC
SLSTR+
Synergy
ACRI
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- GMES-
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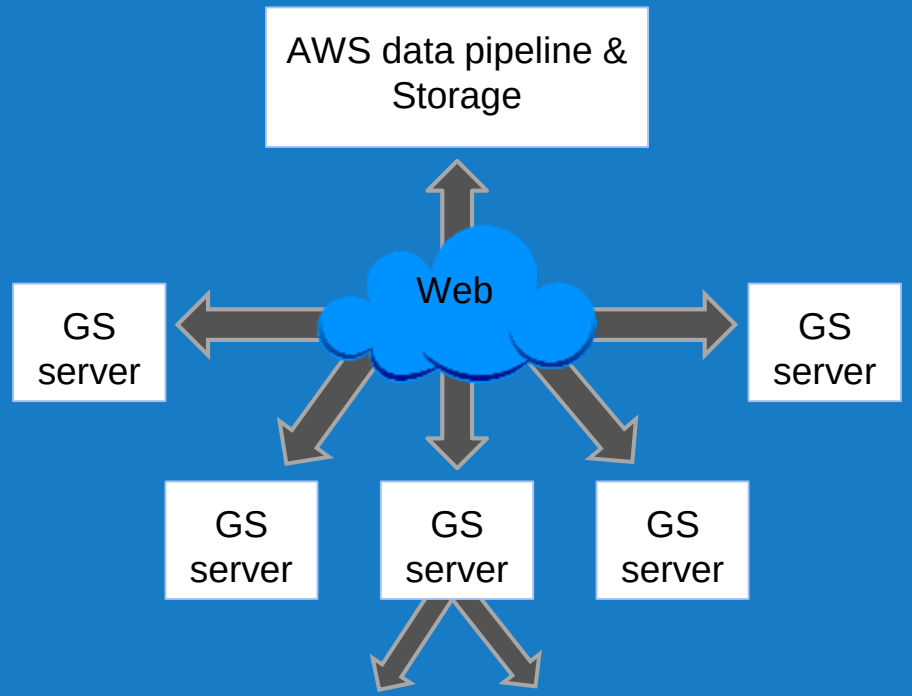
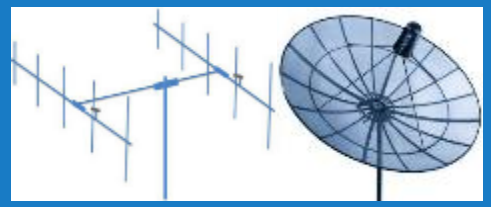
- Users





UHF Tx/Rx

Commissioning, telemetry, tracking & scheduling

X & S-band

Image downloads & software uploads

GS locations

- Australia
- New Zealand
- UK (x2)
- Germany
- Hawaii
- USA (x2)

Spatial Resolution Trend over the past 15 years

Legislation change in the States saw the launch of **Worldview 3** with 0.31m resolution

DigitalGlobe launched **Quickbird** in 2001 had the capability of imaging at 0.61m

Ikonos was the first commercial satellite to collect publically available data at 1m

TerraSAR X, launched in 2007 with an advertised top resolution of 1m, in 2014 Airbus released a new mode capable of 0.25m imaging

Radarsat 1 , the first commercial SAR Mission

Worldview 3
2014
0.31m
0.25m
2015

Worldview 2
2008
0.5m

SPOT 5
2002

Quickbird
2001

Ikonos
1999
1m

Landsat 6

SPOT 2 1993

1990

30-50m

1991 **ERS 1**

Radarsat 1
1995

Envisat ASAR
2002

TerraSAR X
2007

TerraSAR X
(new mode)
2014

0.63m

Optical

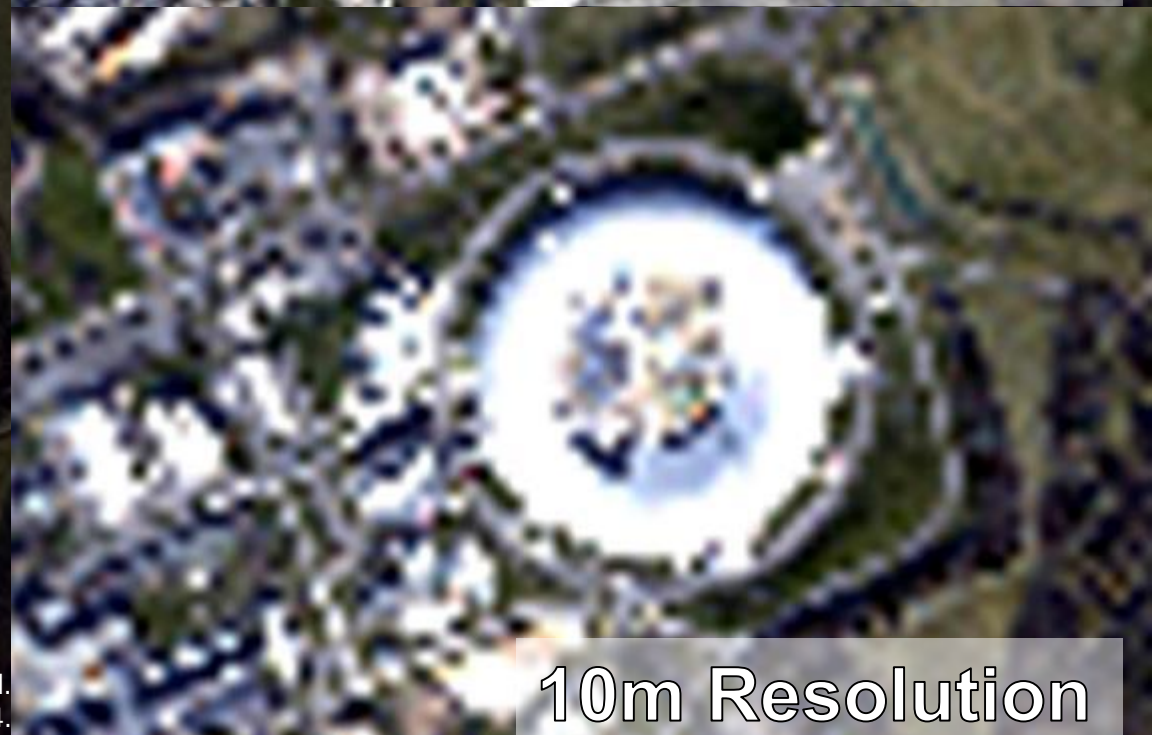
Synthetic Aperture Radar

1m

Resolution

0.5m Resolution

5m Resolution



10m Resolution

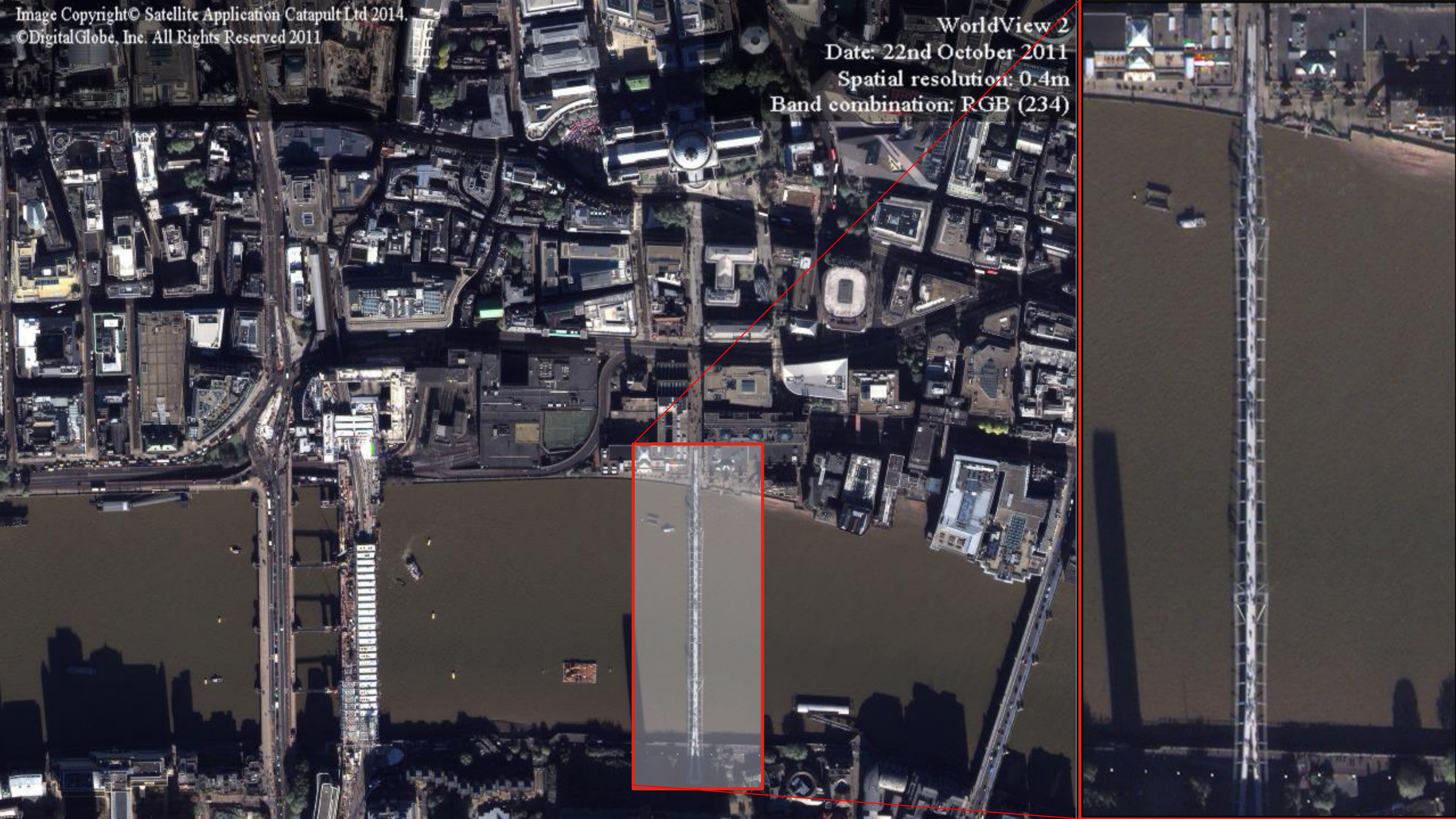


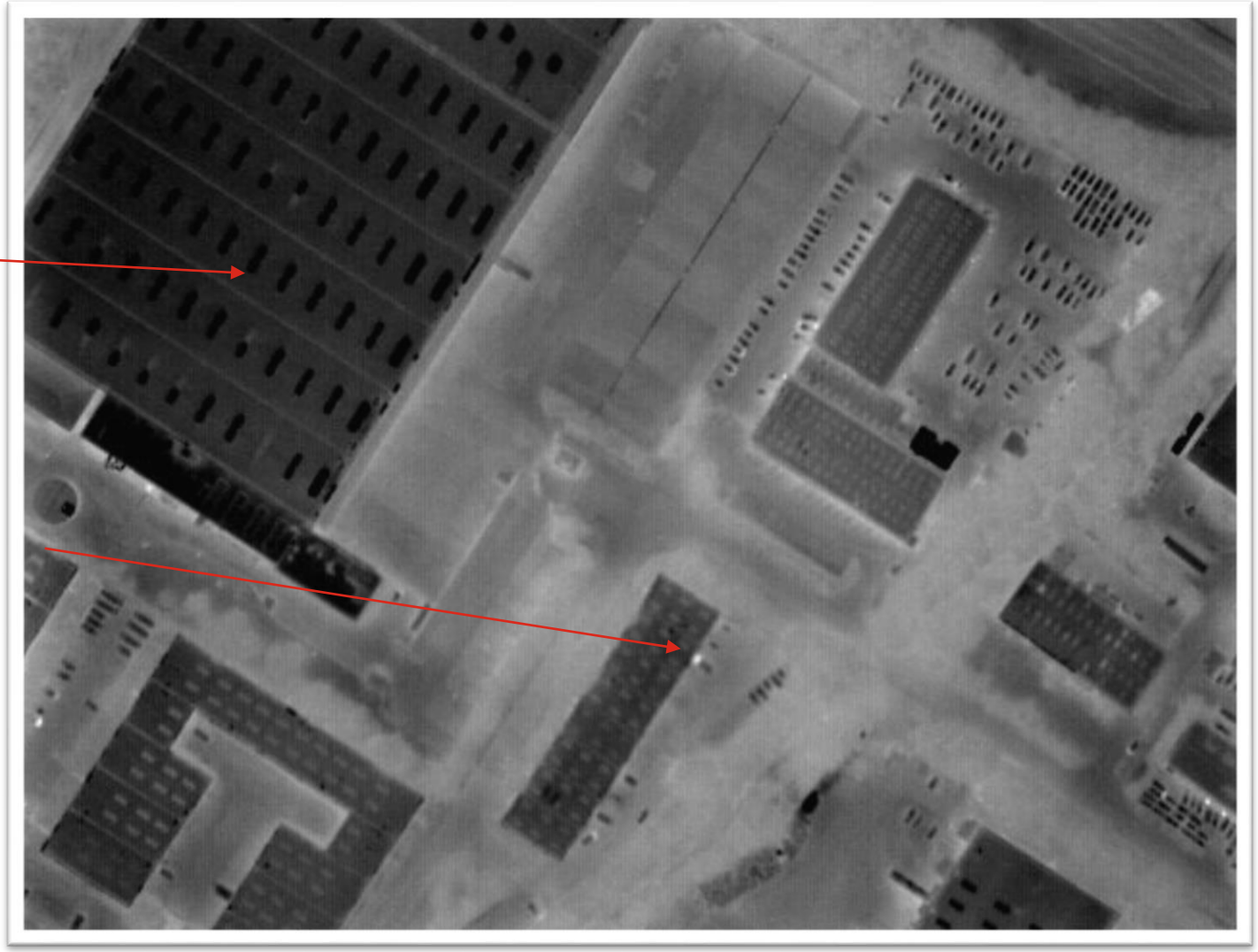
Image Copyright© Satellite Application Catapult Ltd 2014.
©DigitalGlobe, Inc. All Rights Reserved 2011
WorldView 2
Date: 22nd October 2011
Spatial resolution: 0.4m
Band combination: RGB (234)

Situational Awareness

High resolution Thermal Infrared Monitoring
Identification of Thermal anomalies

Refrigerated and Air-con buildings are illustrated as dark

Warmed up Cars show a clear white colour- indicating their high relative heat



The Illegal Fishing Virtual Watchroom

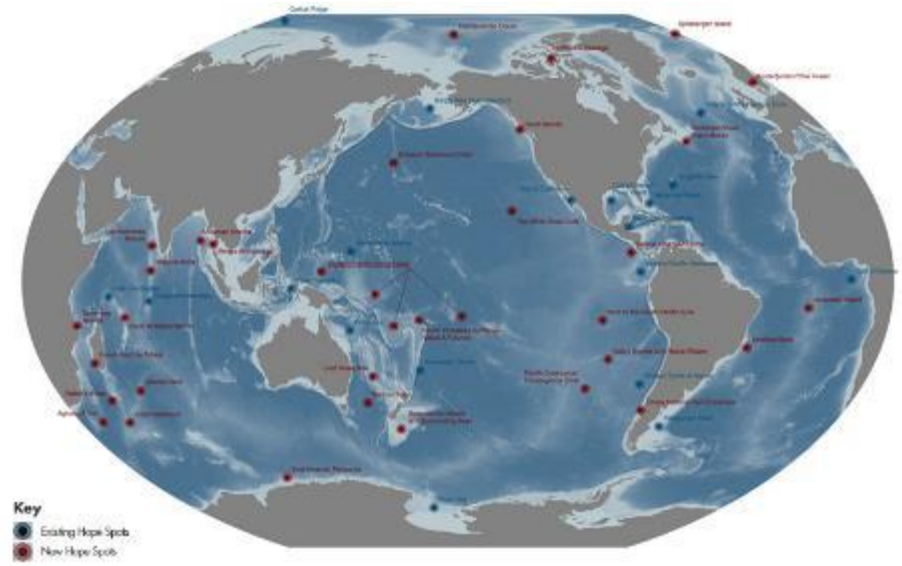
There are over 50 sites worldwide proposed for protection from industrial fishing

If a fishing vessel is not directly transiting and does not have its gear fully stowed, or does not have AIS on it should be in violation of the reserve

Marine reserves are a great test case, zero fishing allowed.

Regulations can be set to facilitate enforcement.

Dark vessels are the primary concern.



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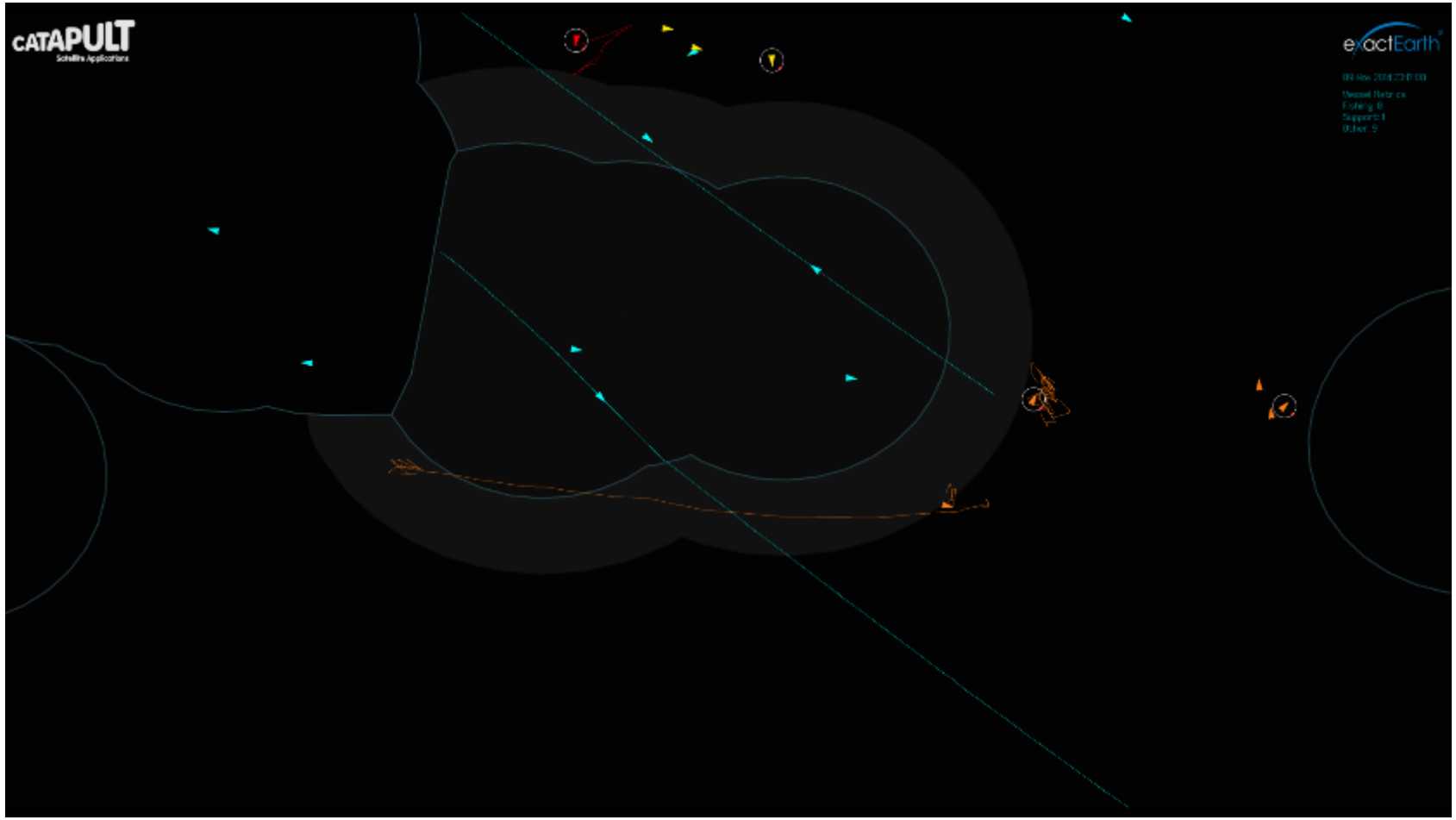
Visualisation

Vessels colour coded by type and depth of data available.

User can filter in various ways to focus on fishing activity.

Marine reserves and surrounding areas highlighted and vessel activity monitored.

Computer highlights vessels to the user via a ring, with coloured regions to convey activity



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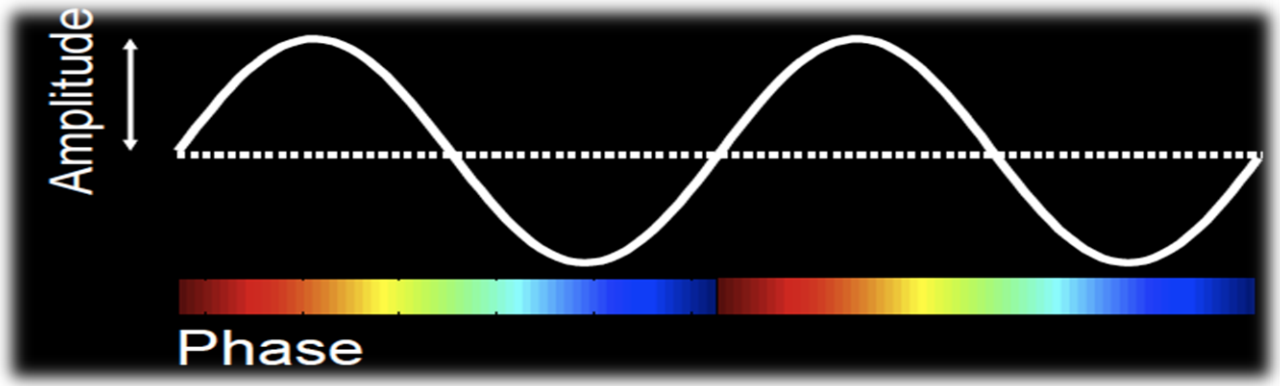
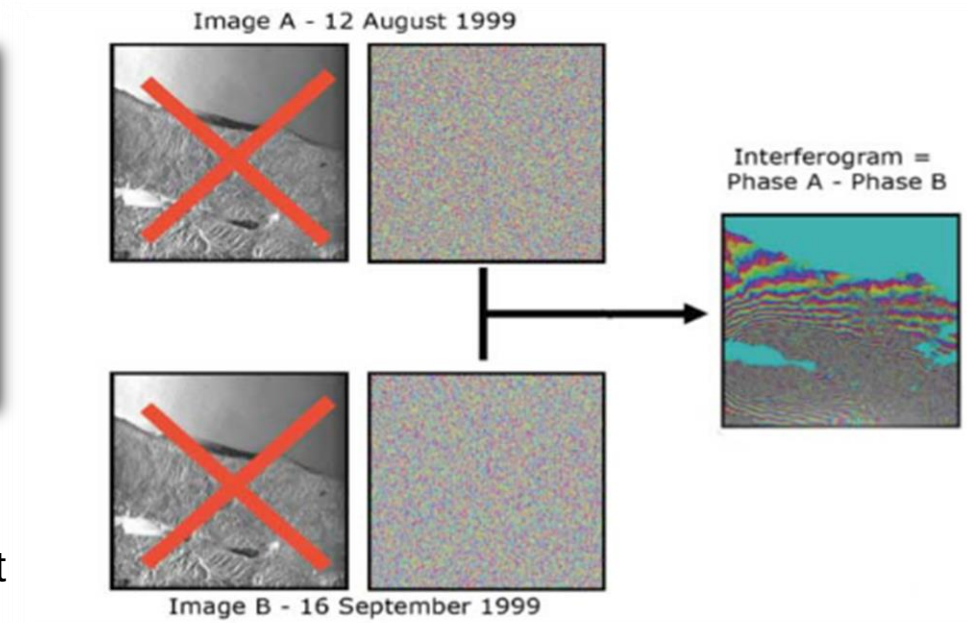
Interferometric SAR

How it works:

1. Two SAR images taken at different time intervals
2. Remove the amplitude from each Image, leaving the phase
3. Subtract the phase of the second image by the first
4. An interferogram!





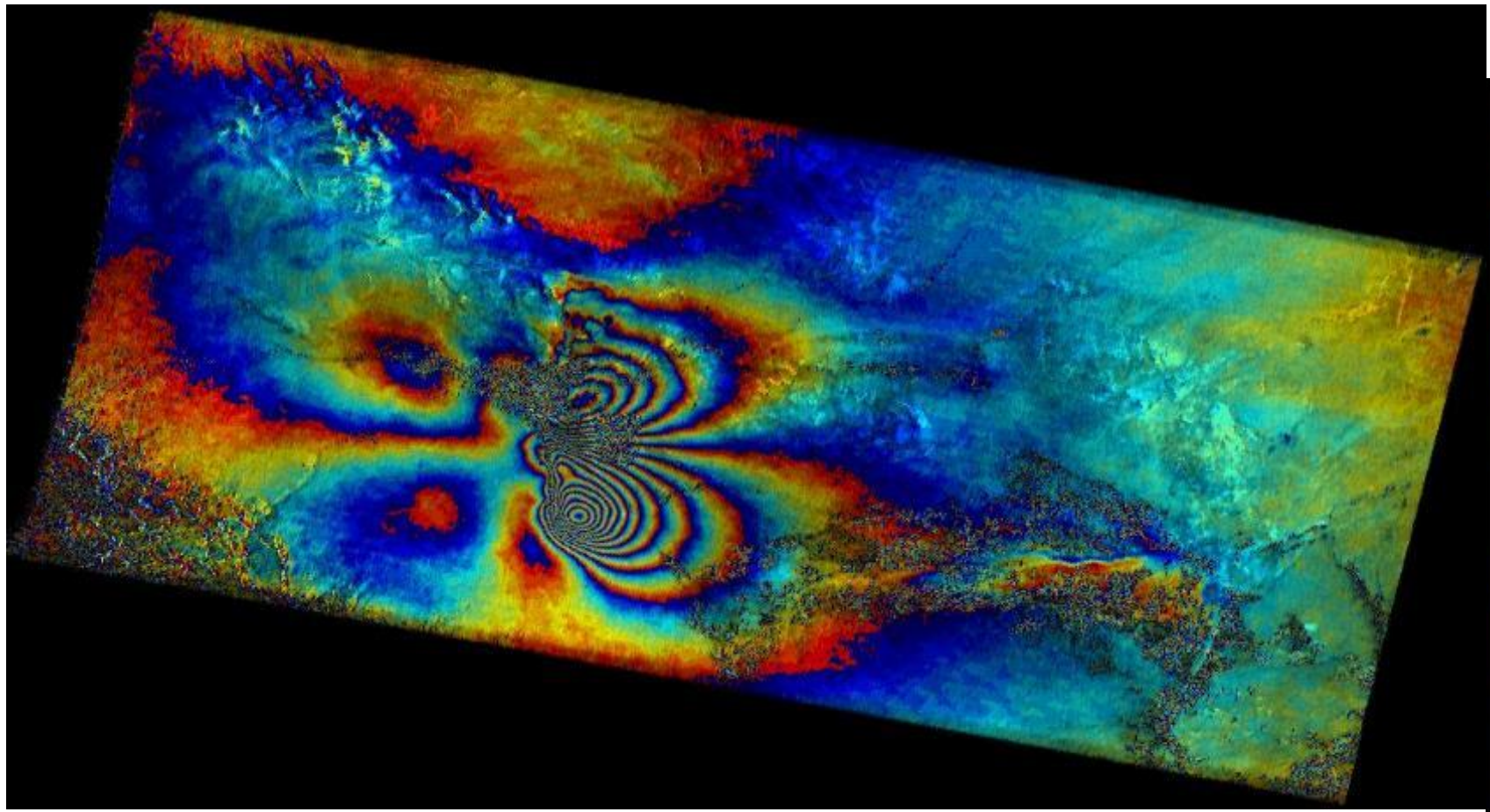
Example

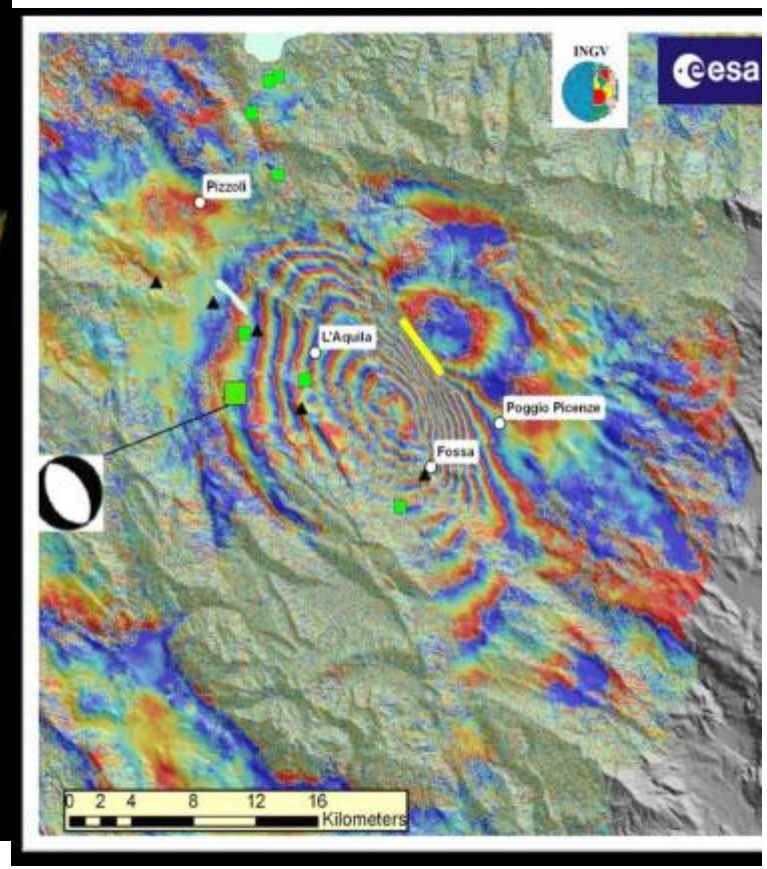
InSAR was used to predicted the Mount Etna eruption of 1998 (Lanari et al, 1998)

InSAR-Risk and Disaster Management

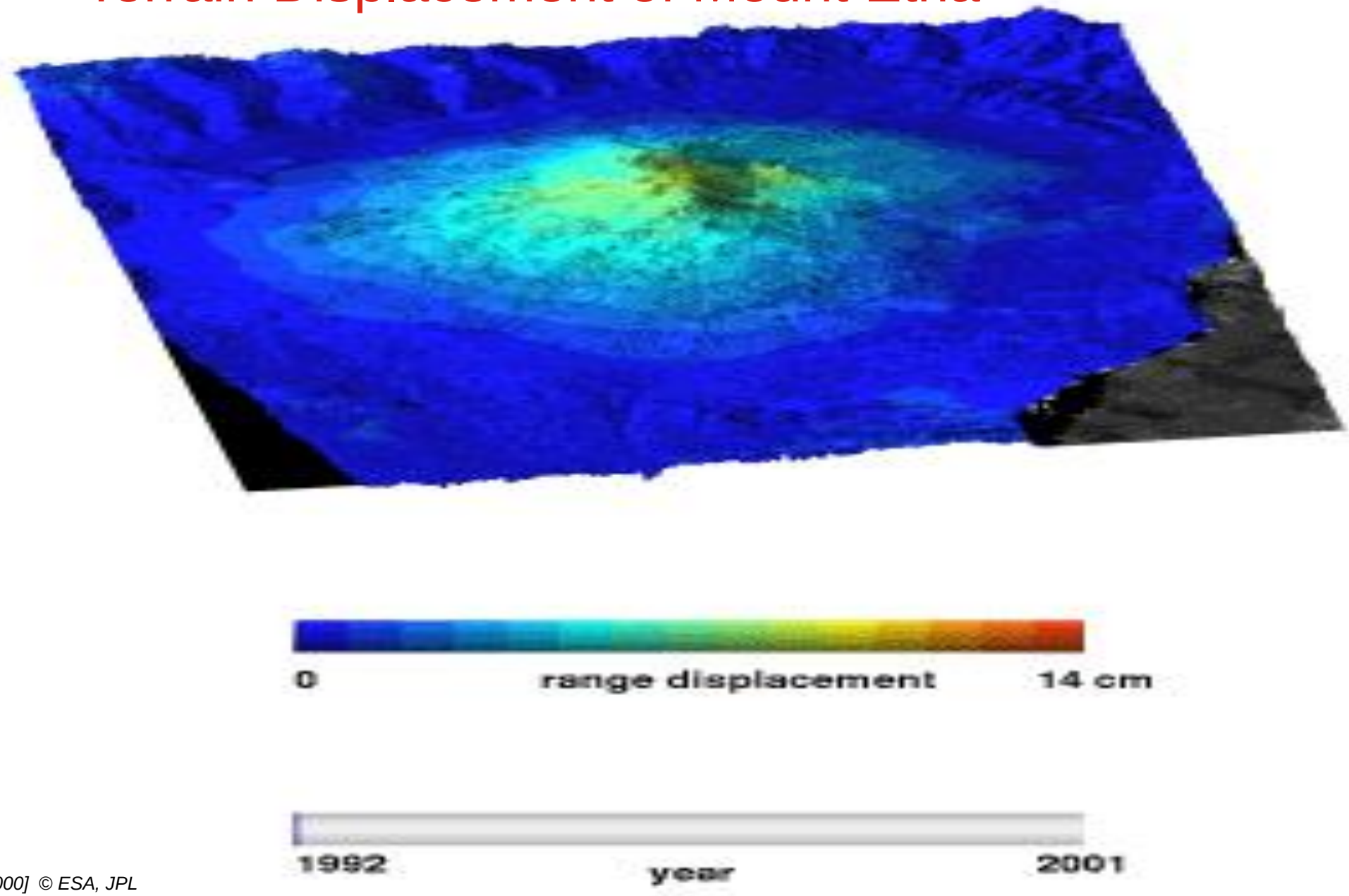
Using Interferometric Synthetic Aperture Radar

To map out highly accurate ground deformation, aiding disaster management and furthering academic knowledge of Geohazards.



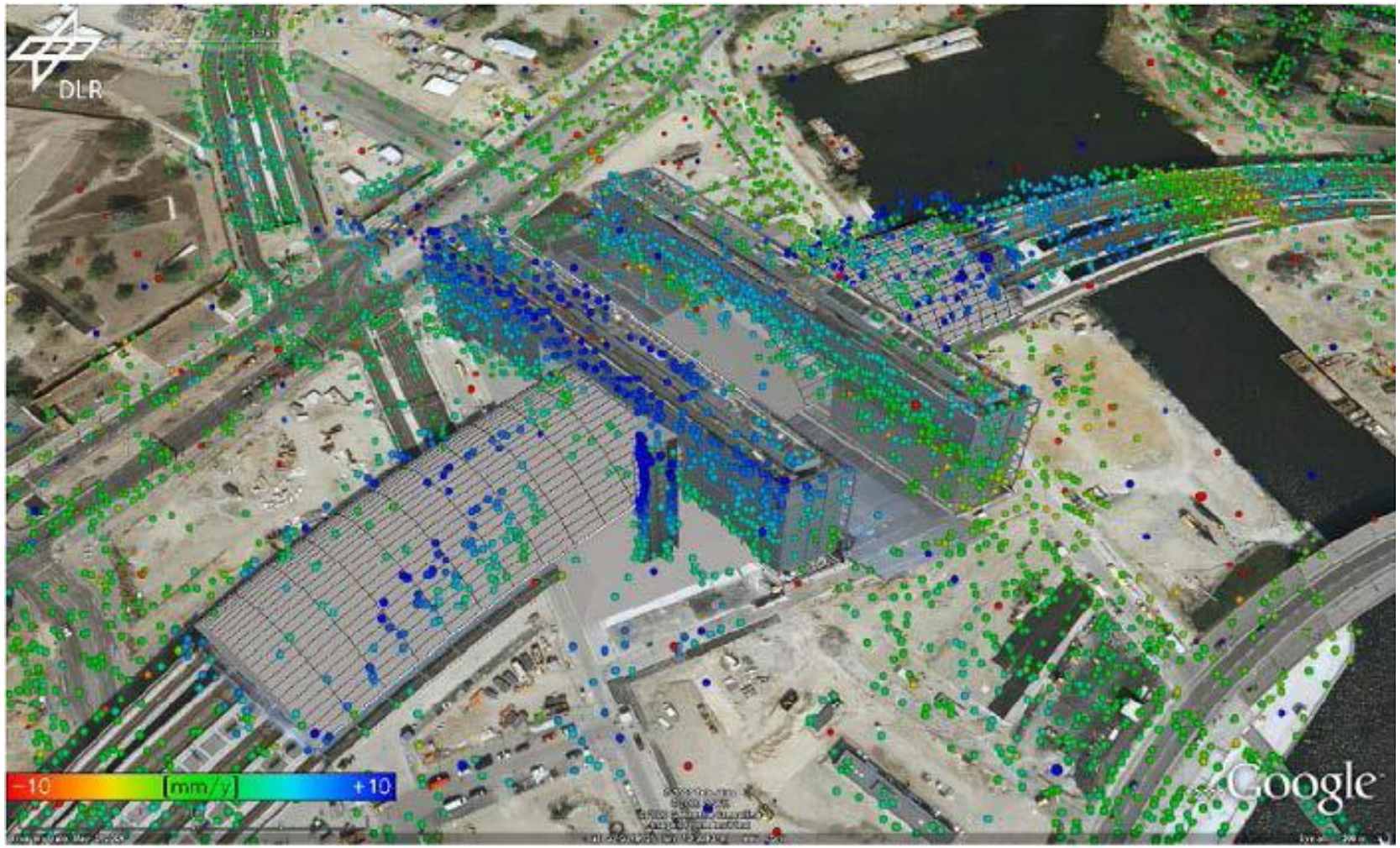


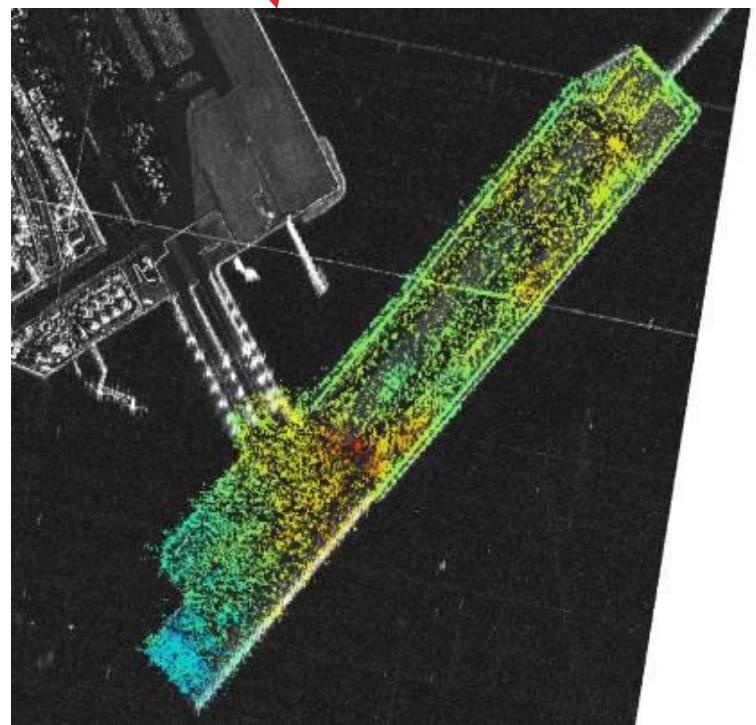
Terrain Displacement of Mount Etna



[ERS-2 data – 1992-2000] © ESA, JPL

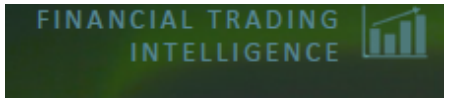
Infrastructure Monitoring

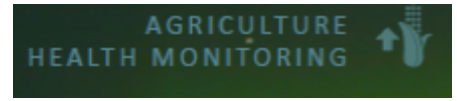




Deutsches Zentrum
für Luft- und Raumfahrt e.V.

Overview - Global EO Market

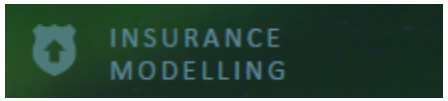




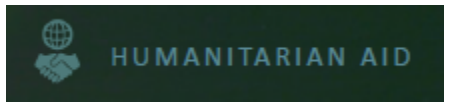
Size of the global EO market and growth rate

- EO commercial data market Value**: $1.4Bn in 2011**
- **Over the next decade the number of EO satellites launched will almost doubled** (149 → 288 by 2021)

(Euroconsult, 2012)

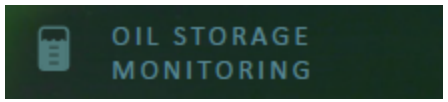


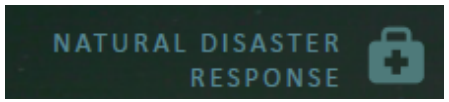
- Main **targeted markets**:
  - Banking & Insurance
  - Agri-food
  - Oil & Gas
  - Mining
  - Maritime
  - Environment and Carbon monitoring



- **Government remains the primary user** of EO data and services, accounting for over **80% of all commercial revenues.**

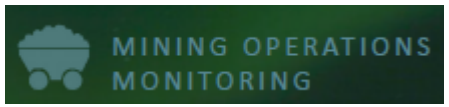
(Euroconsult, 2012)

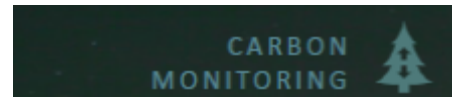




- **70% of the Global EO commercial is captured by the 2 major companies**: Digital Globe (25%)(+25% from merger with GeoEye) and Astrium GEO (20%).

(Spacetec Partners, 2013)





EO new trends and opportunities

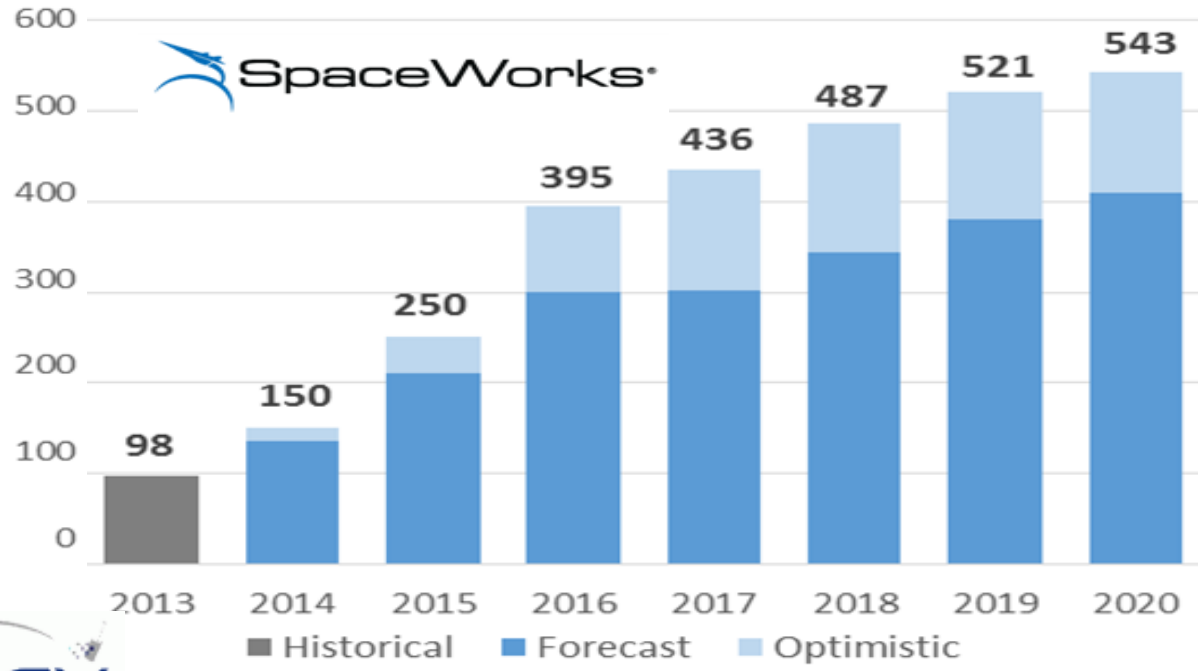
- **More Small Satellites…**

✓ **Smaller** (size), **Cheaper** (fraction of traditional manufacturing and launching costs), **Faster** (deployment and technology adoption);

✓ Between 2,000 and 2,750Nano/Micro-Satellites will require a launch from **2014** through **2020** (Satellite Applications Catapult, 2014);

✓ Size of commercial EO data market by 2020: £1.8Bn **(£970m nano/micro-satellite share)** (Satellite Applications Catapult, 2014).

Nano/Micro-Satellite Launch Projection



…and Pressure on [Business Models]

Skybox Imaging · PLANET LABS · SURREY SATELLITE TECHNOLOGY LTD

✓ *"Including the launch, a nanosat of **CubeSat dimensions** might cost **$150,000-1m**, rather than **$200m-1 billion** for a **full-sized one.**"* (Economist, 2014*);

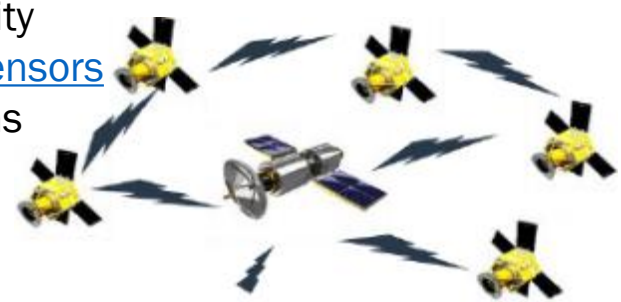
THE WALL STREET JOURNAL. | TECH

Google to Buy Satellite-Imaging Startup for $500 Million

✓ **Google** acquired **SkyBox Imaging:** high resolution satellite photos and videos soon available **for free** (via Google Maps?);

Technology improvements are opening up **new business model opportunities** based on **Small Satellite constellations:**

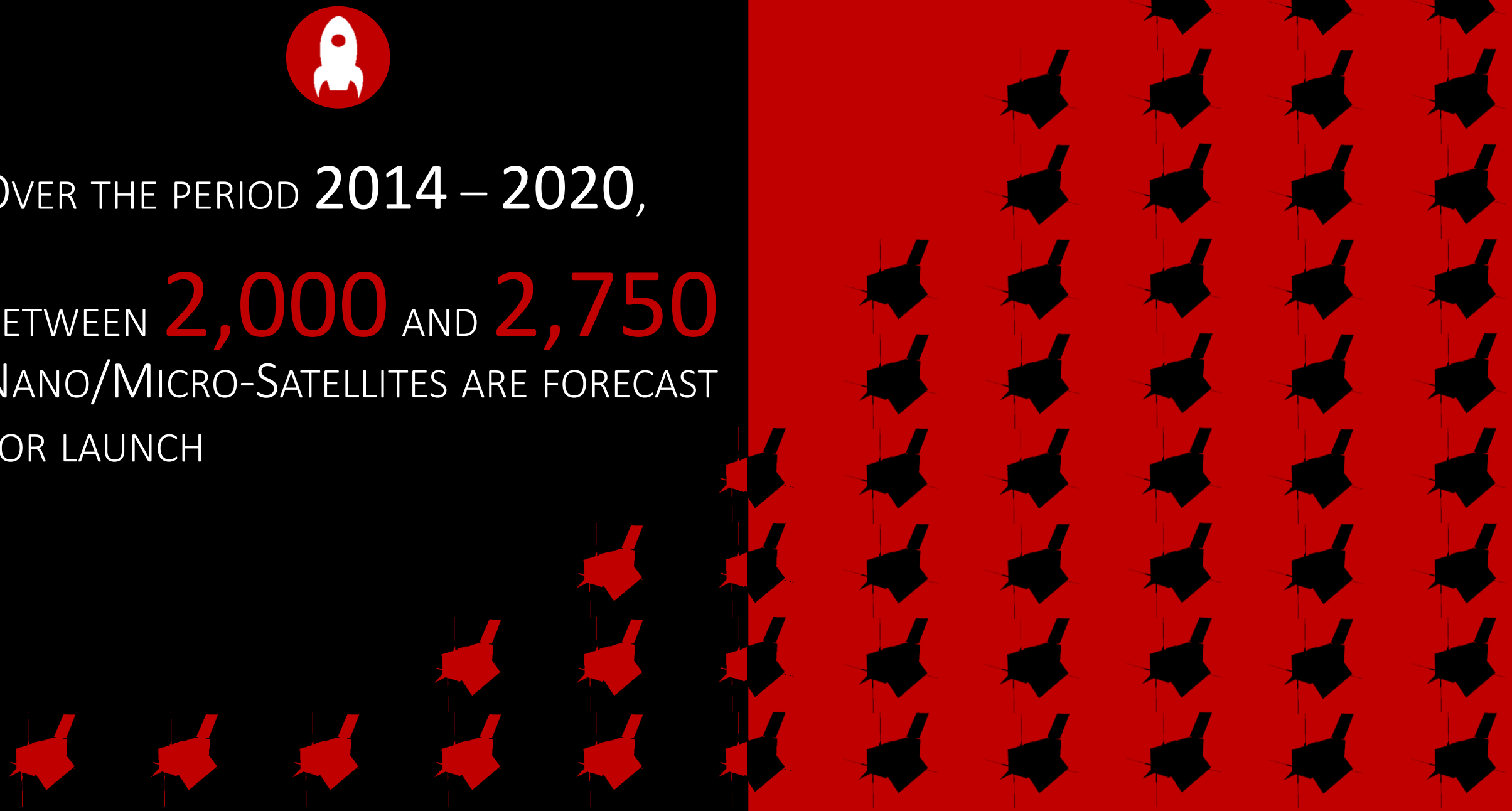
✓ Reconfigurable on-board electronics
✓ Fractioned satellite architecture
✓ Inter-satellite connectivity
✓ Nano-tech and micro-sensors
✓ Micropropulsion systems

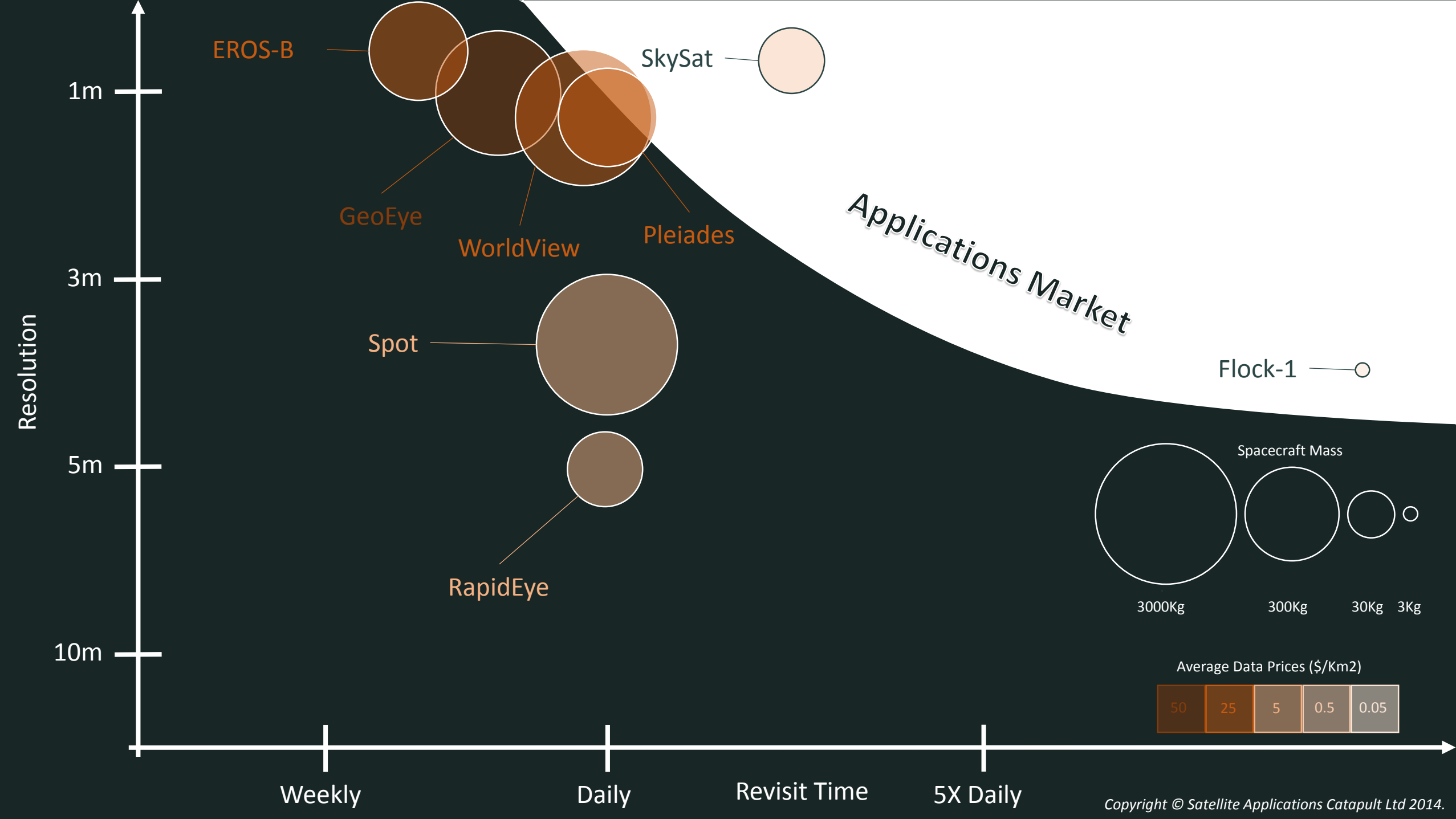


*http://www.economist.com/news/technology-quarterly/21603240-small-satellites-taking-advantage-smartphones-and-other-consumer-technologies

Over the period 2014 – 2020,

between 2,000 and 2,750 Nano/Micro-Satellites are forecast for launch





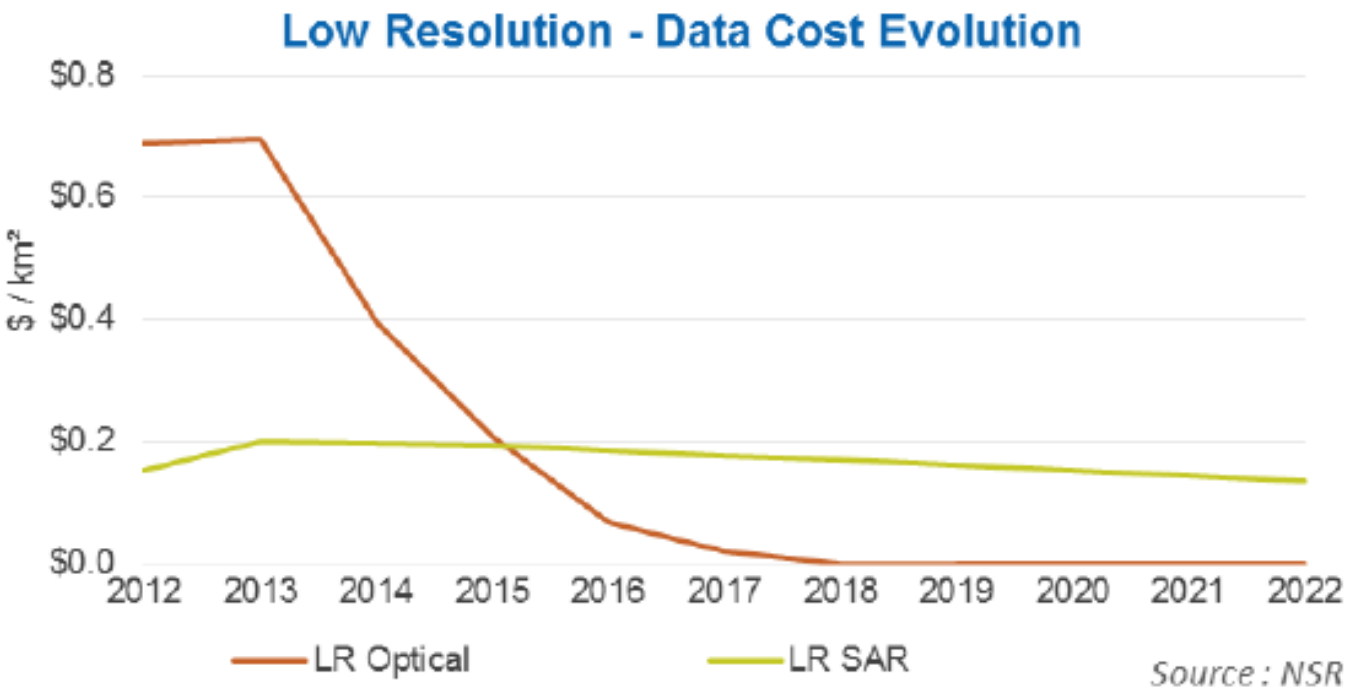
EO imagery: data price trends

BBC TECHNOLOGY

US lifts restrictions on more detailed satellite images

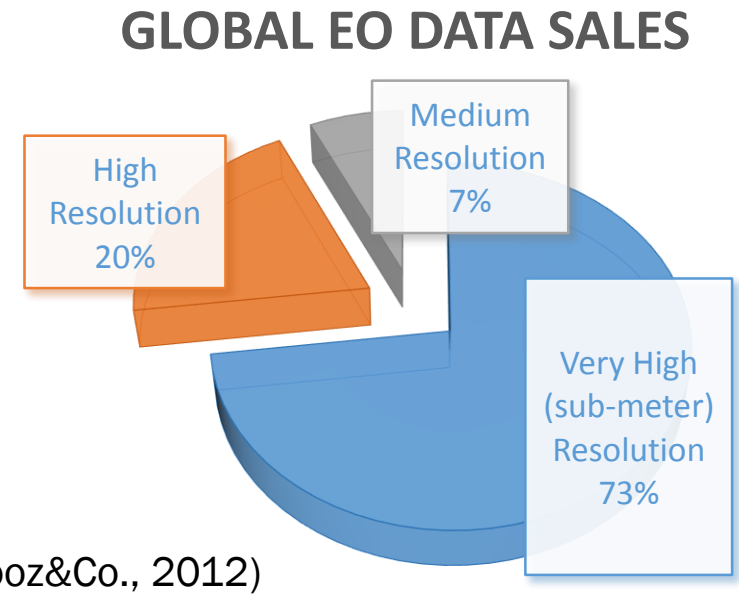
Price down (free data?)

- ✓ Copernicus's Sentinels **data policy:** "Full and open access to Sentinel data for all users."
- ✓ *"Data from the **Sentinel satellites** will [have] [...] data resolutions down to **10m optical** (Sentinal-2 series). At this resolution, **free data is encroaching on commercially available** data (such as Deimo-1) and can impact commercial distribution."* (Euroconsult, 2012)



...and Resolution up

- ✓ **US** has allowed sales of satellite images **up to 31cm resolution;**
- ✓ **Optical data** overall comprises **80% of the market** with **high resolution optical data** retaining the **largest share** of the market (**35%).**
- ✓ **Demand is strong for VHR** and **new satellites** being launched should **push up the share of VHR data sales.**

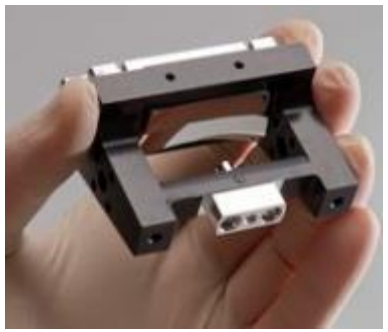


(Booz&Co., 2012)

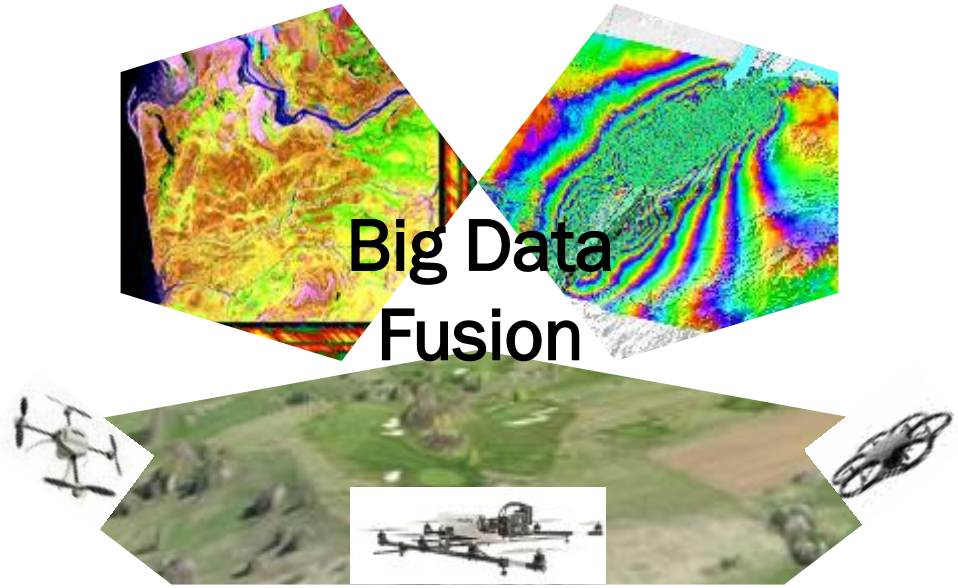
EO imagery: a small part in a Bigger (Data) market trend

Hyperspectral data

- ✓ Hyperspectral data provide much greater richness of information and can have multiple applications on soil analysis (mining, agriculture, hydrology)
- ✓ ESA is working on a miniaturized and cubesat-fit hyperspectral instrument.
- ✓ New satellite missions will further improve hyperspectral capabilities:
  - ✓ PRISMA (ITA) ~ launch in ~~2014~~ 2017
  - ✓ EnMAP (GER) ~ lunch in 2017
  - ✓ HyspIRI (USA) ~ launch in 2022



(ESA, 2014)

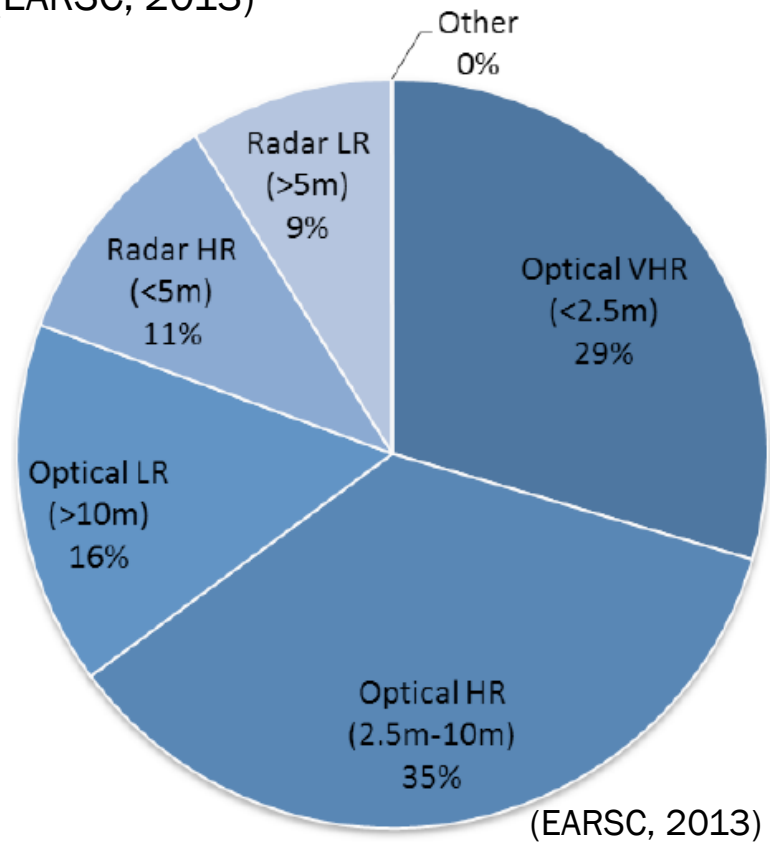


UAVs (and aerial) data

- ✓ Several industries and large companies are attracted by UAVs' **cheaper prices**, **high resolution** and **technology flexibility**.
- ✓ Currently, most of the competition between sat, aerial and UAVs data is at the **0.3 m to 0.5 m range**. (NSR, 2014)

Radar (SAR) data

- ✓ **Number speak for themselves:** only from EU companies a **sales growth of 15,000%, from virtually 0 in 2006** (when only the public ERS-2 and Envisat SAR data were available) **to 20% of overall sales in 2012.**
- ✓ Current radar data EU sales revenue contribution: **£121.5M** (€151.4 M). (EARSC, 2013)

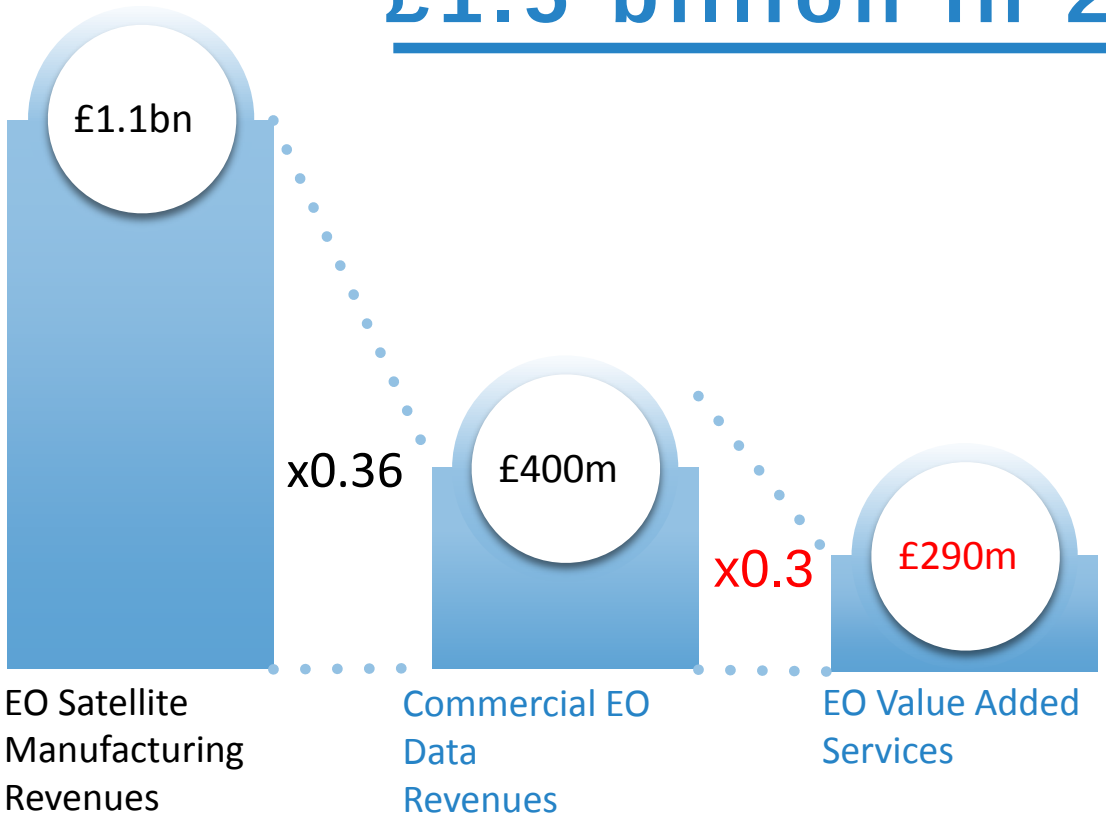


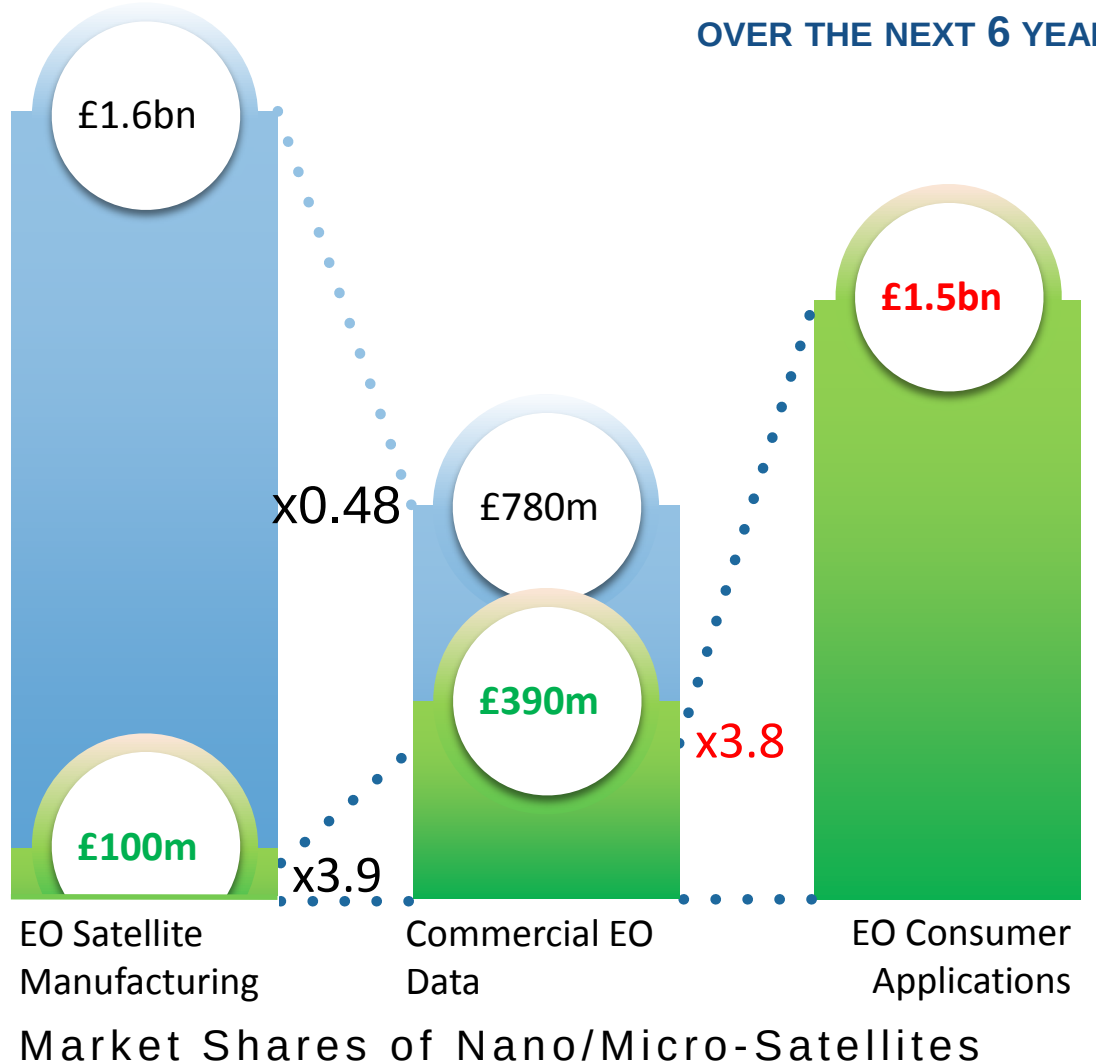
(EARSC, 2013)

THE COMMERCIAL EO DATA MARKET IS PREDICTED TO GROW AT AN AVERAGE OF 14% CAGR OVER THE NEXT 6 YEARS

Downstream Applications enabled by EO Nano/Micro-Satellites missions could result in commercial revenues of

£1.5 billion in 2020

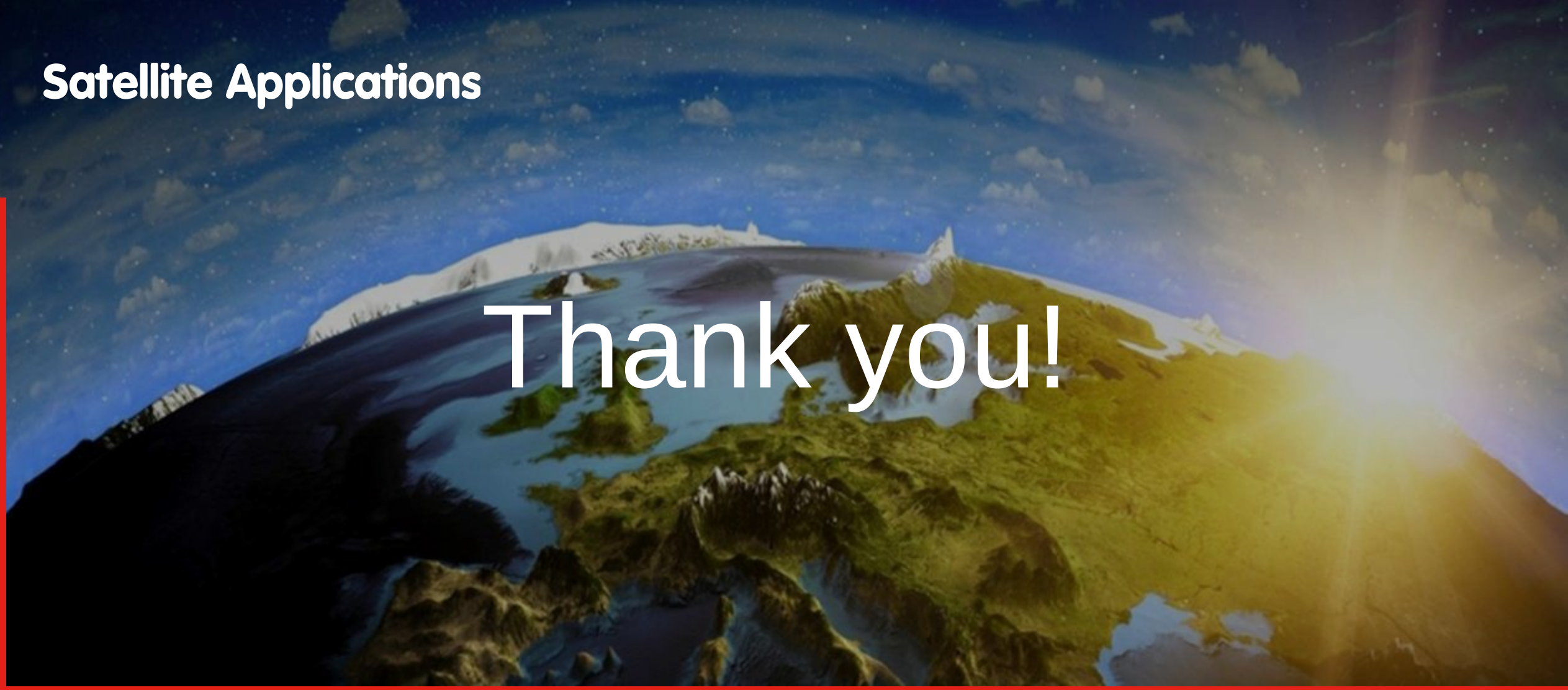




Market Shares of Nano/Micro-Satellites

During the next 6 years, the Upstream/Downstream balance will reverse, bringing the satellite manufacture and EO data markets merely a means for enabling much larger downstream application market

Satellite Applications



Thank you!

Innovate UK
Technology Strategy Board

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