

The UK's Future in Space

Commercial Small Satellites in the Military Domain



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Surrey Satellite Technology Ltd

"Doing Space Differently"

DSET
2019

SURREY



Space is now an essential infrastructure for all national economies, their well-being and security

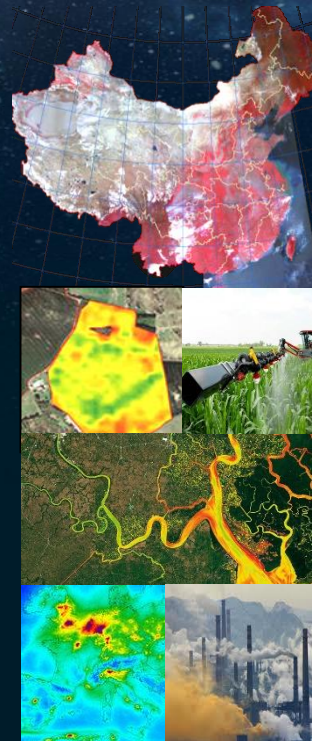
Communications



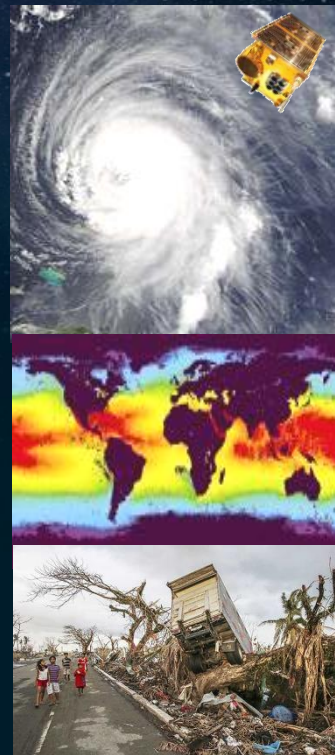
Timing & positioning



Land use/environment

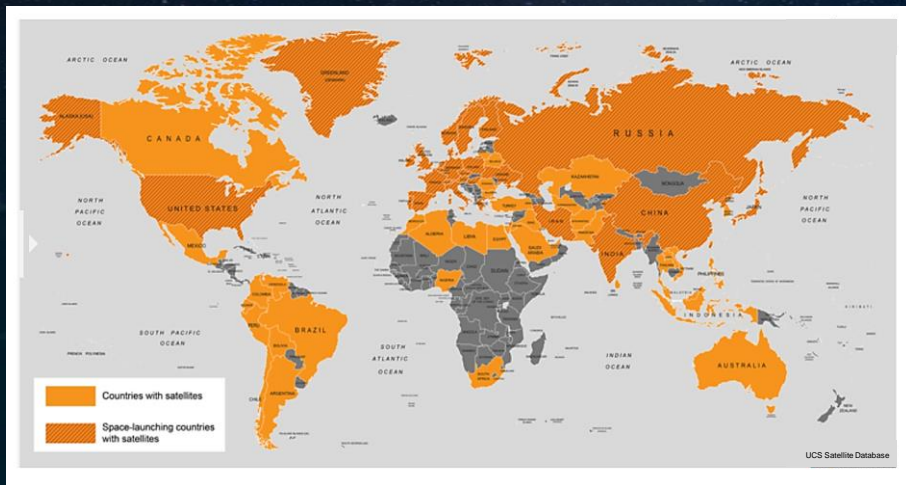


Climate & Disasters



In 2019, everyone has access to space

Space is no longer the preserve of super-powers or the most technically-advanced or wealthy of nations ...



2,063 active satellites orbiting the Earth

	Total	Military
	901 United States	176
	300 China	70
	153 Russia	74
	709 Rest of World	50?

France
Israel
India
Germany
UK

The emergence of small, highly capable but inexpensive satellites has put sophisticated space assets within reach of every nation

The UK pioneered modern small satellites



The world's first modern 'micro-satellite' launched in 1981 exploiting the enormous investments & developments in 'COTS' consumer micro-electronics to build small satellites at a **fraction of the normal cost and timescales...**



Decades -> months

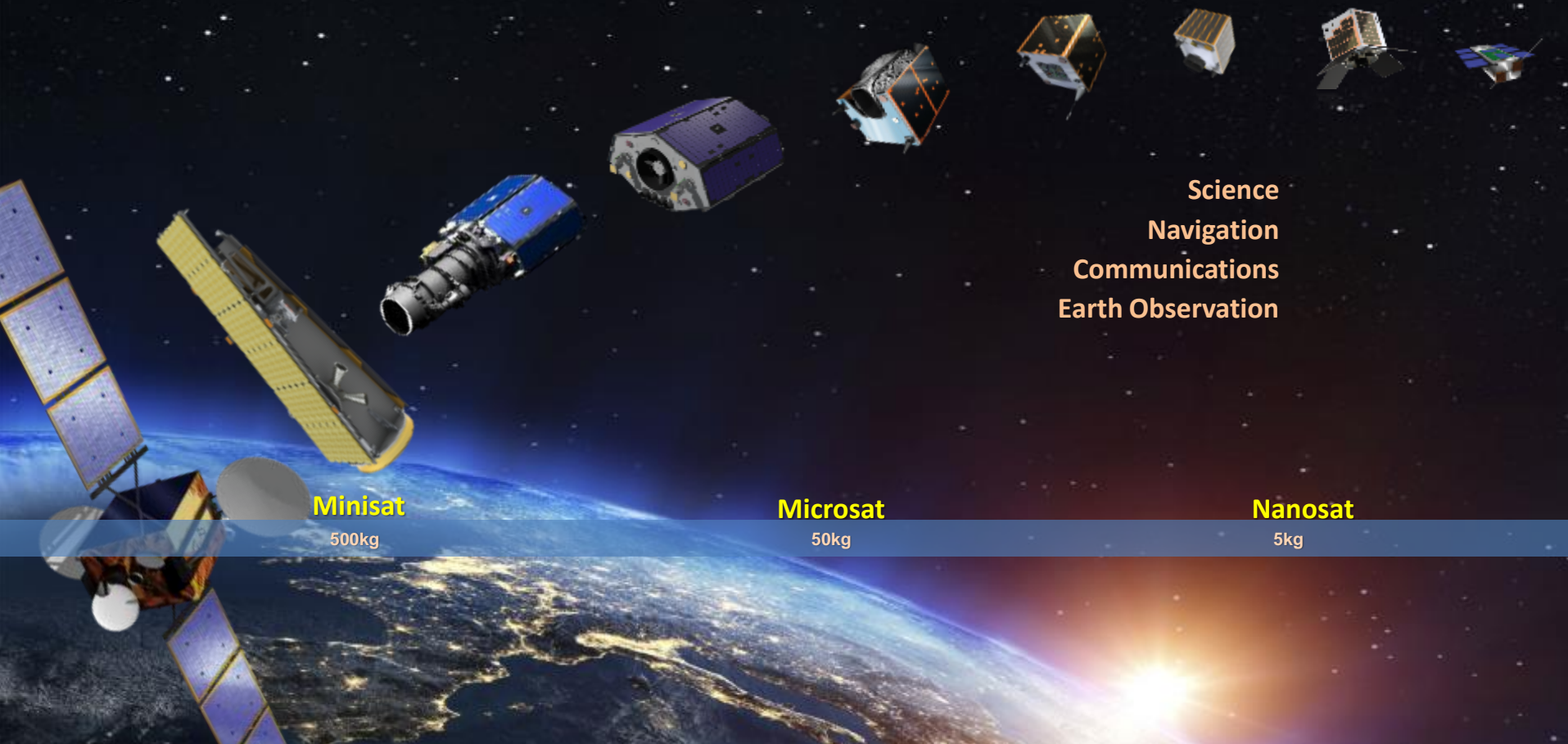
Tonnes -> kg

£Bn -> £M



This has catalysed a totally new commercial and institutional approach to space -- '**NewSpace**'

Small satellites – changed the economics of space



Minisat

500kg

Microsat

50kg

Nanosat

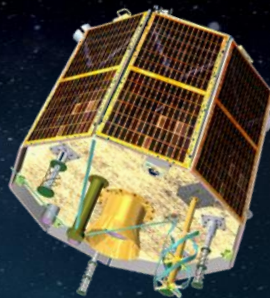
5kg

Science
Navigation
Communications
Earth Observation

The UK led the way...



- 1985:** UoSAT-2 provided global store-&-forward email – before the internet
- 2001:** UoSAT-12 became the world's first web server in space
- 2005:** UK-DMC carrying a Cisco router demonstrated a UK - USAF Virtual Missions Operations Centre using microsattellites + internet

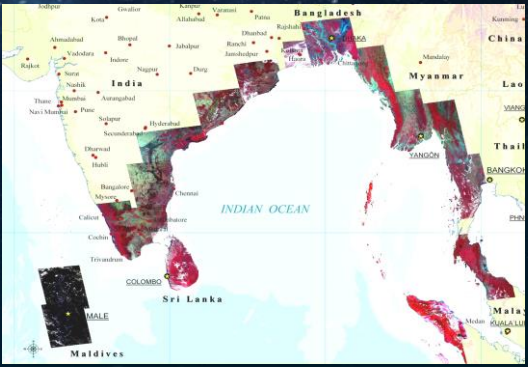
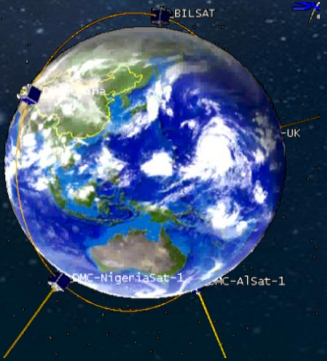
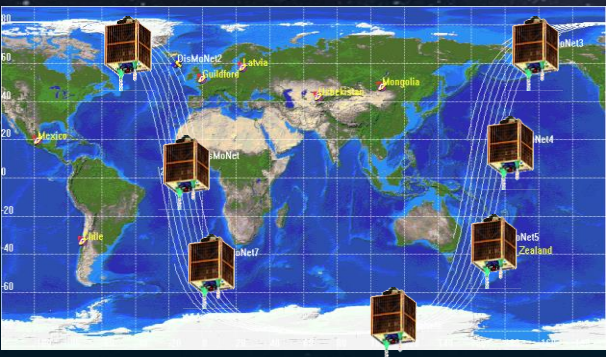


www.UoSAT-12.com



Also in Earth Observation constellations

International Disaster Monitoring Constellation (DMC)



RapidEye Commercial EO Constellation)

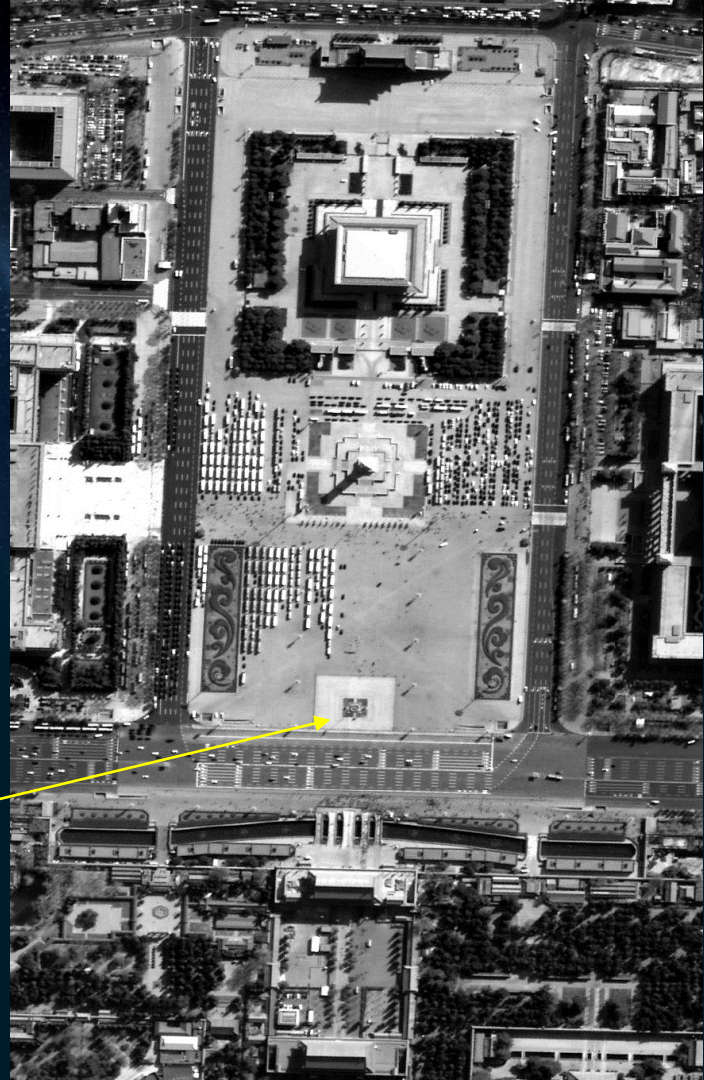


High resolution Earth Observation constellations



3x EO minisatellites constellation – launched in 2015 7-year op lifetime
1-m GSD (0.85-m) pan, 4-m 4-band m/s, 3000km swath length







Video from space...

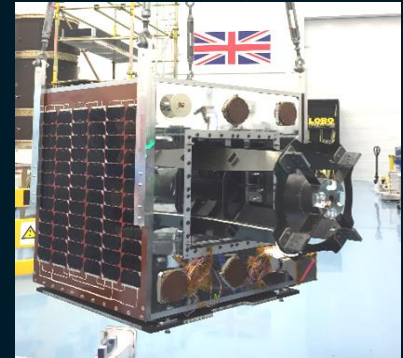


Carbonite-1 launched 2015 on PSLV

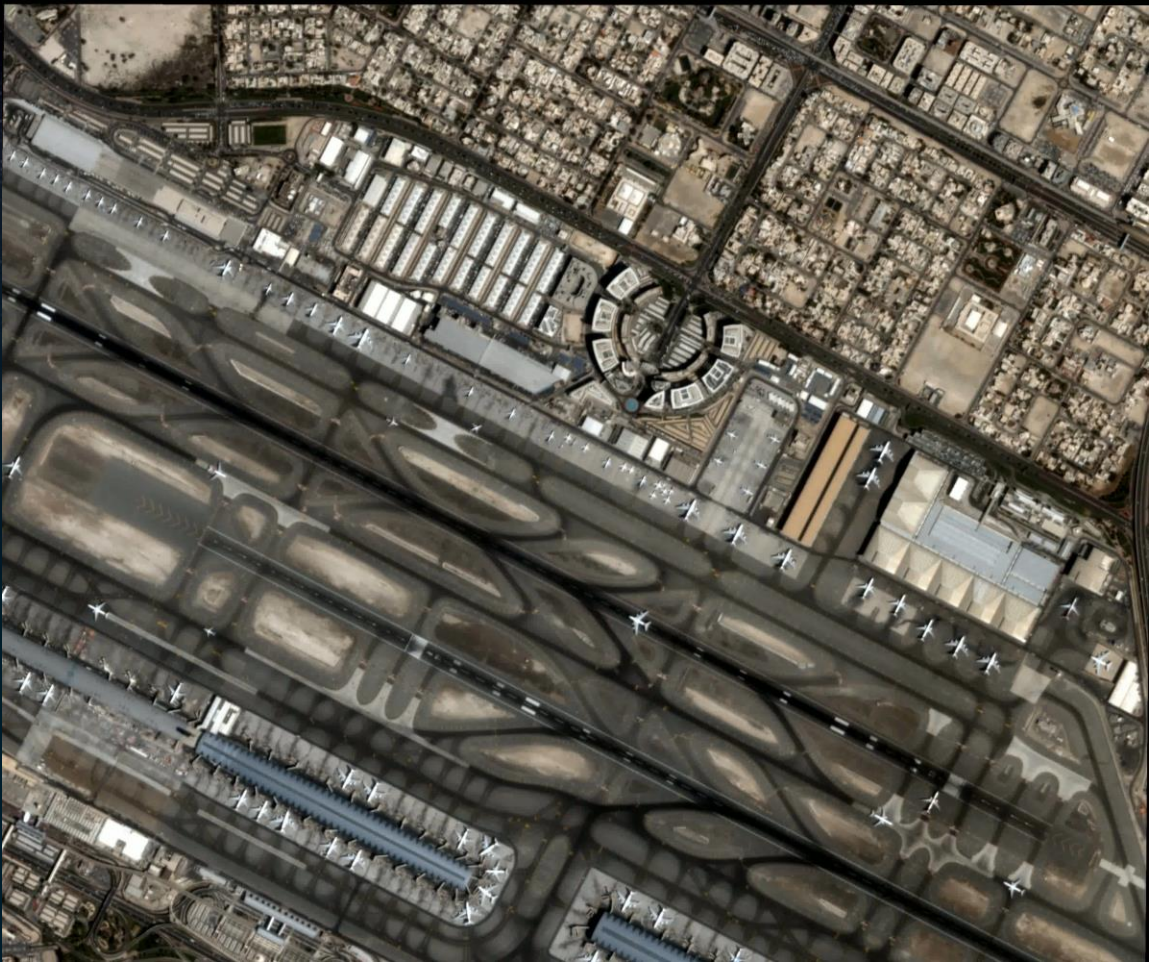
- 1-metre GSD pan & 4m m/s
- 75kg microsatellite 1/10th of the cost – 8 months
- using COTs devices
- 1m HD (4k) colour video 30 fps



Carbonite-2 launched in January 2018 on PSLV



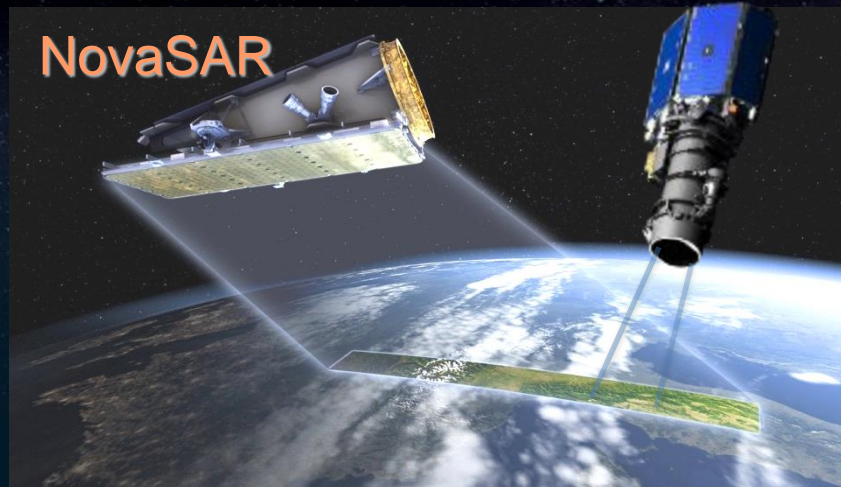
Video from Space



Carbonite-2 video
(traffic flow)

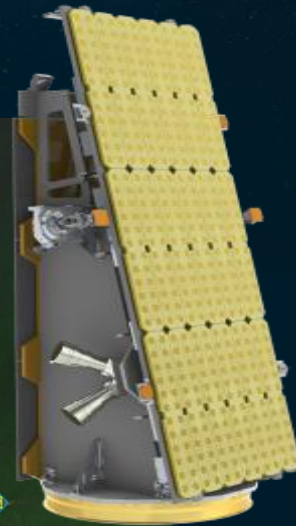
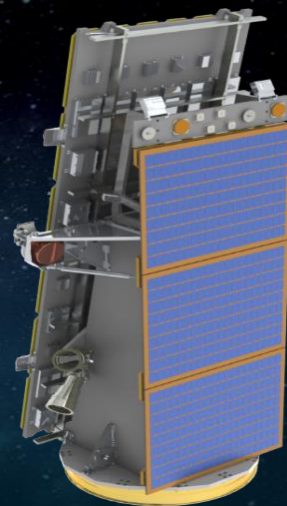


Low-cost radar remote sensing (SAR)



- All-weather day/night sensing
- Low-cost S-band SAR minisatellite
- Maritime surveillance + AIS
- De-forestation, flood monitoring

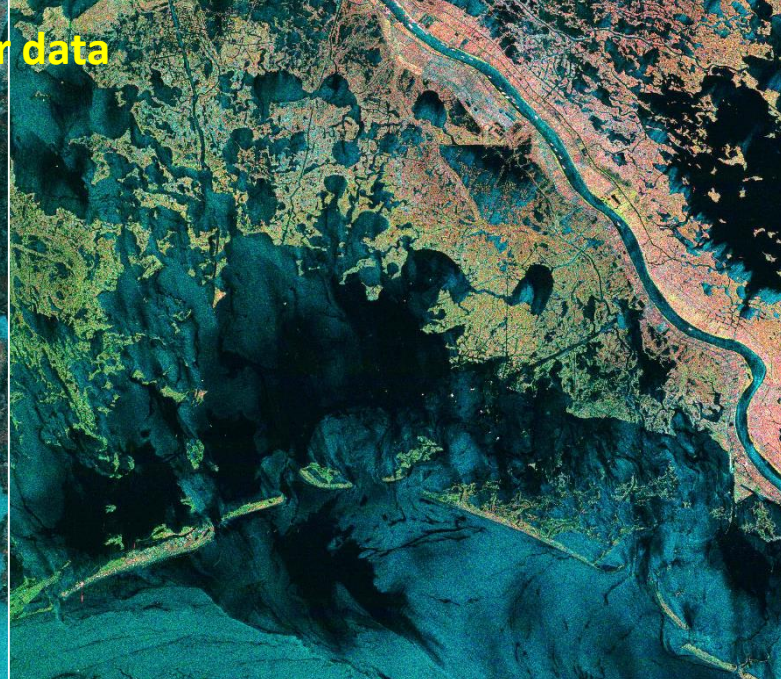
Launched on PSLV in Sept'2018 with S1-4 optical satellite



NovaSAR Multi-polar data

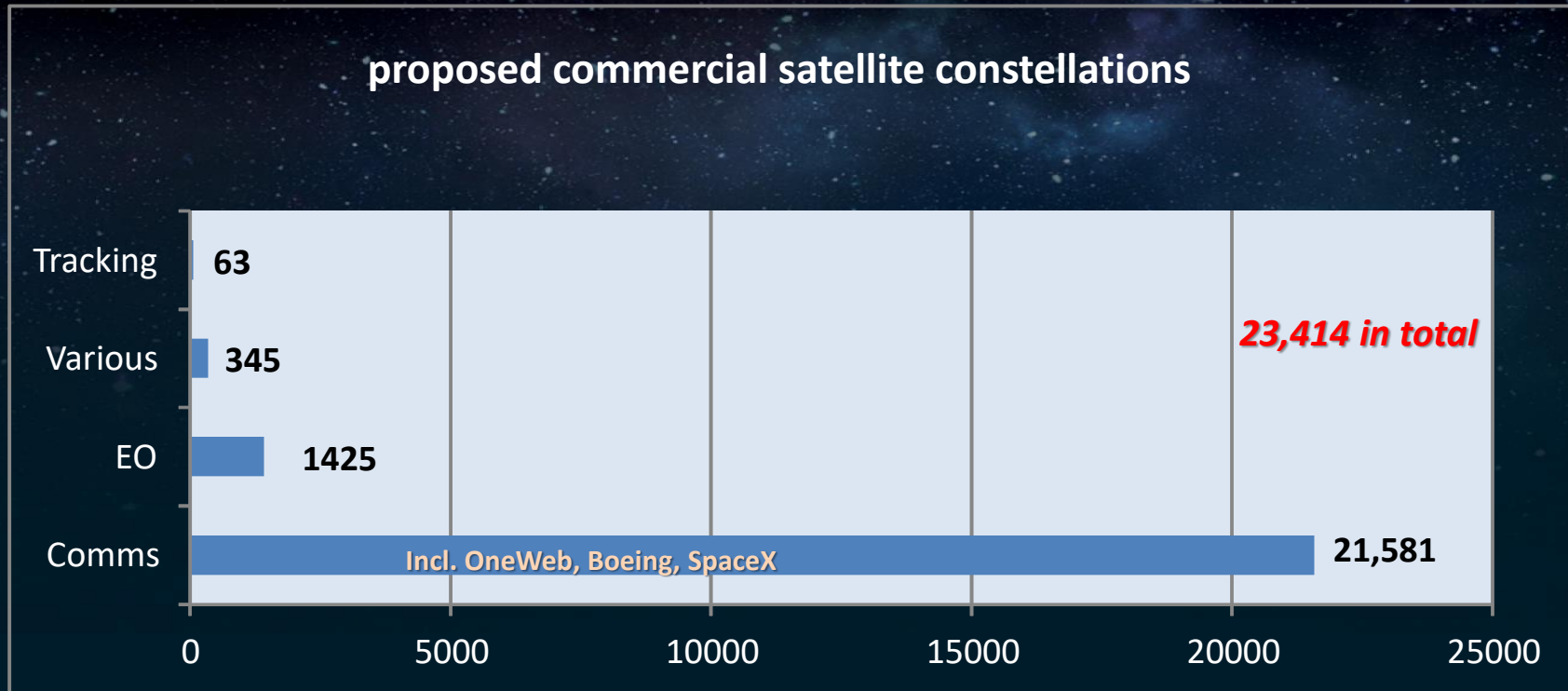


NovaSAR Multipolar Image, Suez Canal and Red Sea



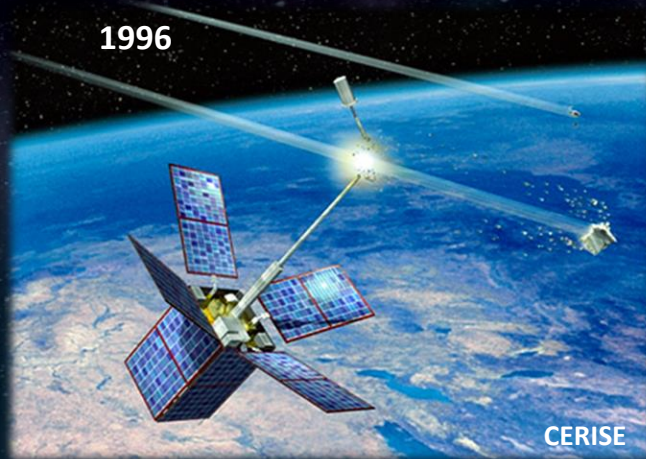
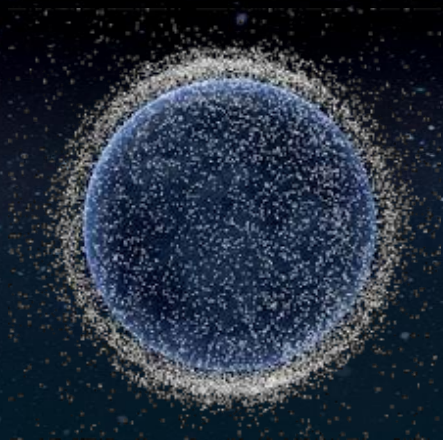
NovaSAR AIS Capture, Cape of Good Hope

"NewSpace"



The promise of high-speed low-latency broadband connectivity worldwide
The potential to bring remote regions into the global economy

Orbital debris & space traffic management

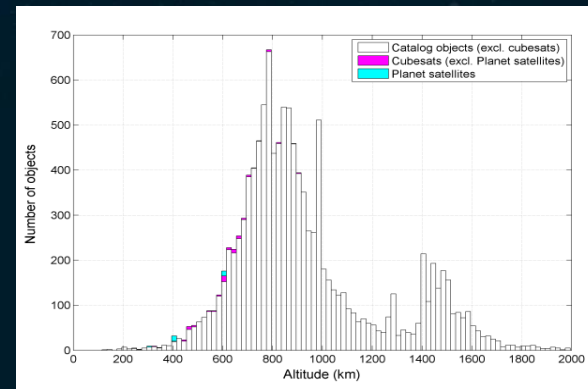


Space debris is a issue for all of the space community

The satellite community has to come up with solutions

- Intrinsically safe satellites
- De-orbit technologies (tethers, sails, electric propulsion)
- Clean-up missions with capture technologies

Space traffic control



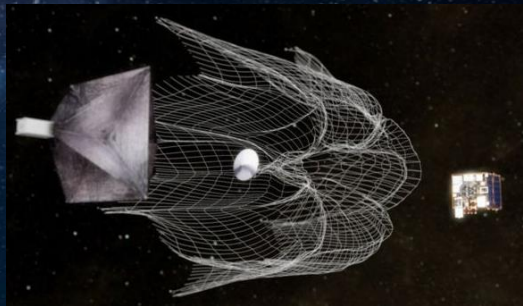
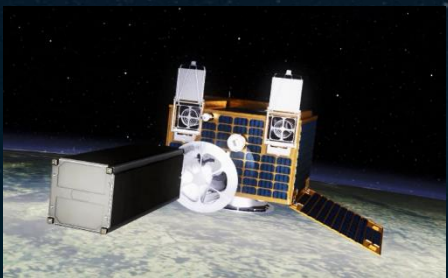
Space debris – active removal

RemoveDebris mission

EU-funded project led by Surrey

Two systems:

- Net deployer (5m ϕ) with Cubesat target
- Harpoon System and target honeycomb panel on retractable boom

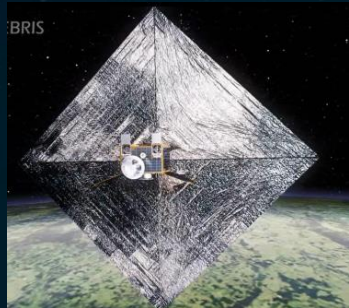


Deployable Sail for re-entry after experiment

Ejected from the ISS in July 2018

Net demonstrated in Sept 2018

Harpoon in Feb 2019

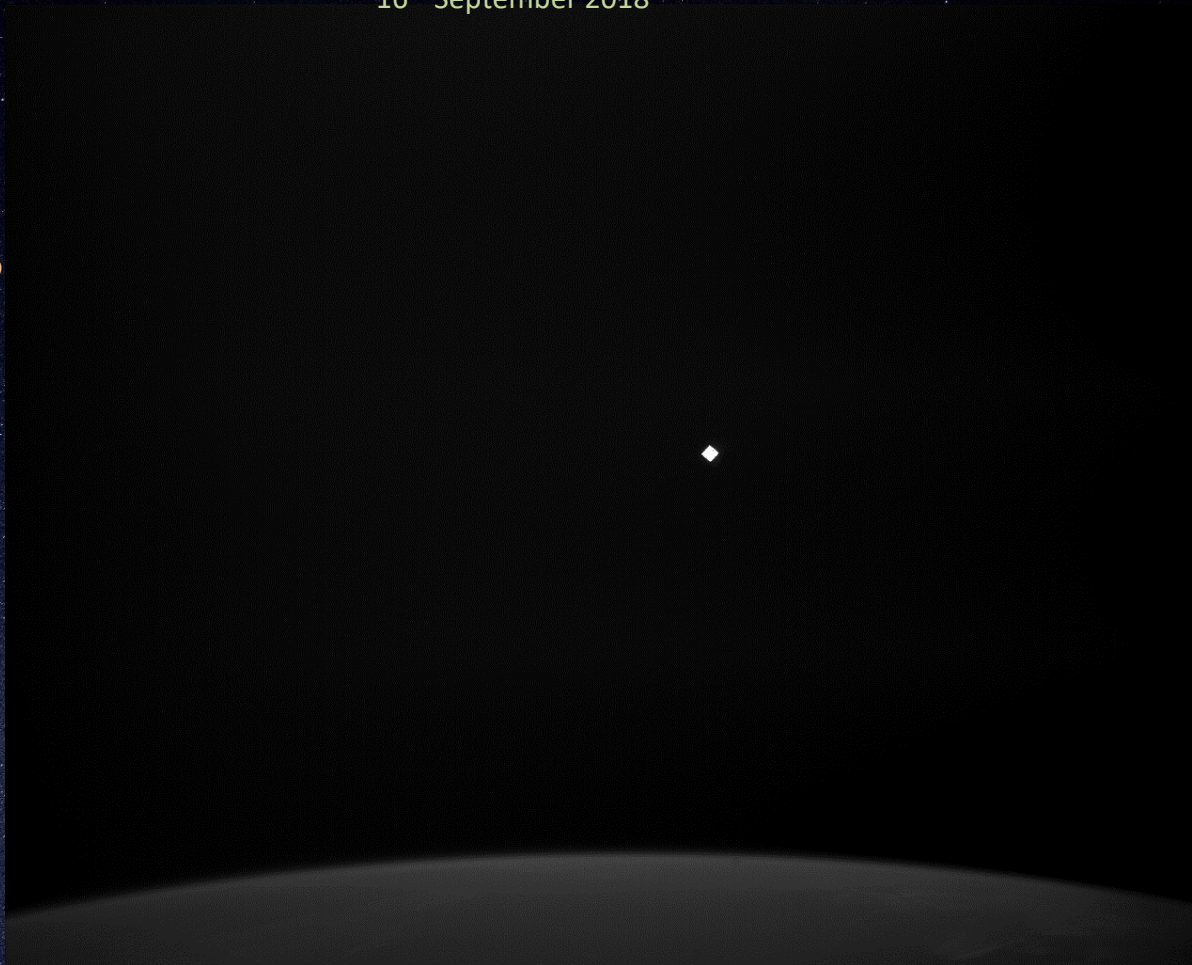


RemoveDebris – net demonstration in orbit

16th September 2018

TIMELINE - video captured in orbit by mothership

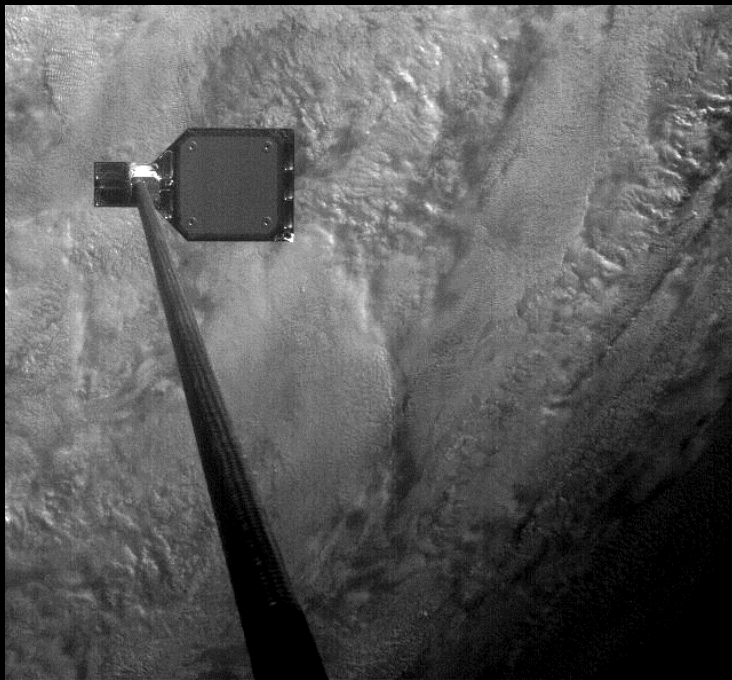
1. Deployment of target 'debris' sub-satellite from mothership
2. 'Debris' sub-satellite deploys its panels and tumbles
3. Mothership deploys the net to capture the 'debris'



February 2019

TIMELINE - video captured in orbit
by mothership

1. Harpoon's target deployed on an extendable boom from mothership
2. Harpoon fired from mothership at target
3. Harpoon pierced target and captures with its tether it as it fractures from boom



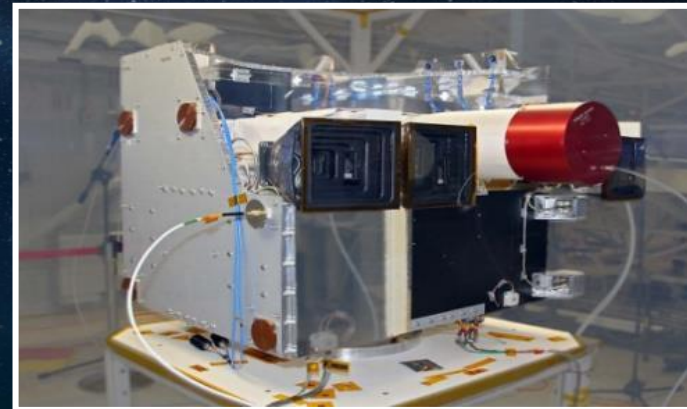
Space Situational Awareness

The UK contributed to the Canadian SSA Sapphire mission

- Providing tracking data on Resident Space Objects (RSOs) in Earth orbits between 6,000 km and 40,000 km

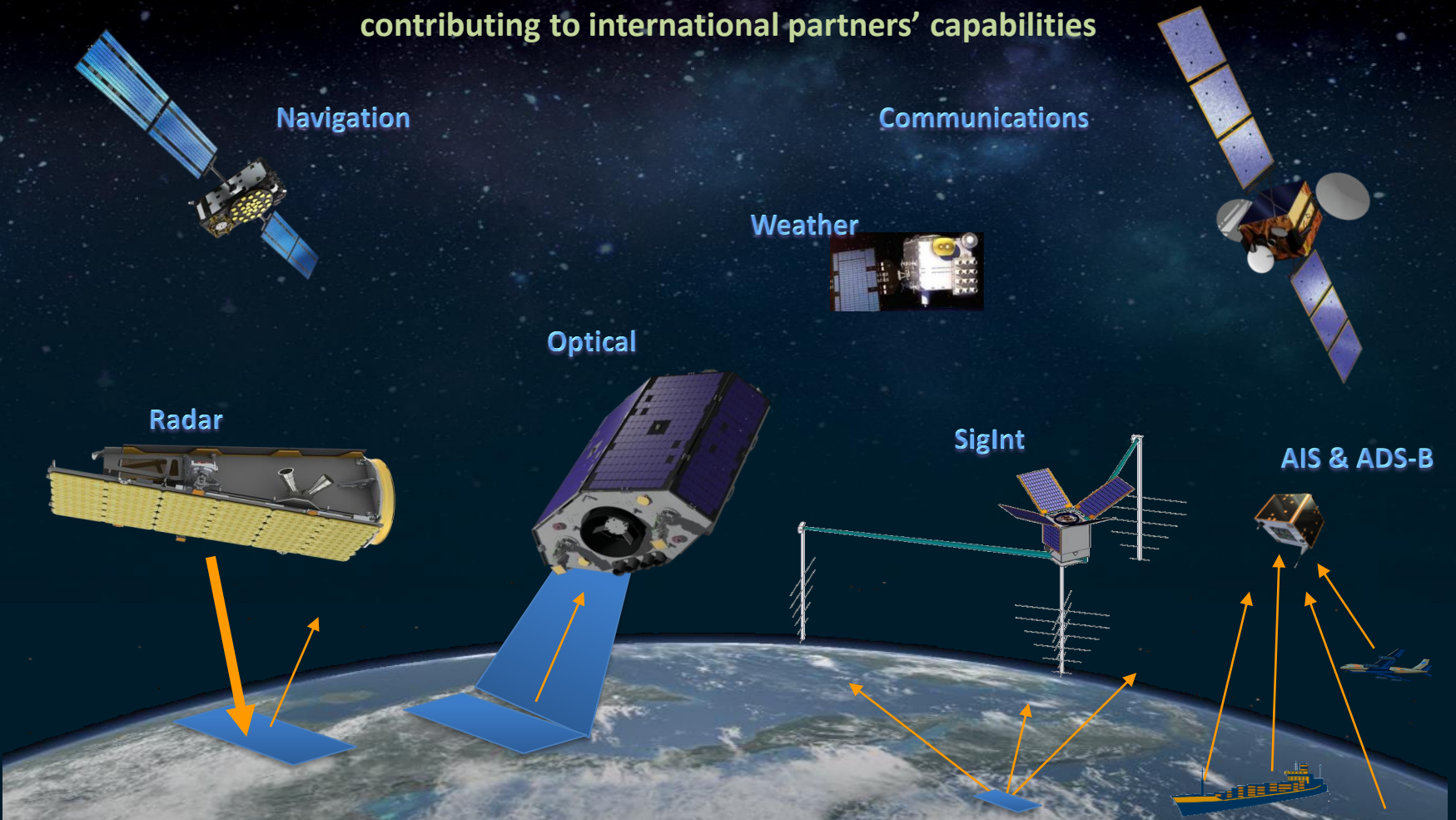
The UK could contribute improvements to SSA

- The tracking of smaller objects, (down to 1 cm in size)
- More frequent and more precise tracking in order to maintain more accurate orbits
- Assessments of hostile satellite configuration, operational status and current activity
- Launch detection
- Warning of space weather events



Potential UK sovereign capabilities

contributing to international partners' capabilities

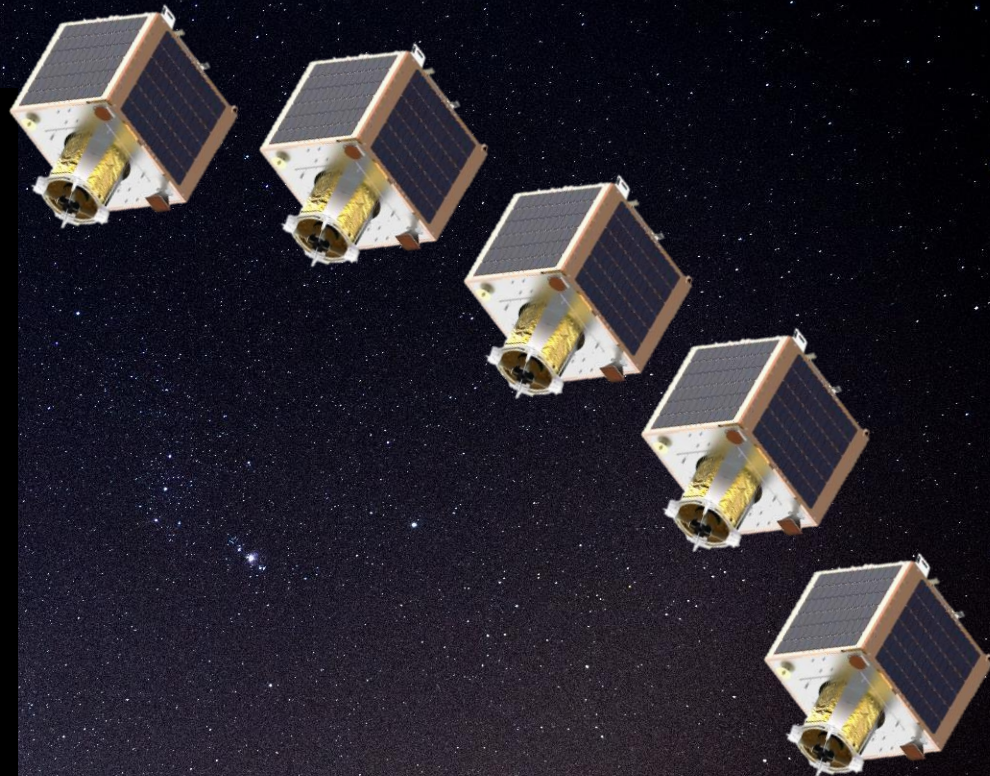


UK optical rapid-revisit constellation

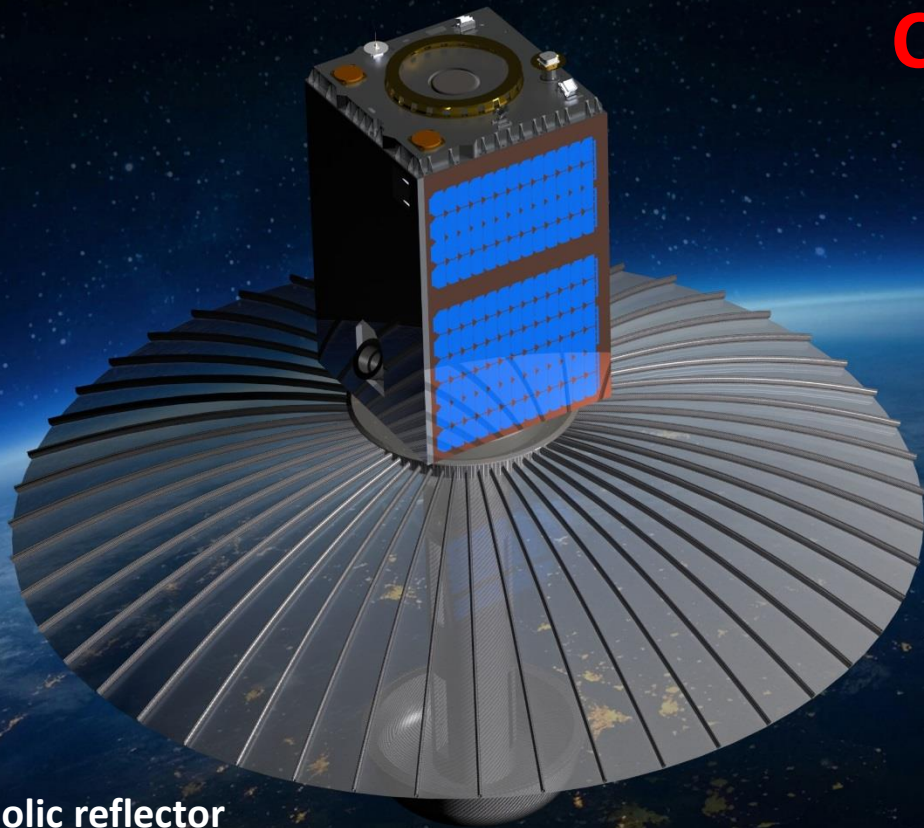
Operational system

Building upon Carbonite (1&2)

- 1-metre GSD imagery – incl. video
- Rapid revisit
- Rapid tasking capability – responsive imaging
- Sovereign capability – independence of action
- Contributing to allies capabilities – sharing the burden
- Industry working with MoD – increasing agility and VFM



CarbSAR

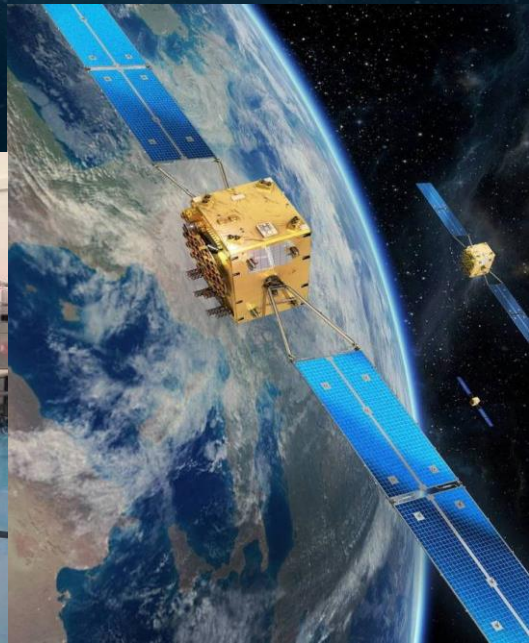
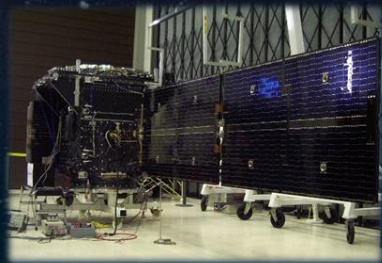


<1m GSD, X-band,
3-5m deployable parabolic reflector
5x5km swath spotlight mode

Sovereign navigation/timing system

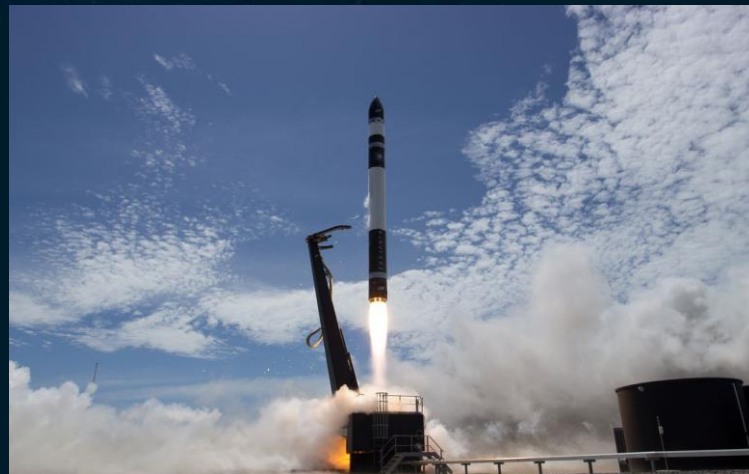
The UK built the first Galileo test satellite (GIOVE-A) for €30M ...and then the 34 Galileo payloads for the full operational constellation

The industrial capability exists in the UK for a sovereign system – if needed for BrExit Galileo GNSS risk mitigation



UK sovereign launch

- The **cost of launch** has been constraining the **smallsat market** and driving the manufacturing cost of smallsats – cost of launch is often 2-3 times the cost of the satellite
- **Mega-constellations** are driving **satellite manufacture costs down** – this will then require low cost small launchers for replenishment
- By 2030, some **11,000 launch demands** have been **estimated** for new constellation installations and replacement missions - this is stimulating many new small launcher initiatives
- The UK will soon have Space Port(s) and a feasible opportunity attract business and to possess an **end-to-end sovereign space capability** – at an affordable scale



Emerging trends...

Small satellites have exploited advances in microelectronics, whilst the structural designs have remained based largely on conventional techniques

But... new materials combined with robotics have given rise to new satellite/spacecraft manufacturing techniques that enhance small satellite capabilities and also further reduce cost and timescales

Robotic additive (and subtractive) manufacturing techniques now make possible product geometries that were previously physically impossible by human hands

Digital manufacturing provides freedom of location and dramatically increased speed of the design evolution and the product innovation cycle.

Digital factory



Software-defined satellites



In-orbit assembly

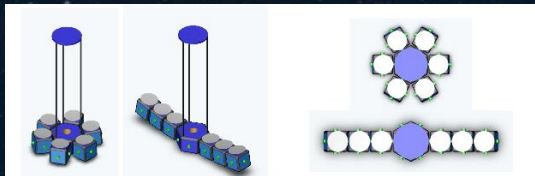


In-orbit manufacture



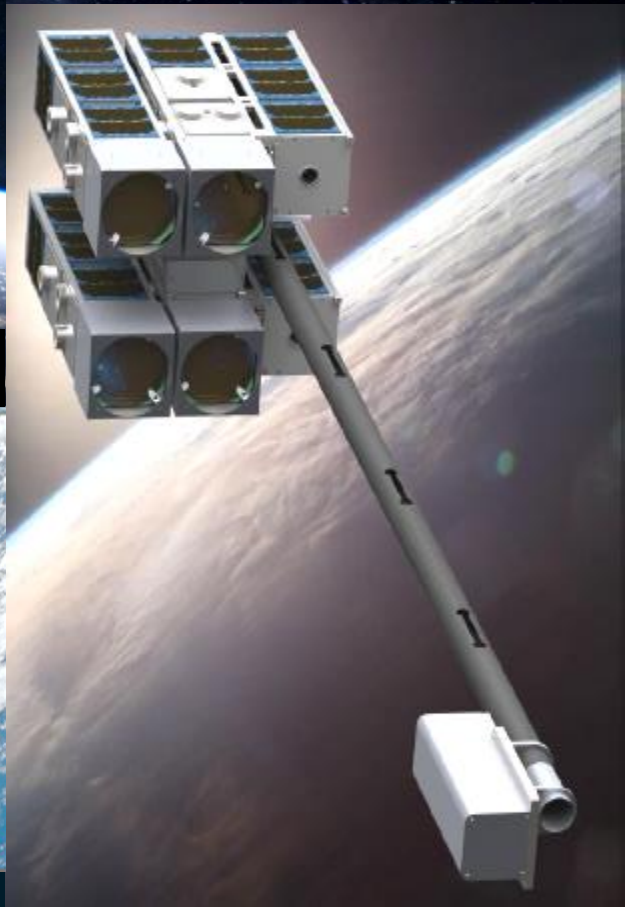
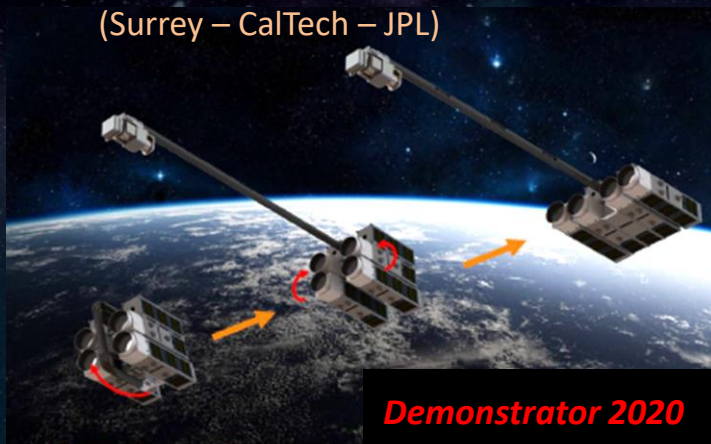
In-orbit assembly & reconfigurable spacecraft

In-Orbit robotic assembly of multiple 'mirror-craft' to form large adaptable observation platforms



Reconfigurable apertures

In-orbit assembly of a 4.5 metre diameter mirror aperture could provide persistent video with a resolution of ~2 metres over a 100 km square from GEO



The UK has the national capability

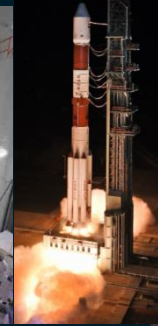
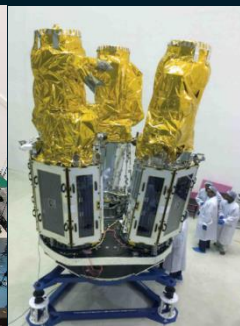
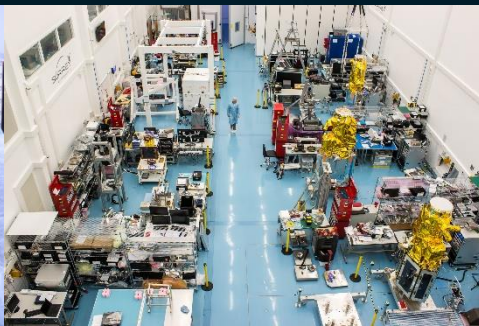


69	satellites launched
38	launches (11 vehicles, 10 sites)
500+	orbit-years satellite operations
22	Galileo nav. payloads launched
12	nav. payloads in manufacture

Vertically integrated capability



we design them **build them** **test them** **prepare for launch** **launch** **operate in orbit**



Summary

- The UK has the national capability in small satellites to support MoD space to provide utility, value & capability.
- SSTL / MOD collaboration on Carbonite demonstrated the potential of commercial space technology to Air Command and the value of close collaboration with industry
- Commercial small satellite technology has been a positive disruptive force in the commercial world – MoD can take advantage of this.
- SSTL is the leading UK small satellite mission prime



Thank You!