Launch of the Imperial Space Lab

1 July 2013 9:30-6pm
Lecture theatre G34, Sir Alexander Fleming Building, Imperial College London,
South Kensington campus (building 33 on map)

The aim of the event is to launch the Imperial Space Lab, a new multidisciplinary research network that facilitates collaboration and idea generation across Imperial, and with external academic and industry partners. The Imperial Space Lab aims to communicate Imperial's research, strengthen funding applications and promote innovative partnerships with the space industry.

Programme:
9:30 Registration with refreshments

10:00 Welcome, Introduction to Imperial and the Imperial Space Lab; Professor Sir Keith O'Nions, President and Rector, Imperial College London and Professor Steve Schwartz, Imperial

Session 1: Space Science (Chair, Professor Mark Sephton)
10:15 UK Space Agency; Dr David Parker, Chief Executive
10:40 Space Missions to the Outer Planets; Professor Michele Dougherty, Imperial
11:05 Imperial's involvement in NASA's next Mars mission, InSight; Dr Tom Pike, Imperial
11:30 Earth Observation Activities at Imperial; Dr Helen Brindley; Imperial
11:55 European Space Agency; Magali Vaissiere, Director of Telecommunications and Integrated Applications

12:20 LUNCH and poster session

Session 2: Space Technology (Chair, Professor Michele Dougherty)
13:20 Space Physics: Instrumentation and Industrial Partnerships; Chris Carr, Imperial
13:45 Satellite Applications Catapult; Paul Febvre, CTO
14:10 Geochemistry and Meteoritics, Professor Mark Sephton; Imperial
14:35 SSTL; Phil Davies, European Business Development Manager
15:00 EADS Astrium; Chris Ward, Head of UK R&D

15:25 BREAK and poster session

Session 3: Space Services and Funding Opportunities (Chair, Professor Steve Schwartz)
16:00 STFC External Innovations Programme Funding Schemes; Dr Vlad Skarda
16:25 Telespazio VEGA UK; Ian Encke, Head of Geo-information Business Development
16:50 Inmarsat; Rupert Pearce, CEO, and Marcus Vilaça, Chief Scientist & VP Technology Strategy
17:15 Close; Professor Maggie Dallman, Dean, Faculty of Natural Sciences, Imperial
17:30 Reception

To register and for more information please visit http://imperialspaceresearch.eventbrite.com/ or view the Imperial College London events page
All talks are 20 minutes long + 5 minutes questions

Imperial College London

Launch of the Imperial Space Lab

Professor Steve Schwartz

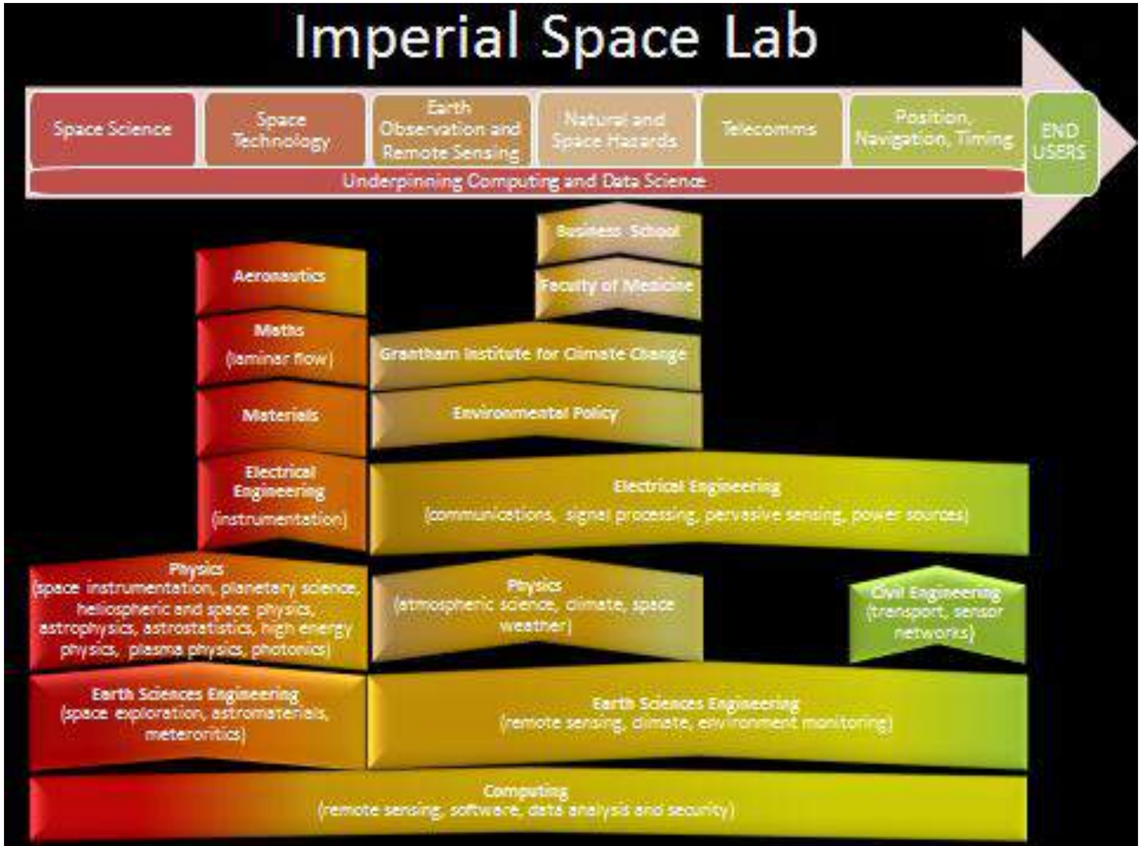
Chair in Space Physics and Director, Imperial Space Lab

1 July 2013

Imperial Space Lab www3.imperial.ac.uk/spacelab

Director: Professor Steve Schwartz

- Multidisciplinary research network that facilitates collaboration across Imperial and with external academic and industry partners
- Aims to promote innovative partnerships with the space industry and communicate our research
- ~80 researchers from Faculties of Engineering, Natural Sciences, Medicine and Business School across seven major themes:



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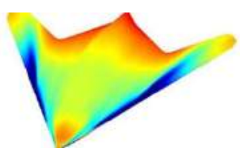
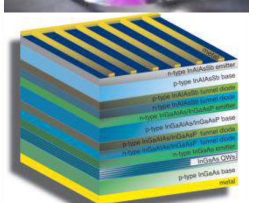
Space research at Imperial

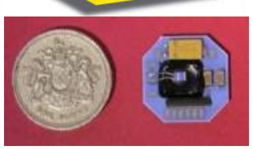
Research covers upstream (space technology providers) and downstream (space technology users) sectors;

Ranges from blue-skies research in planetary sciences to applications such as navigation and positioning solutions

Technology

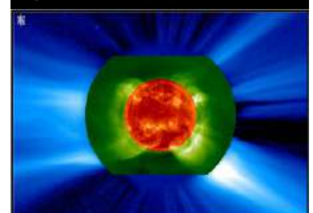


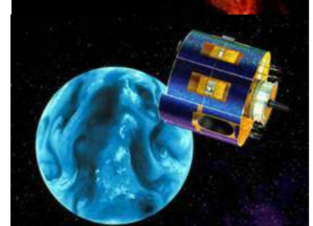




- Aerial robotics- jumpgliding microrobots
- Aeronautics and mathematics: laminar flow control
- Computing-Software: autonomous sensing for telecommunications, timing, data processing
- Materials- MASER, low noise amplifiers for space & terrestrial comms
- Solar energy
- Space weather monitoring constellation

Science





- Planetary Science
- Heliospheric & Space Physics
- Astronomy & Astrophysics
- Astrostatistics
- Earth Observation

See the posters for more information!

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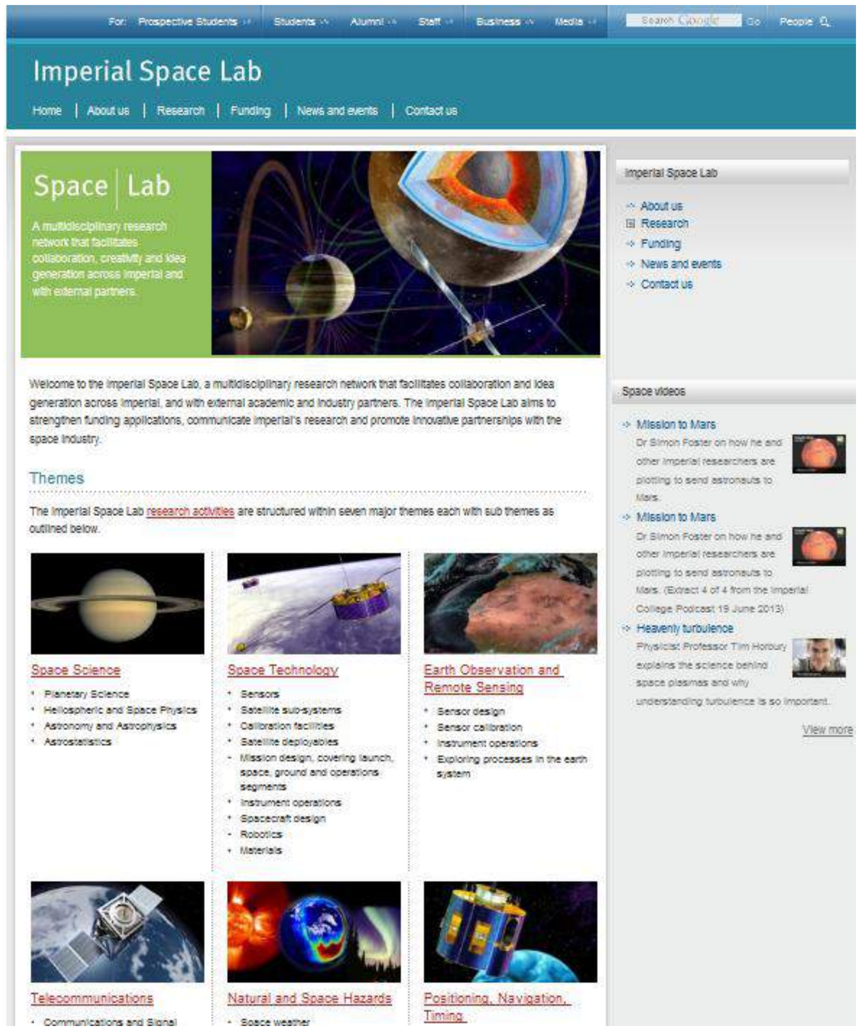
Imperial Space Lab www3.imperial.ac.uk/spacelab

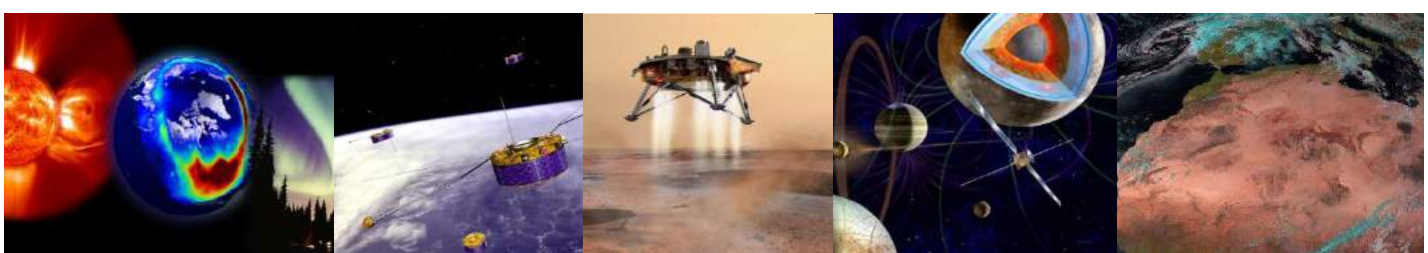
Director: Professor Steve Schwartz

For more information on our research visit www3.imperial.ac.uk/spacelab



Why work with Imperial's space researchers?

- Gain exposure to world-leading research
- Utilise educational and training excellence
- Connect to expertise in translation and knowledge transfer
- Collaborate with world-renowned academics
- Access a global pool of talented students
- Join a network of partners and public funding bodies
- Grasp the opportunity to influence on a global scale



How we can work together:

Through people and training:

- Access to student pool through industry sponsored studentships and internships
- Industry sponsored fellowships, including through Imperial's Junior Research Fellowship programme
- Short or long term secondments
- Courses: Continuing Professional Development, Master's courses and tailored programmes
- Consultancy services-Imperial Consultants
- Access to facilities and associated expertise

Through project funding:

- Direct funding for single projects
- Large, strategic partnerships
- Spinouts and venture capitalist funding
- Commercialisation and technology transfer activities
- Leveraged and matched funding for research

Thank you

Website: www.imperial.ac.uk

Twitter: @imperialcollege

iTunesU: http://www3.imperial.ac.uk/itunesu

Facebook: http://www.facebook.com/imperialcollegelondon

YouTube: http://www.youtube.com/imperialcollegevideo

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Space Missions to the Outer Planets

Michele K. Dougherty FRS
Professor of Space Physics, Space and Atmospheric Physics Group

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Imperial involvement and leadership

Our world class science output drives the instruments we build and our space mission involvement

Focus on two outer planetary missions:

- NASA/ESA Cassini/Huygens mission to Saturn system
- ESA JUICE mission to Jupiter system

Cassini – PI on magnetometer instrument

- orbiting Saturn since July 2004, mission end in September 2017
- discovery of water vapour atmosphere at Enceladus

JUICE – ESA Science Definition Team Lead and PI of magnetometer instrument

- ESA's first L-class mission, due for launch in 2022, arrival at Jupiter in 2030, mission end 2033
- focus on 3 of Galilean moons with liquid water oceans, orbit Ganymede
- emergence of habitable worlds around gas giants

High profile success of Cassini science drove JUICE science and selection

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Technology links

World leading, low noise, stable fluxgate magnetic sensor (Ultra Electronics)

Recent developments:

- miniaturised sensor based on anisotropic magneto-resistive materials
- radiation hardened ASICs (Astrium)

Areas of new focus linked to the JUICE mission include:

- radiation environment and modeling
- miniaturisation
- optimisation of instrument resources
- integrated payload approach
- integrated payload data handling project (Astrium)
- internal charging
- long, stiff magnetometer booms


INTERNATIONAL PARTICIPATION IN
CASSINI
SATURN ORBITER AND HUYGENS TITAN PROBE
DENMARK
BELGIUM
FRANCE
UNITED STATES
GERMANY
ITALY
UNITED KINGDOM
NETHERLAND
AUSTRIA
FINLAND
NORWAY
SWEDEN
IRELAND
SWITZERLAND
SPAIN
CZECH REPUBLIC
POLAND
ISRAEL

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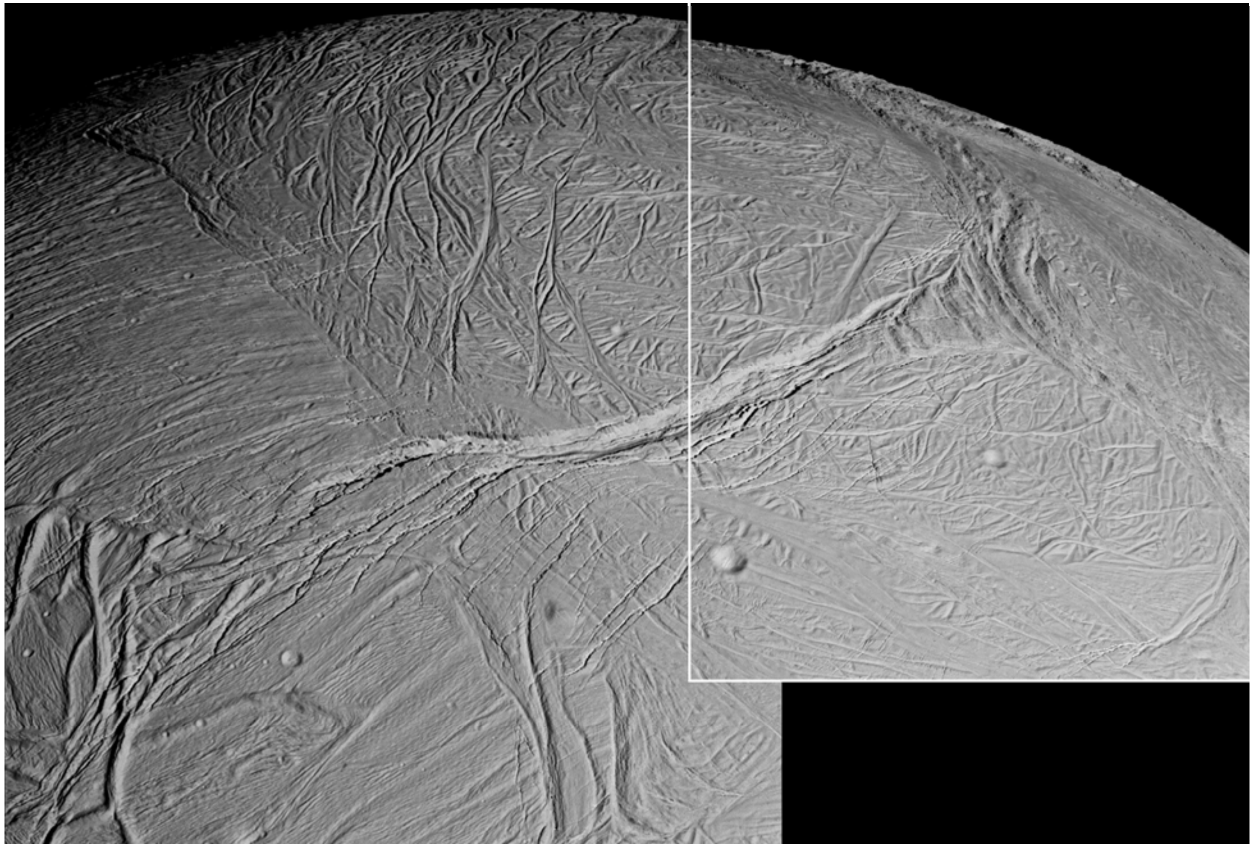
London

Enceladus



Three Cassini flybys
(1265km, 500km, 173km)

In inner magnetosphere

Source of Saturn's E ring?

Relatively young surface

Cracks on surface

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Saturn's ring system

- Rings are an enormous, complex structure
- E ring largest planetary ring in solar system
- Particle's in rings mainly water ice

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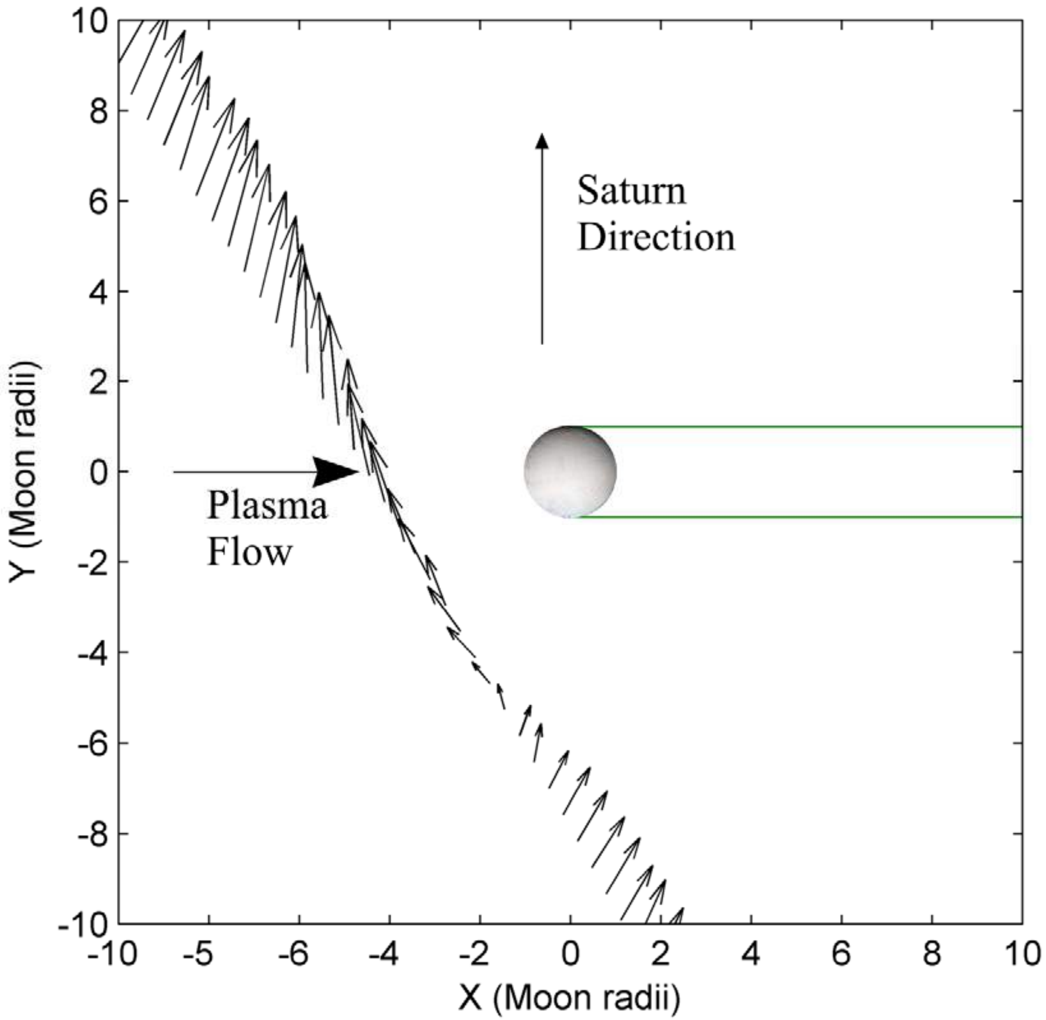
Surprising magnetic field observations

Large increase in ion cyclotron wave activity

Water group ions



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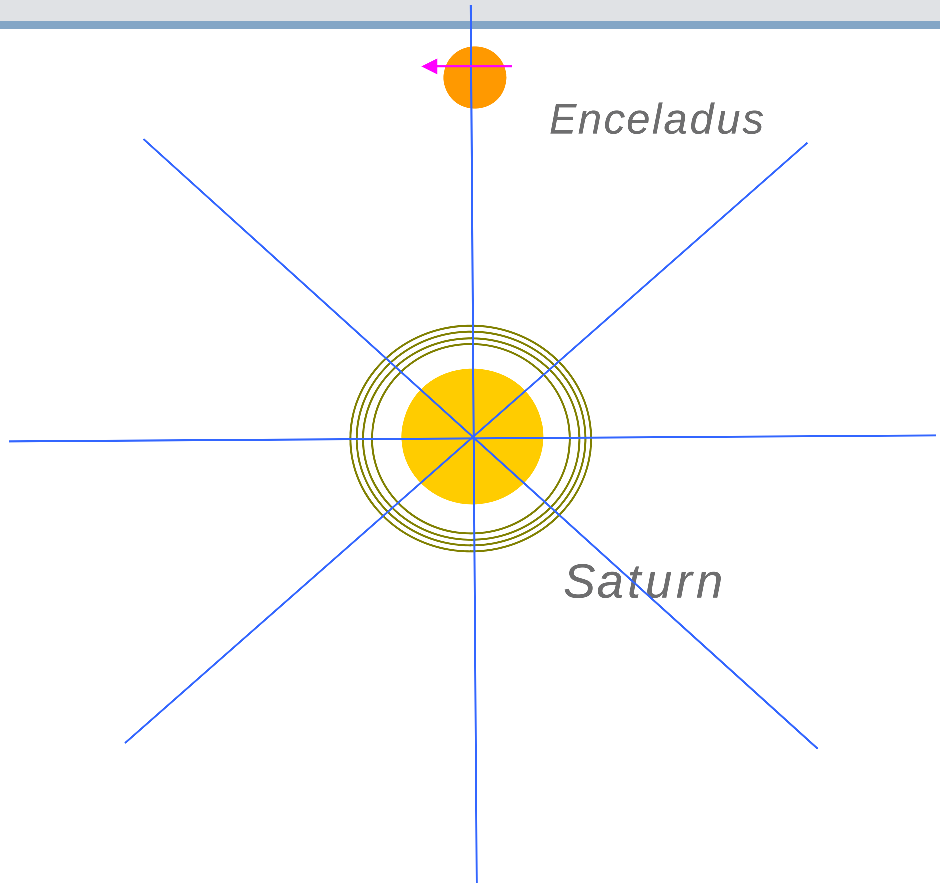
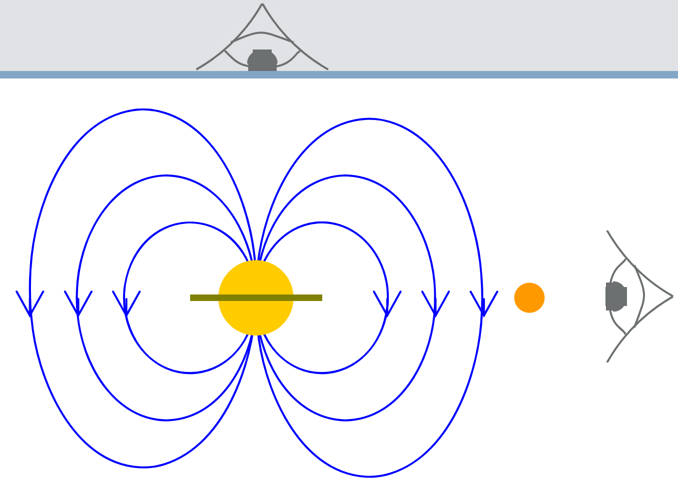
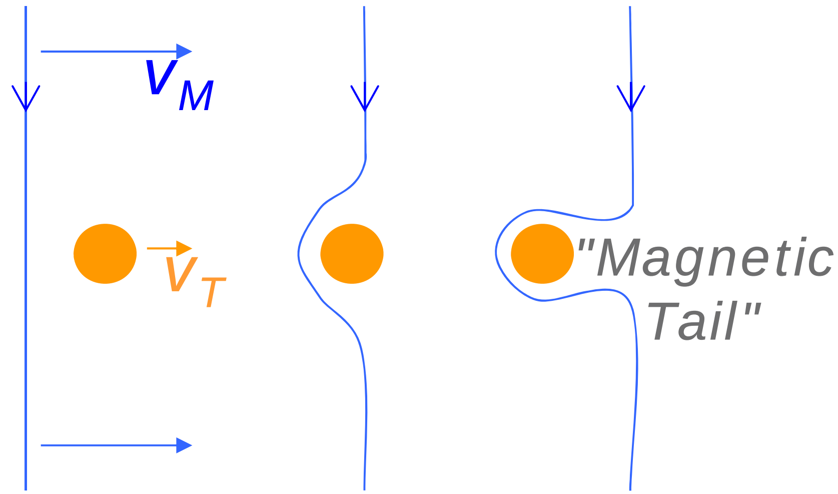
Field Line Draping

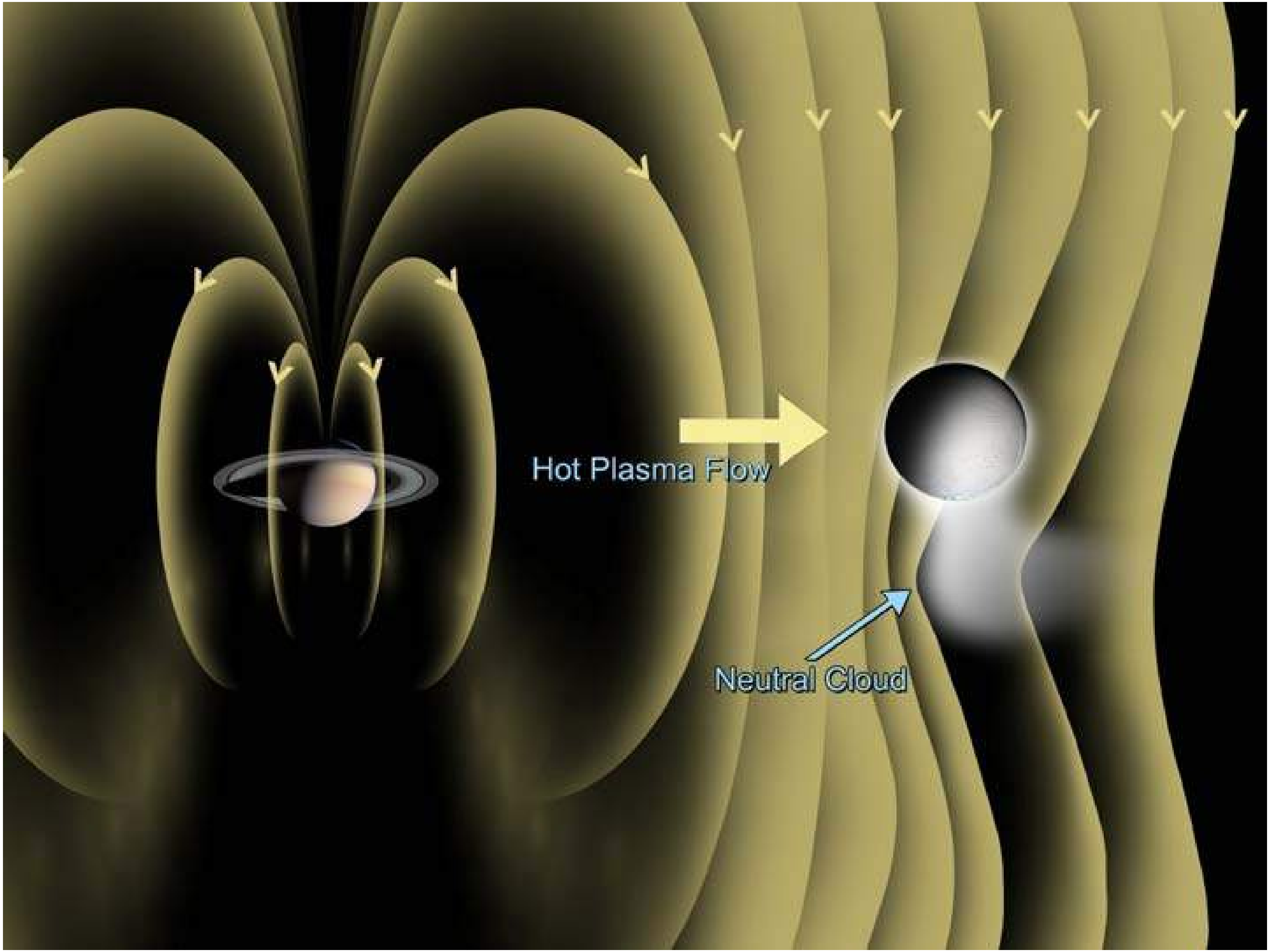


"Co-rotating" plasma





$V_M > V_T$



Hot Plasma Flow
Neutral Cloud

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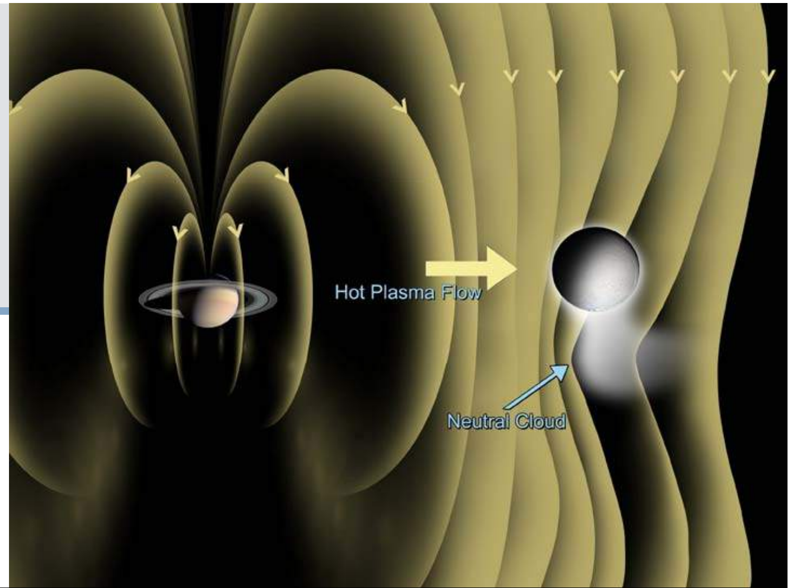
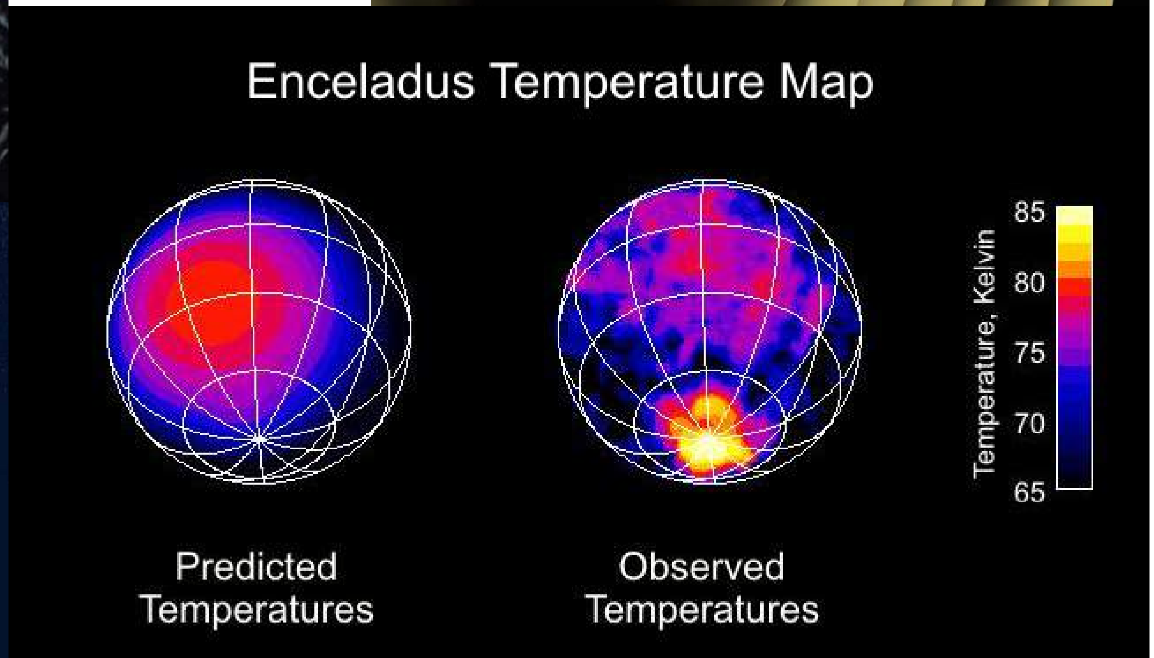
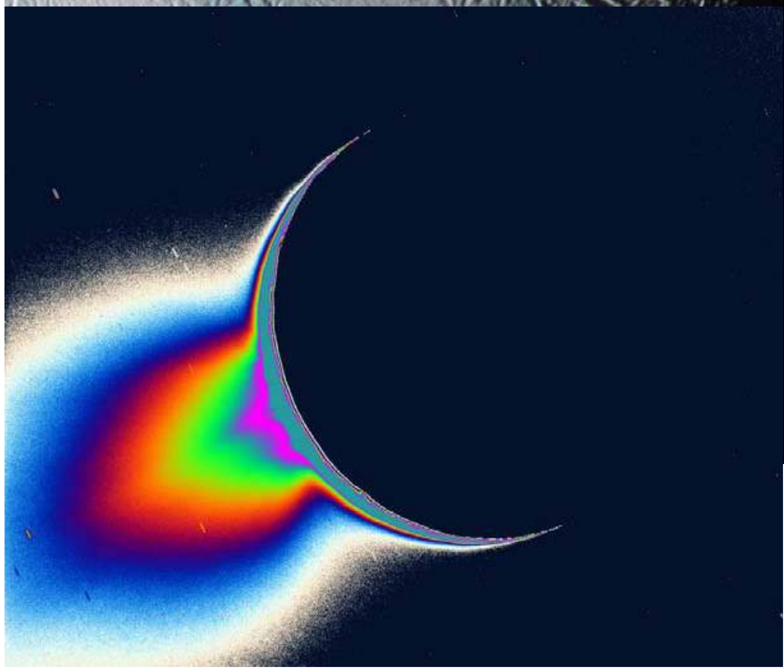
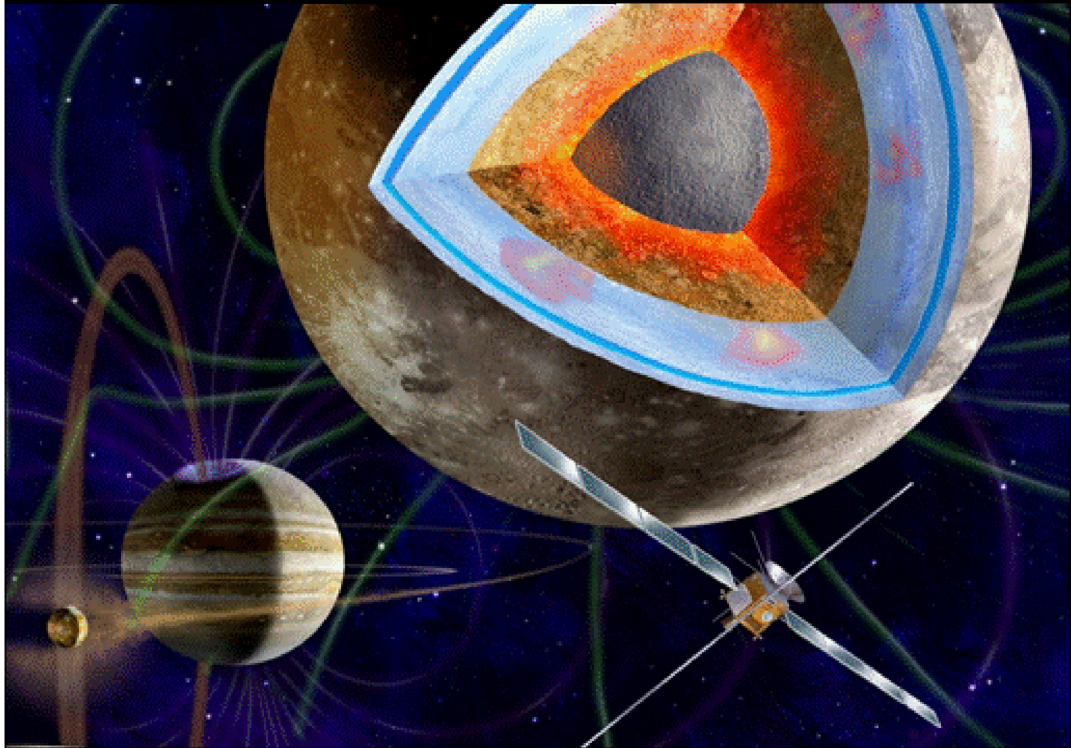
Example of interdisciplinary success







Internal heat source, water vapour plume with organic material and dust, variable outgassing rate



JUICE Science Themes

- *Emergence of habitable worlds around gas giants*
- *Jupiter system as an archetype for gas giants*

- *Focus on three moons: Ganymede, Europa and Callisto*
- *And the Jupiter magnetosphere and atmosphere*

JUICE concept

- *European-led mission to the Jovian system*
- *First orbiter of an icy moon*
- *Launch planned in 2022*
- *Jupiter Orbit Insertion 2030*

Exploration of the habitable zone

JUICE

Three large icy moons to explore

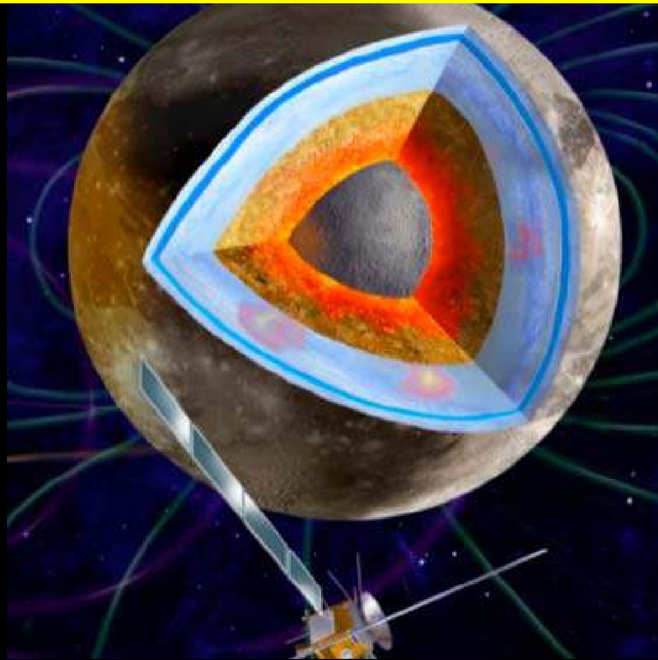
Ganymede
- Largest satellite in the solar system
- A deep ocean
- Internal dynamo and an induced magnetic field – unique
- Richest crater morphologies

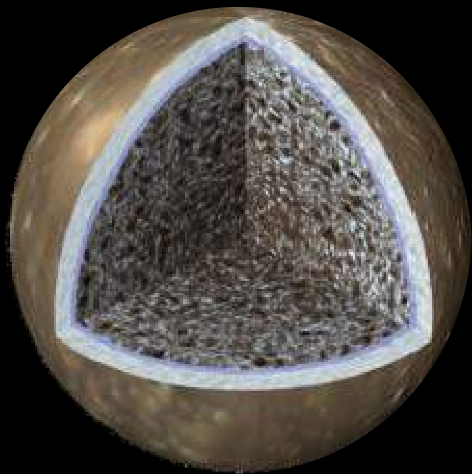
- Archetype of waterworlds
- Best example of liquid environment trapped between icy layers

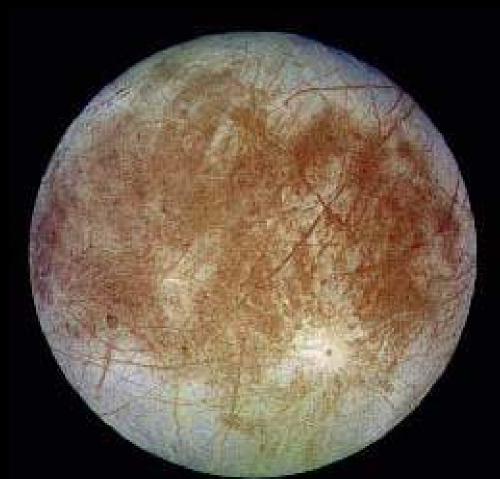
Callisto
- Best place to study the impactor history
- Differentiation – still an enigma
- Only known example of non active but ocean-bearing world
- The witness of early ages

Europa
- A deep ocean
- An active world?

- Best example of liquid environment in contact with silicates







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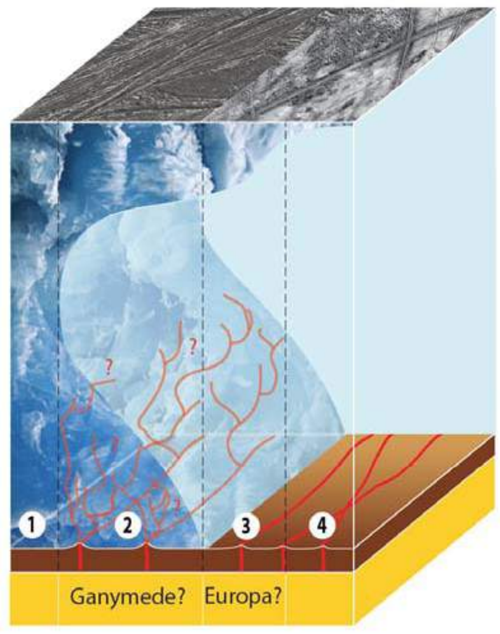
Science Case I: Resolve interior structure of icy moons



Resolve strength of induced magnetic fields

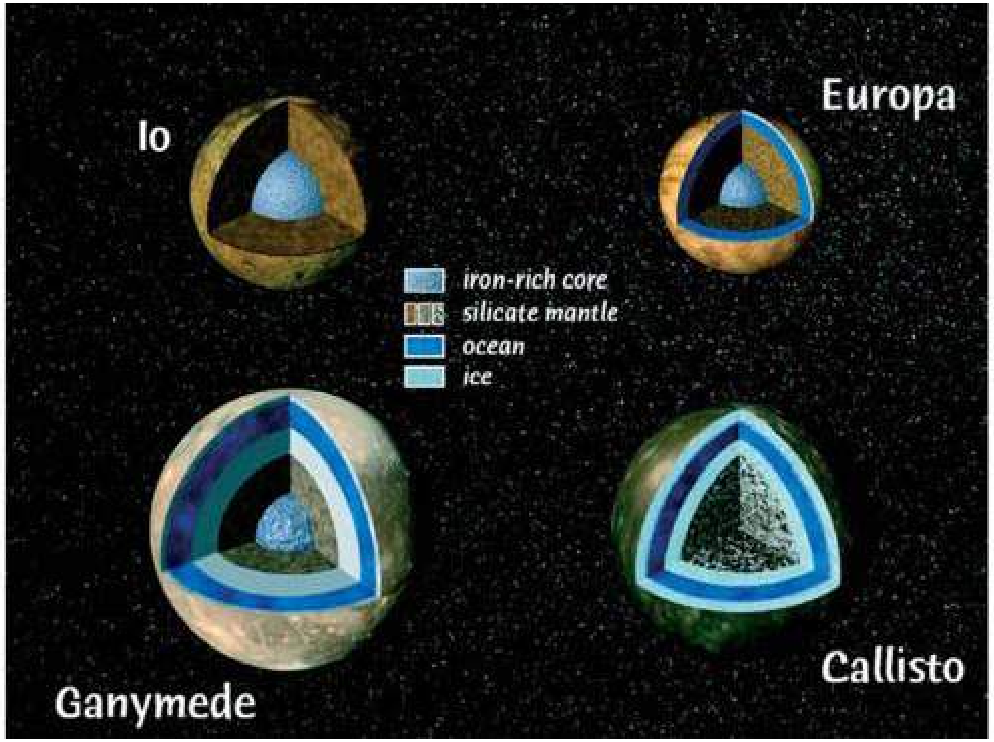
What are depth of the liquid oceans beneath icy surfaces

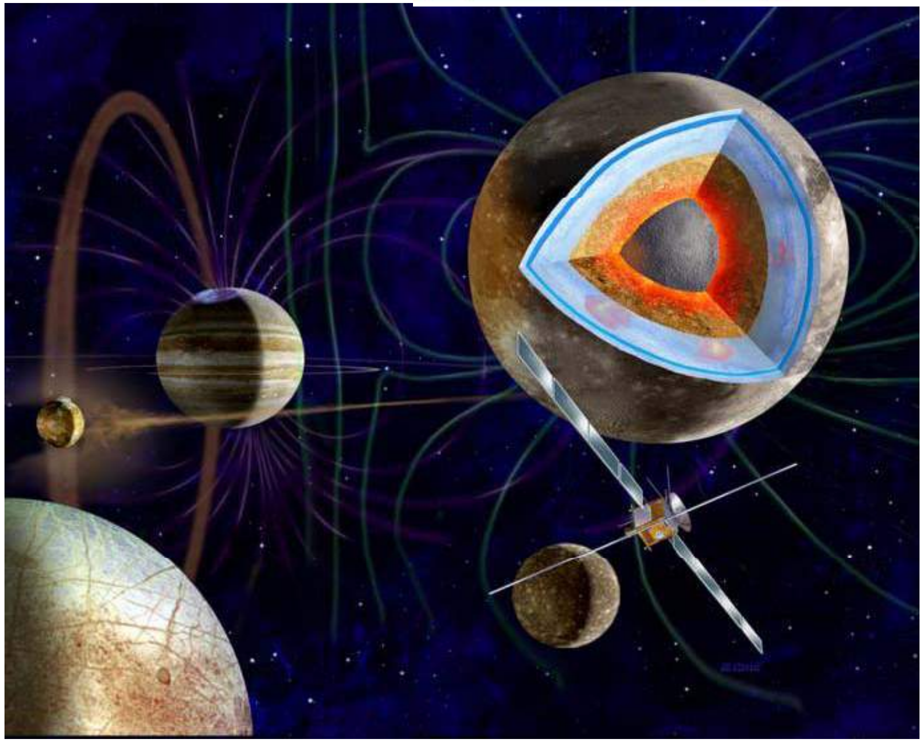
What is the conductivity of the water?

Resolve strength of Ganymede internal magnetic field

Implications for the deep interior structure of Ganymede

Compare differentiated with undifferentiated body





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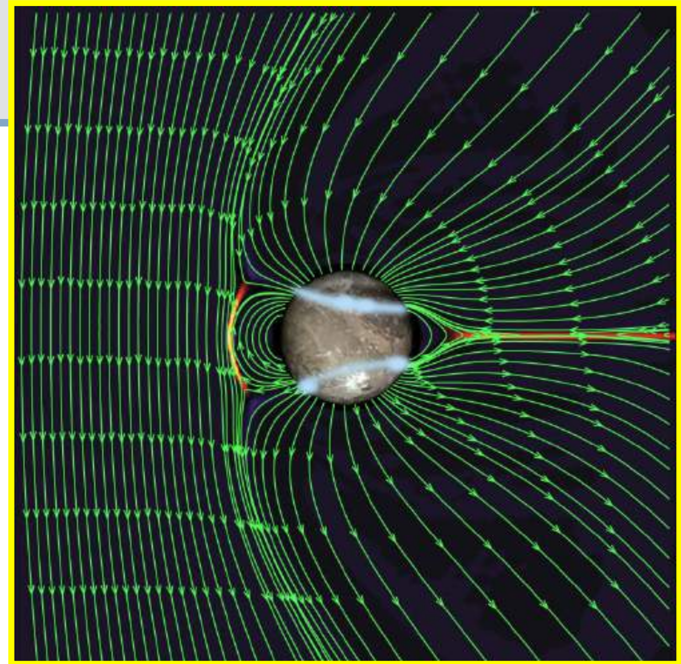
Science Case II: Dynamical plasma processes

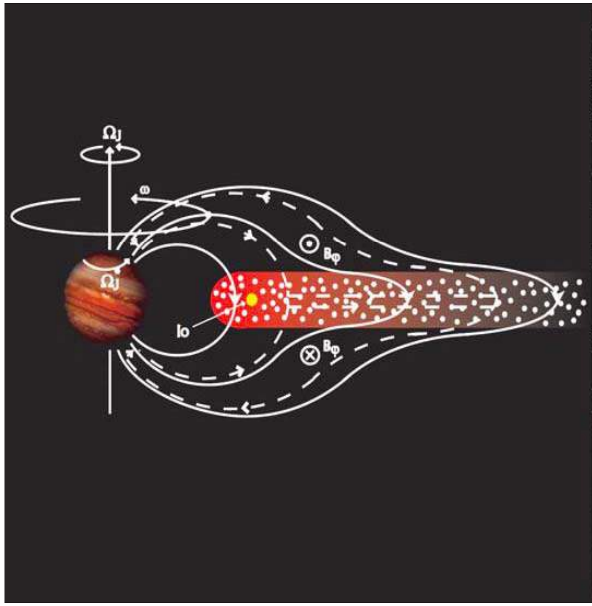


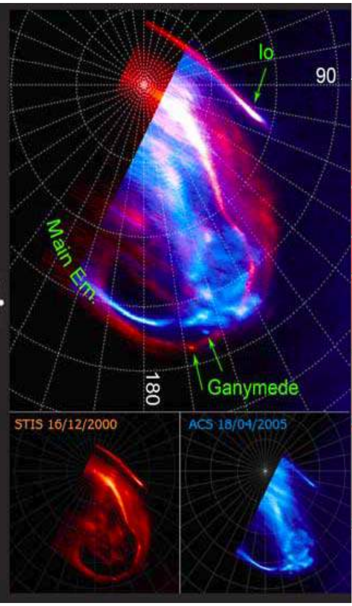
Magnetic field measurements are vital to allow better understanding of dynamical plasma processes

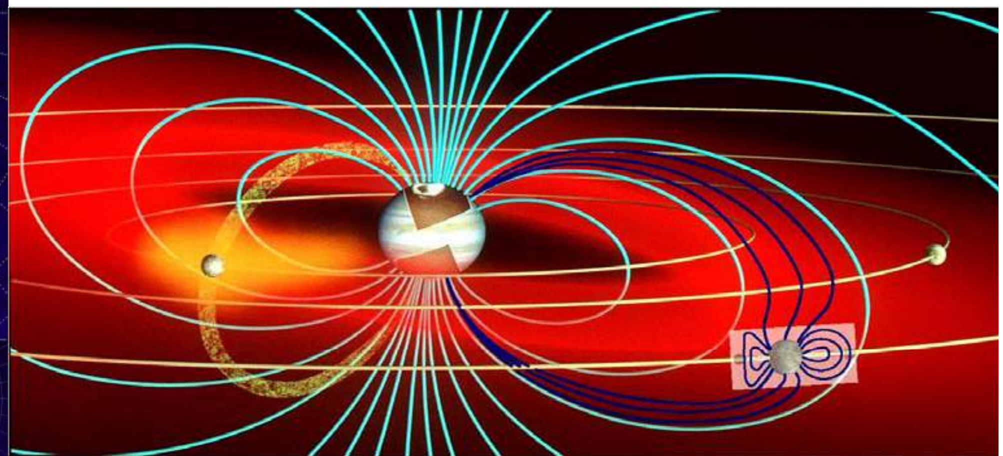
Interactions of the magnetosphere of Ganymede within the Jovian magnetosphere

Dynamics of Jovian magnetodisk

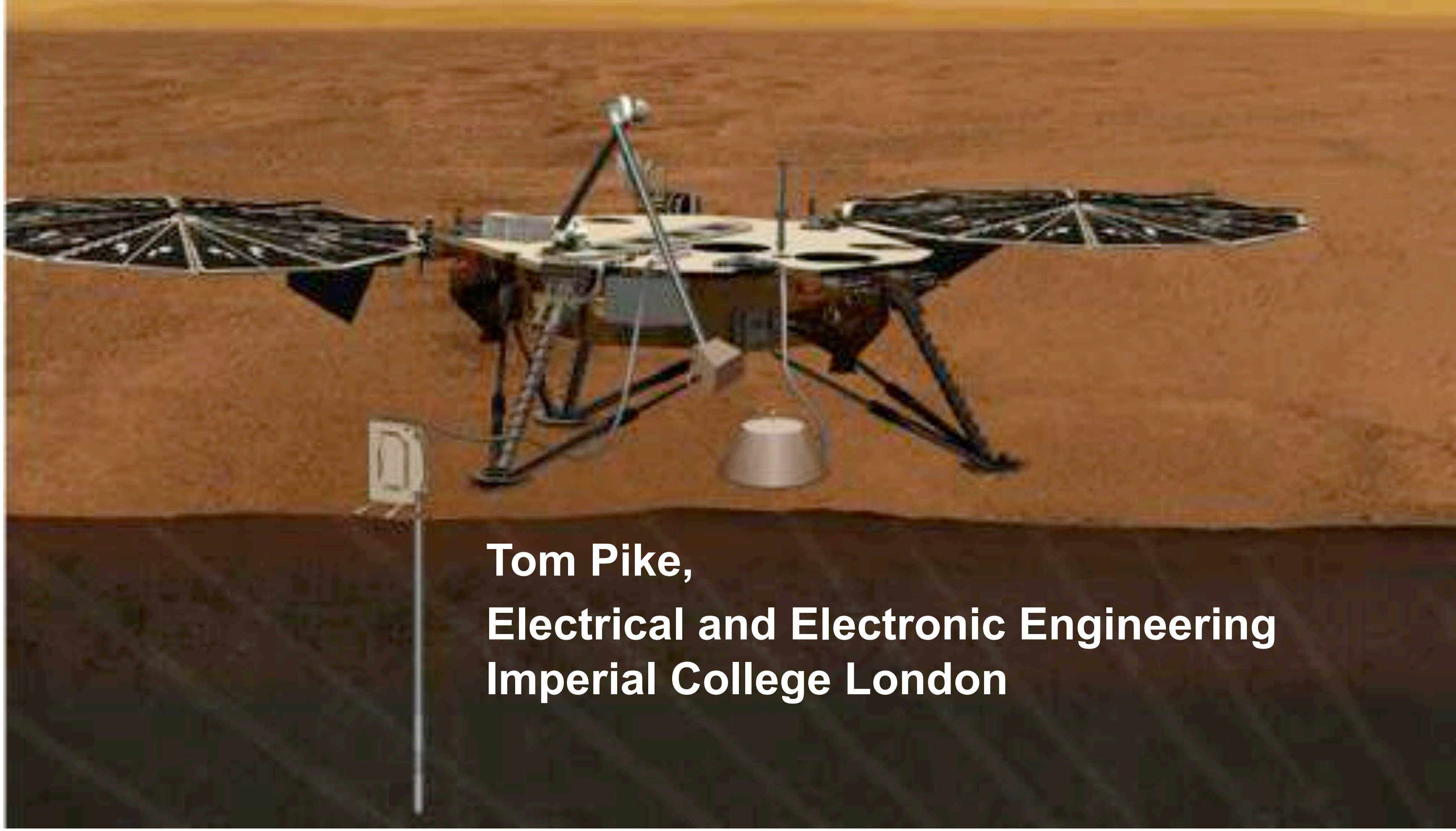
Generation of aurora and of the various current systems which arise







Imperial's contribution to InSight: NASA's 2015 Mission to Mars

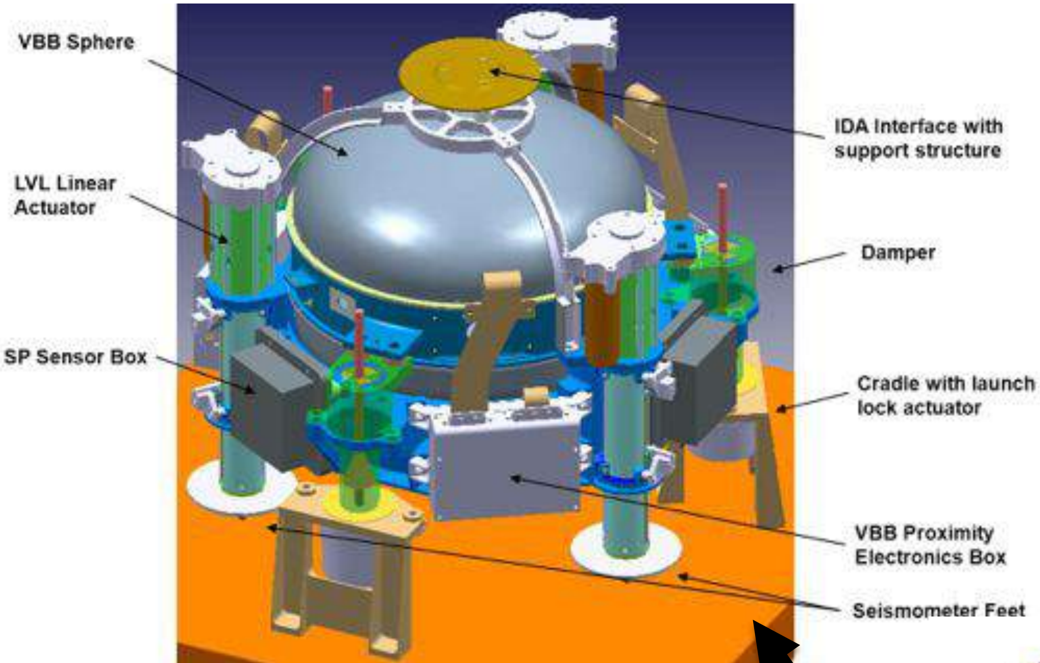


Tom Pike,

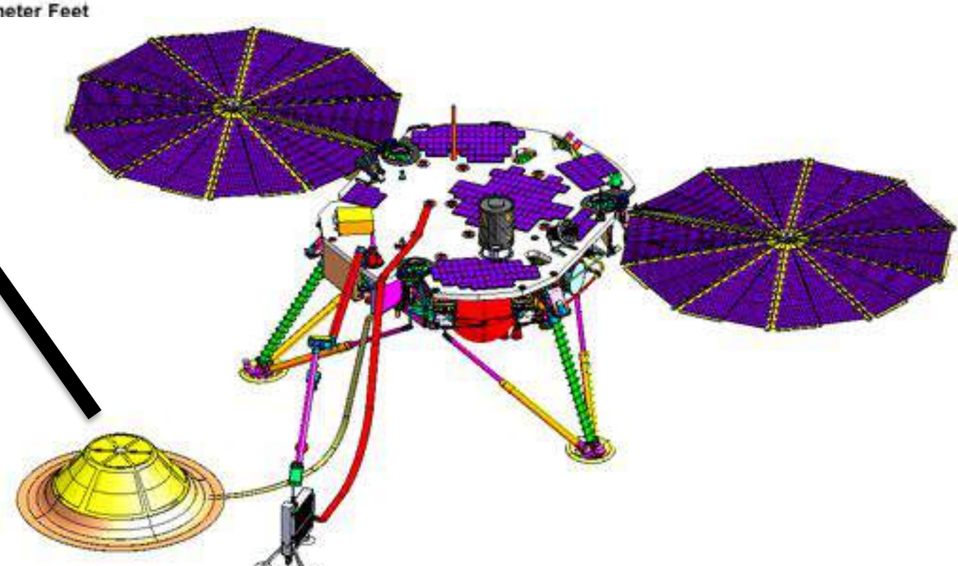
Electrical and Electronic Engineering
Imperial College London

InSight JPL NASA cnes DLR ETH LOCKHEED MARTIN MPS isae Imperial College London IPGP

InSight Mission to Mars



- NASA Discovery Mission with a predominantly European payload
- Launch March 2015
- Land September 2015
- Operate for at least two years
- First determination of the internal structure of another planet



- Major instrumentation: a deployed seismic station
- Includes a large seismometer (VBB) and a three-axis microseismometer (called SP for short period)

InSight

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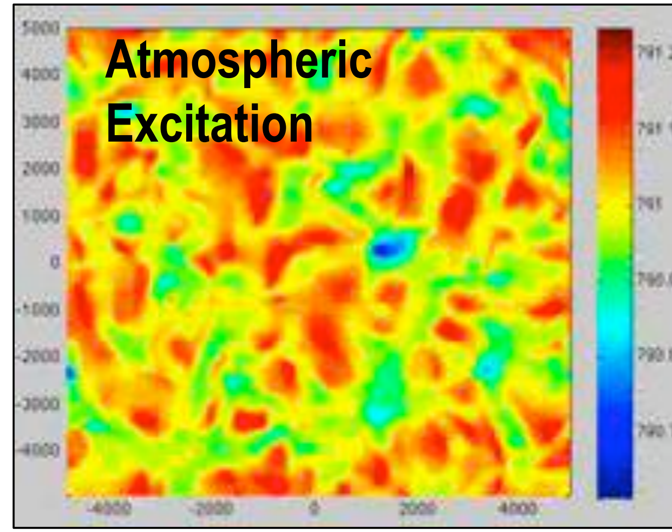
Seismicity on Mars



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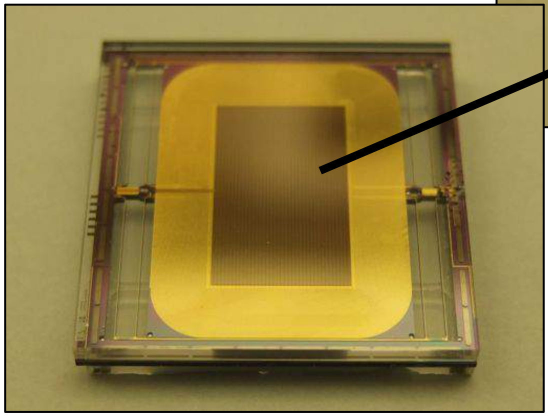
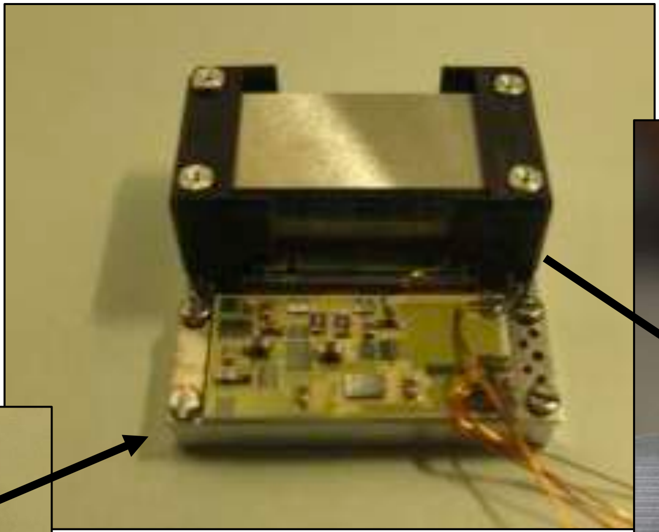
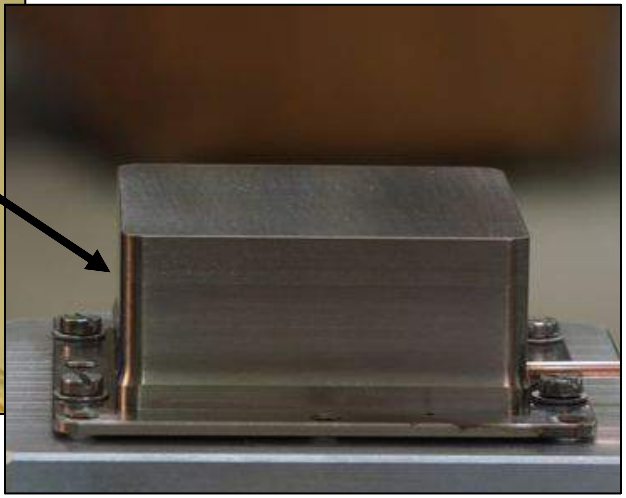
Microseismometer Sensor Head

Three enclosures, x y and z, fabricated at Oxford each contain their proximity electronics and a single-axis micromachined silicon sensor from Imperial







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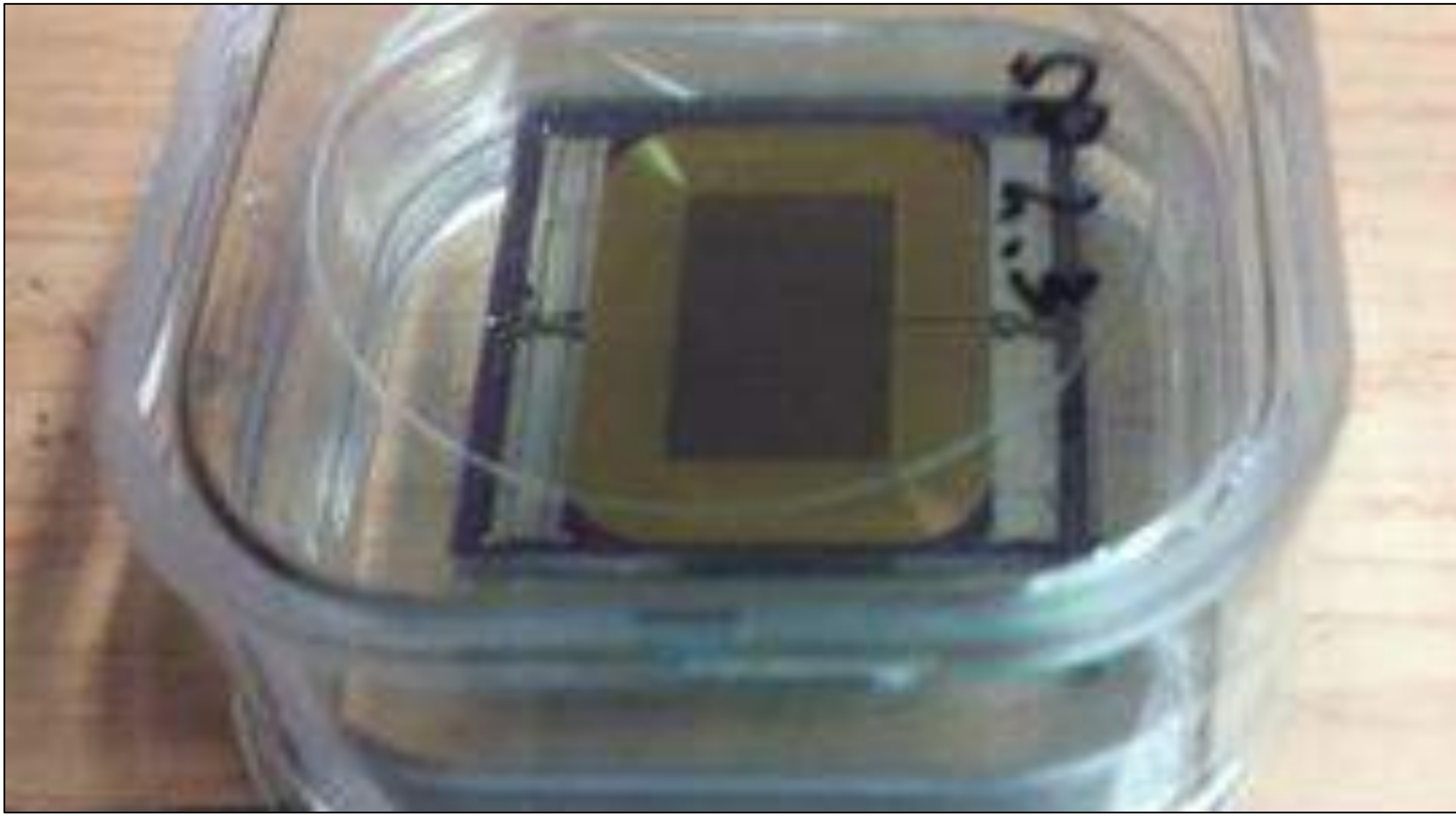
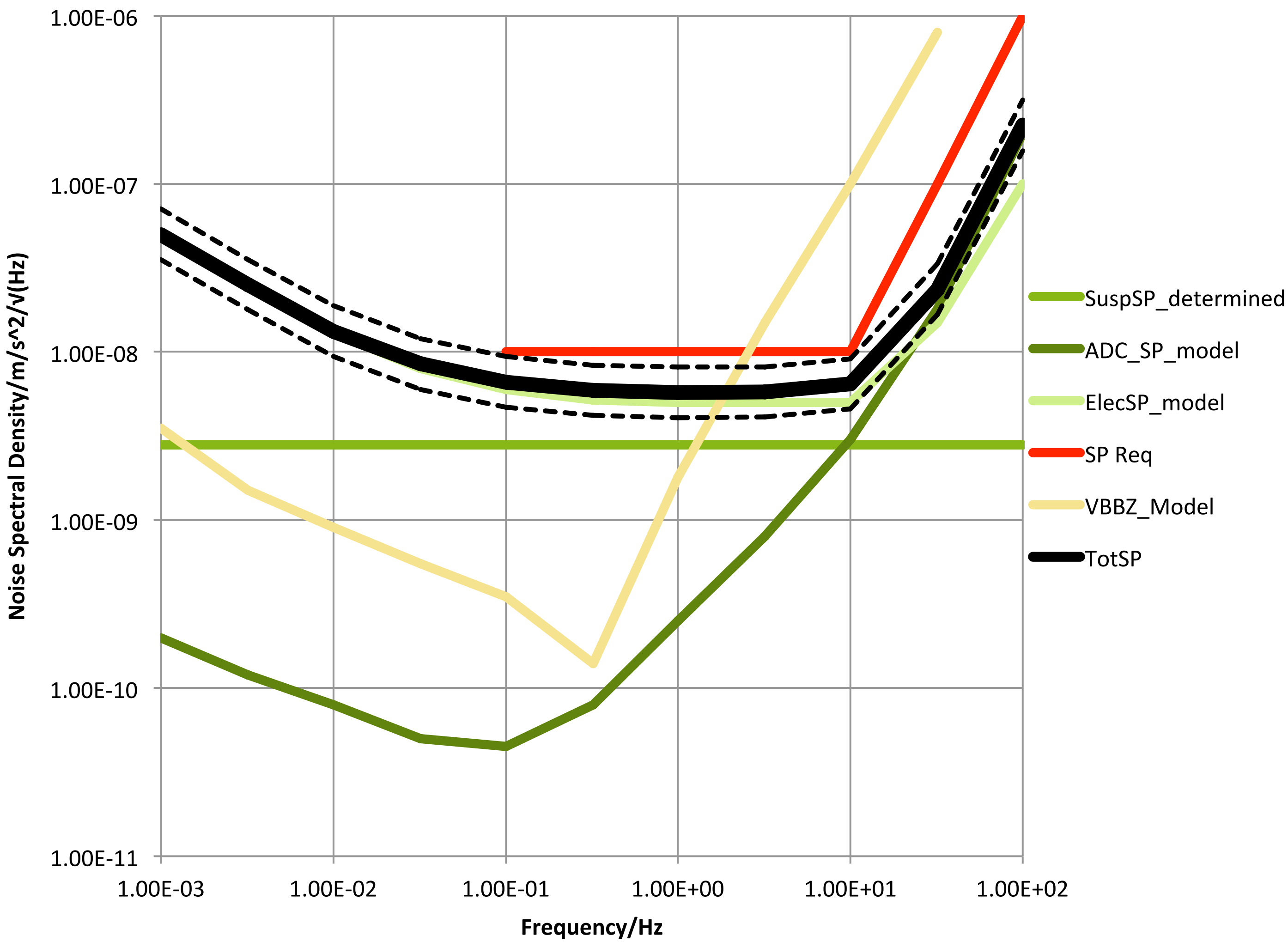
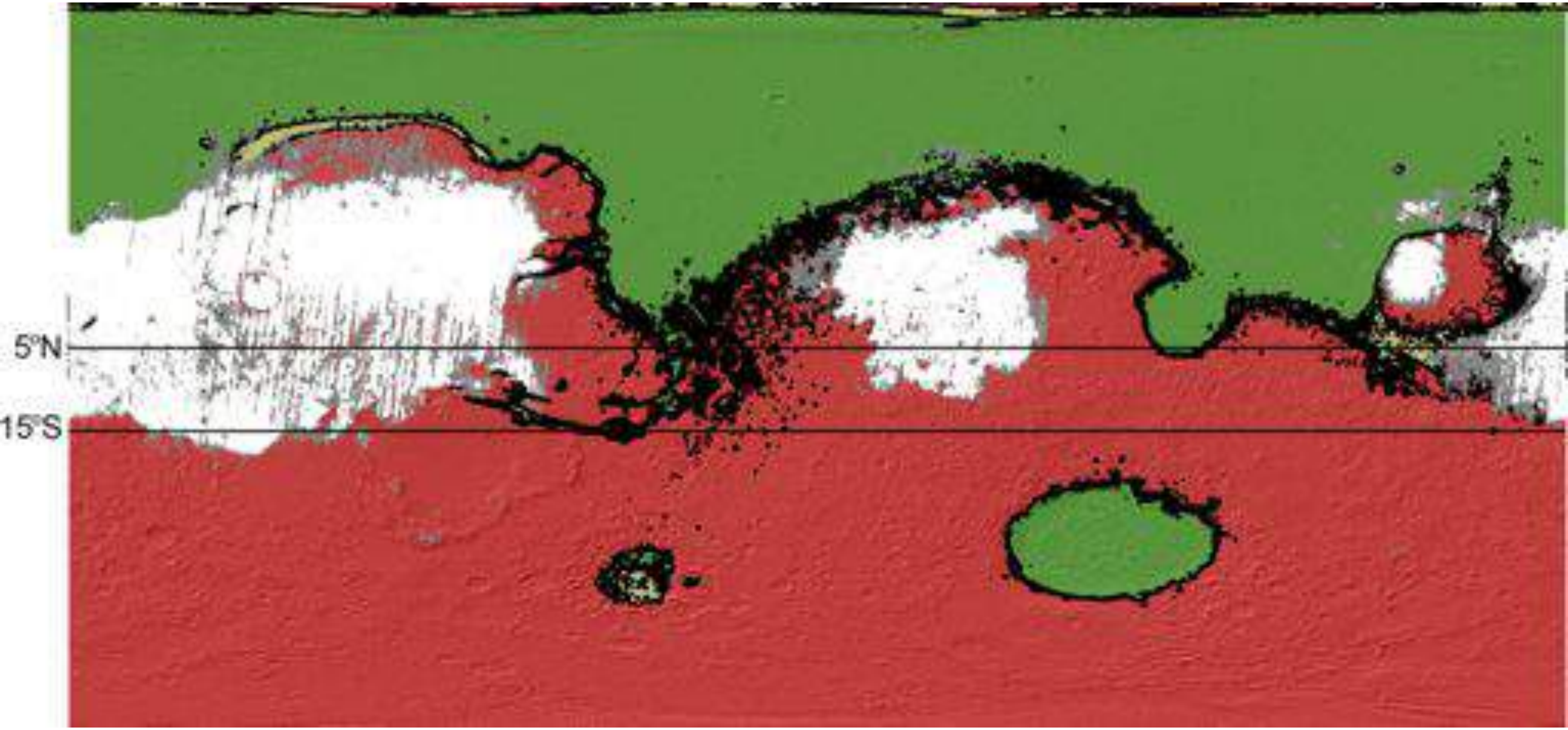
Delivery of first sensor



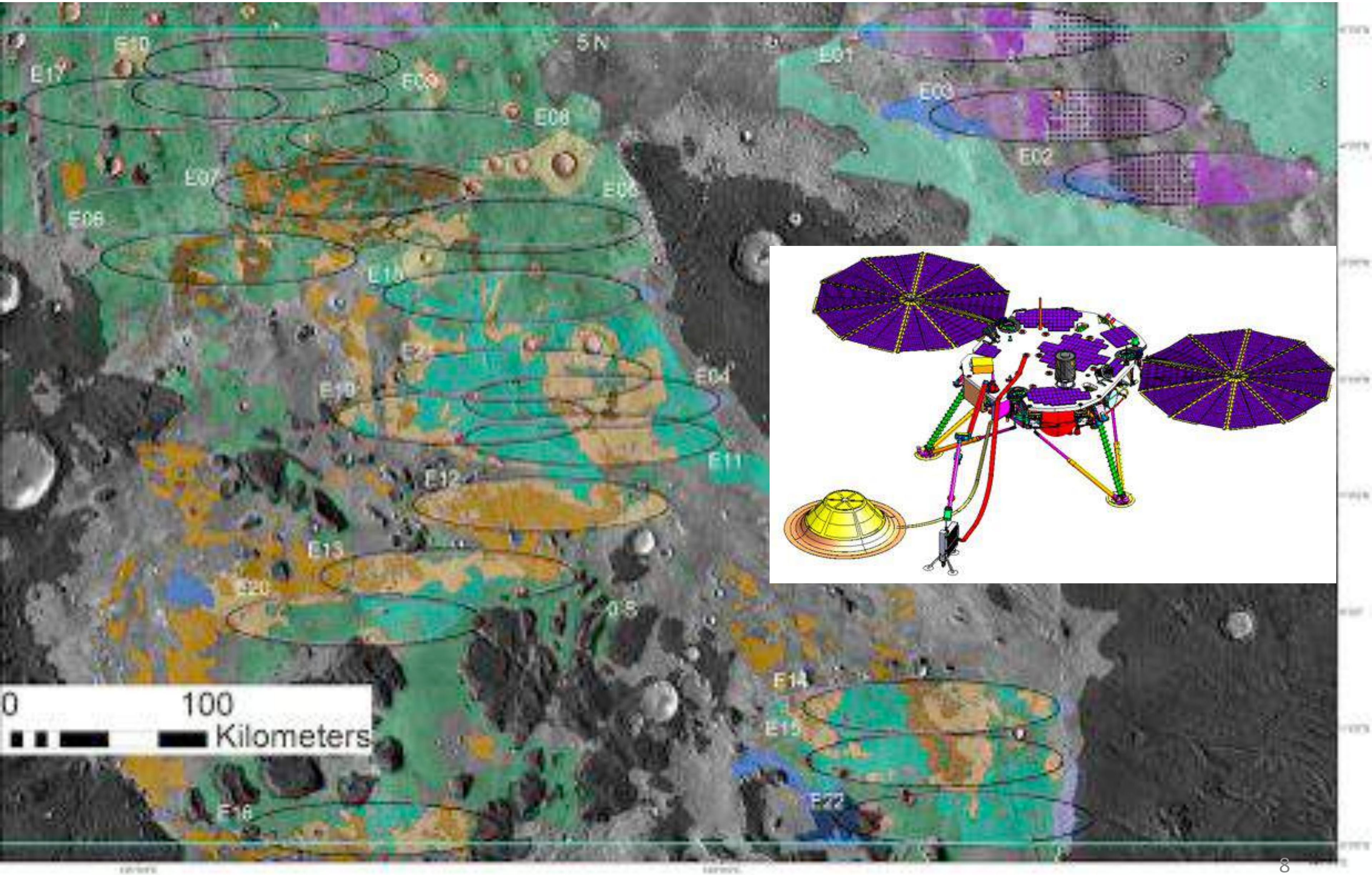
SP noise budget current status



Where to Land



In detail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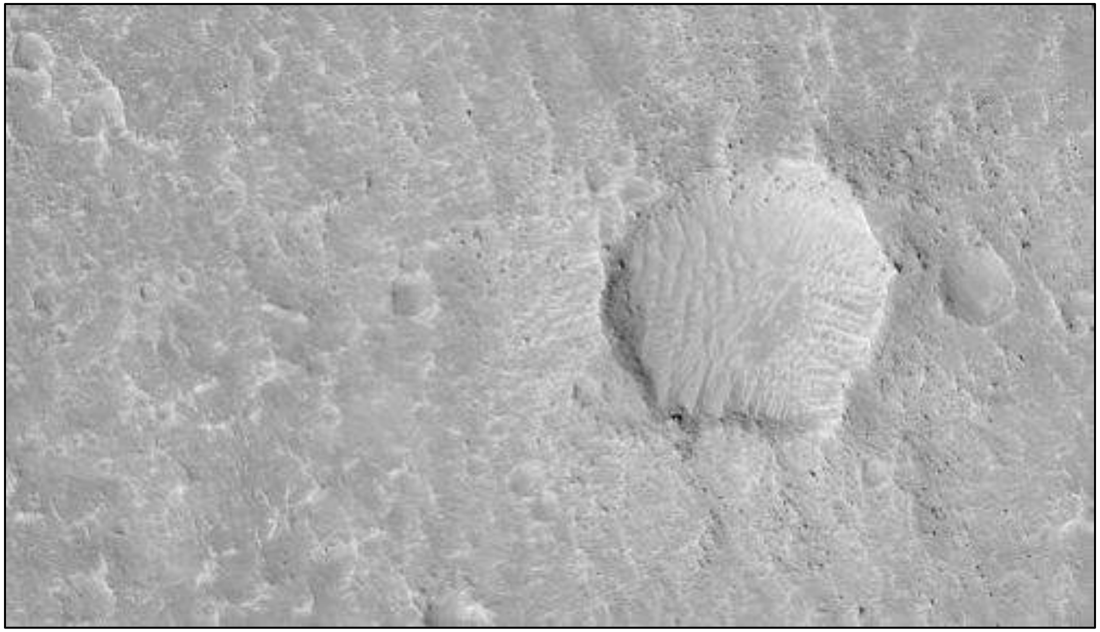
100
Kilometers

Assumptions



- What we've got

What we'd like

Science Operations Center, Tucson

Water Ice identified during Phoenix mission

InSight

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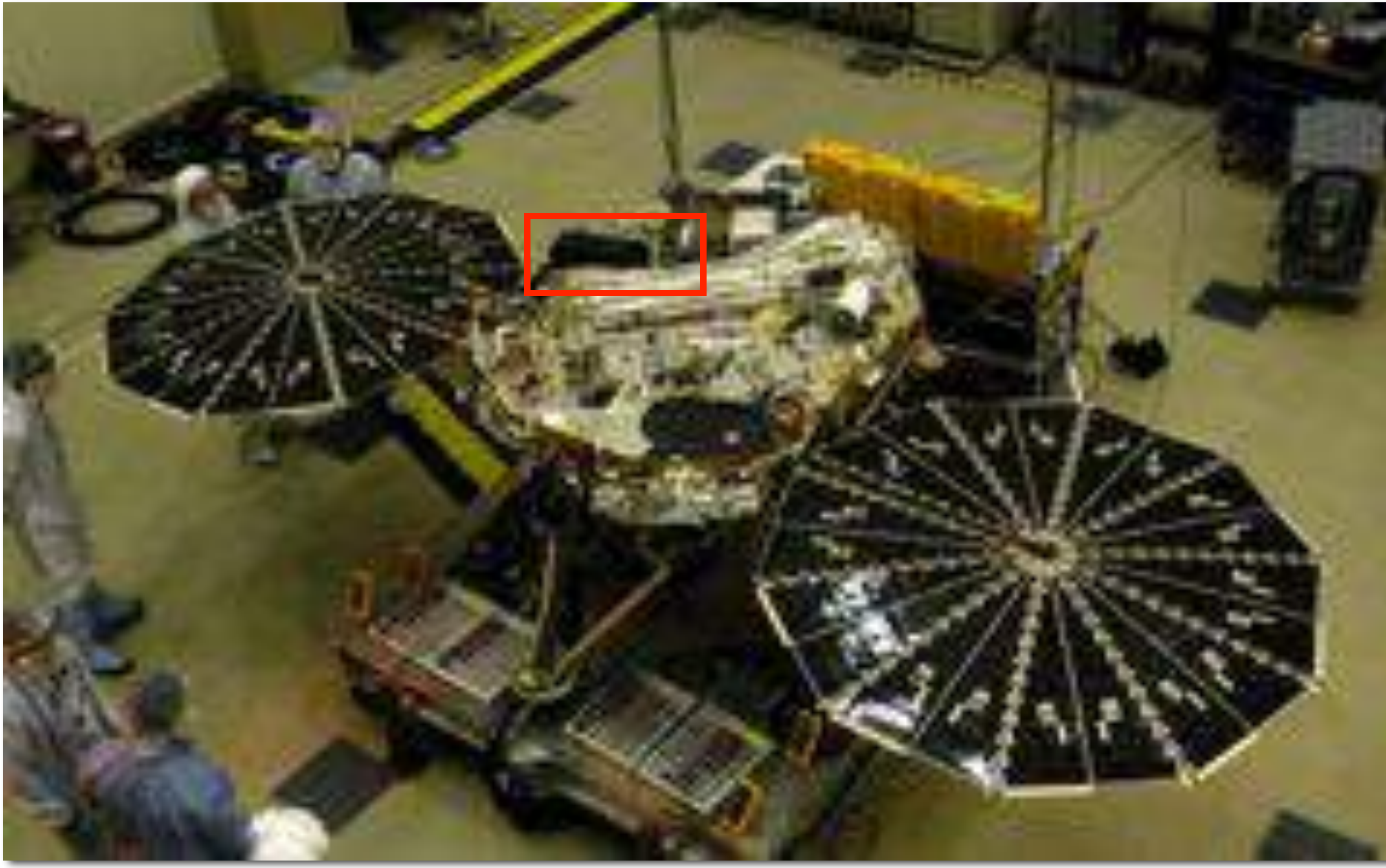
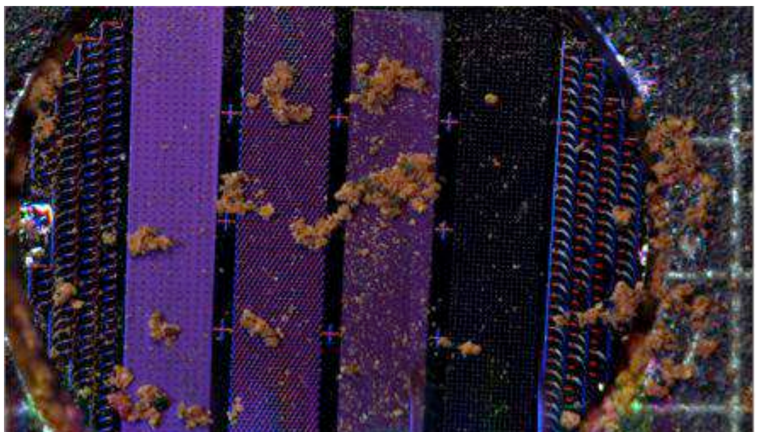
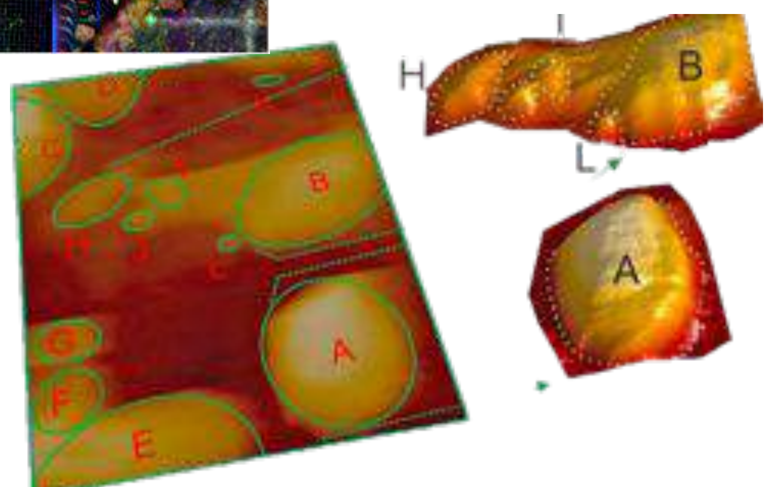
Microscopy Station on Phoenix

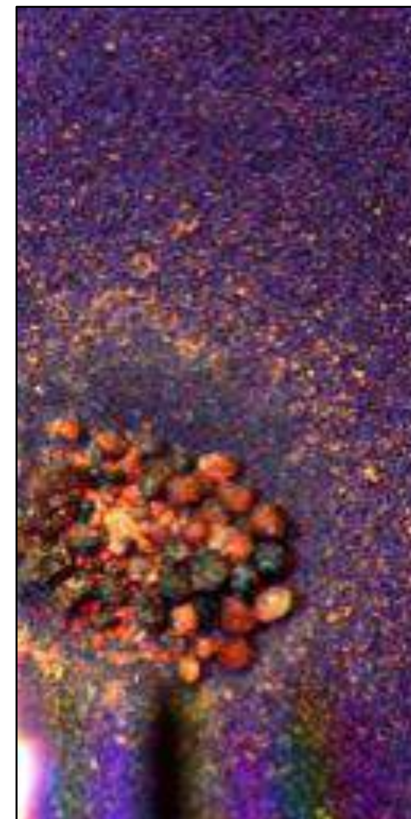


Microscopy data from Phoenix

- In 2008 Imperial provided the only UK hardware to the Phoenix mission
- Helped produce the first microscope data from Mars, down to 100nm resolution

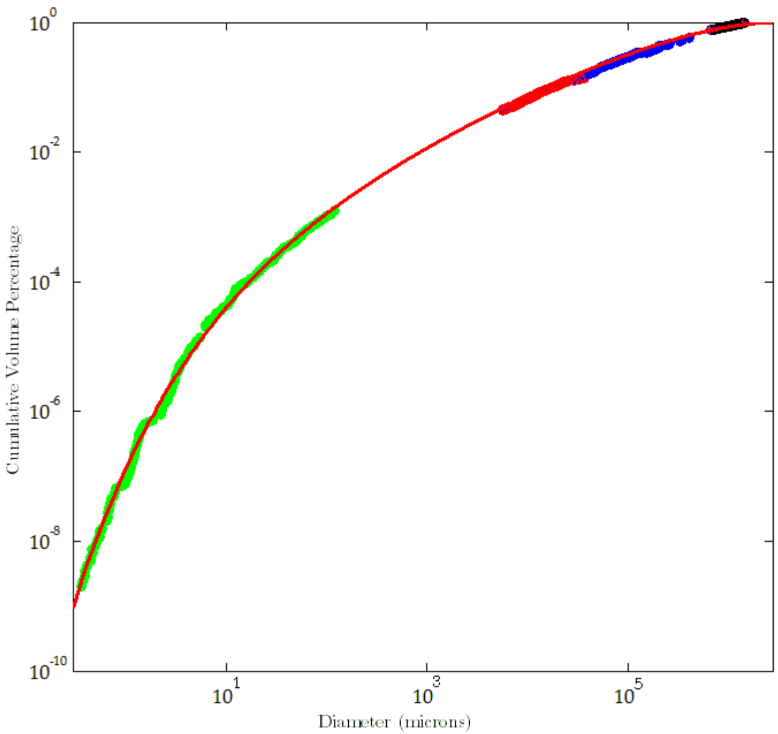




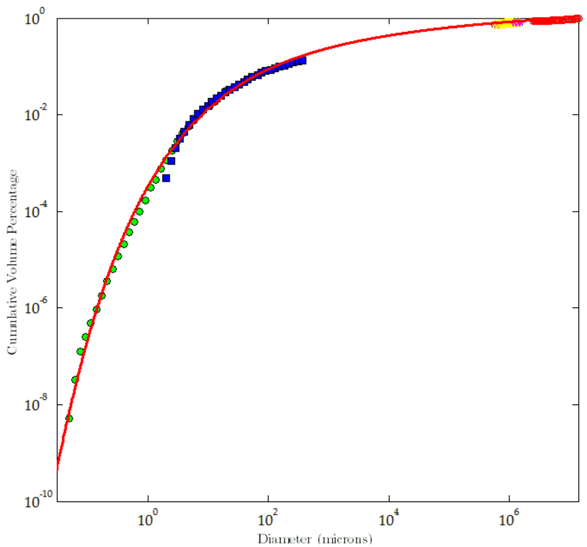


Modelling our data

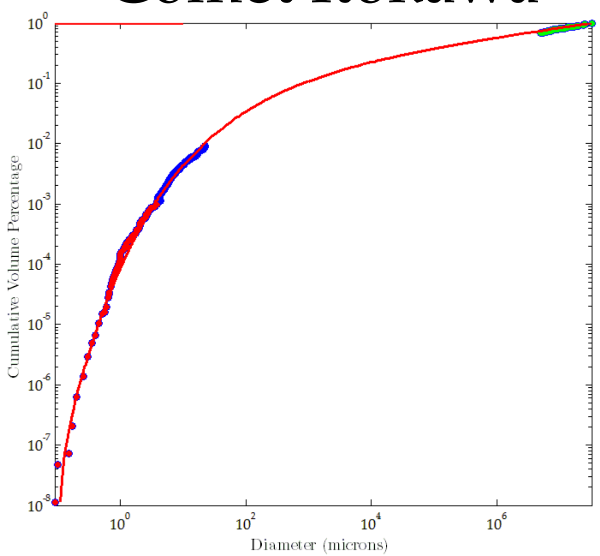
- We've developed a model from fragmentation theory to explain the particle size distributions we see
  - Mars



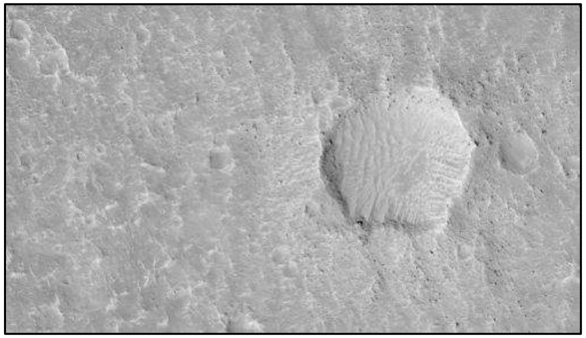
- The Moon

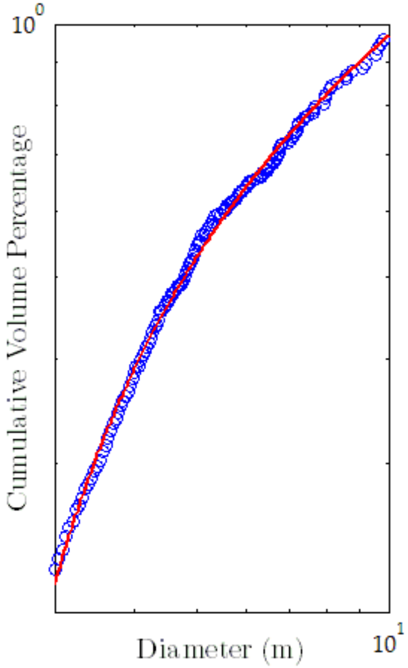


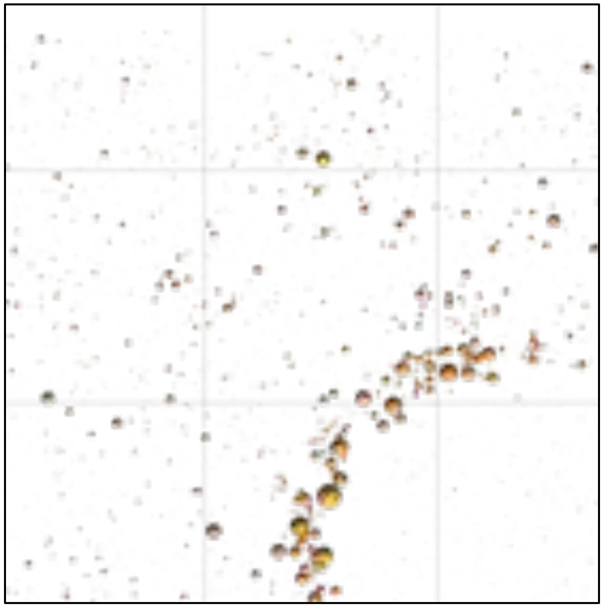
- Comet Itokawa



Extending from HiRISE



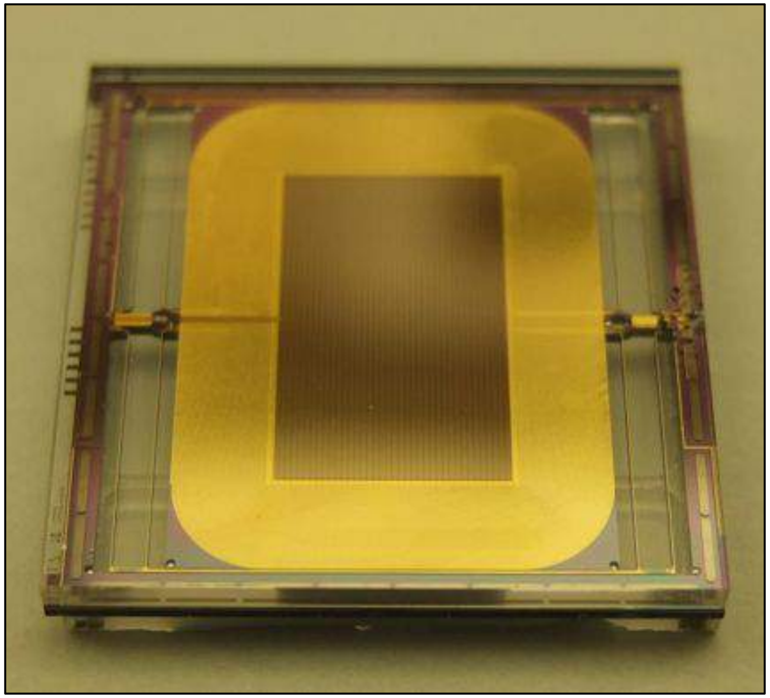


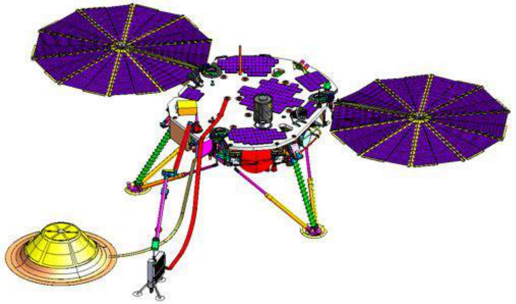


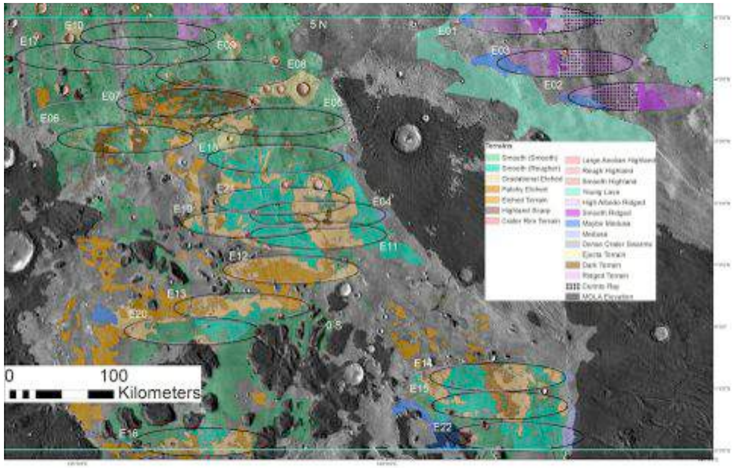
- Look below the resolution of HiRISE

Conclusions

- We have demonstrated a robust micromachined seismometer capable of surviving thousand of g's shock and reaching a sensitivity below 1 ng/√(Hz) for InSight in 2015
- We're using data and modelling from our 2008 Phoenix to select just where to land







Thanks

- The Imperial Team:
  - Aifric Delahunty, Gunagbin Dou, Anisha Mukherjee, Constantinos Charalambous
- The Oxford Team
  - Simon Calcutt, Neil Bowles, Paul Coe, Jon Temple
- Kinemetrics, Inc.
  - Ian Standley
- JPL
  - Matt Golombek: landing site selection
  - Bruce Banerdt: PI (thanks for the rocket!)
- UK Space Agency
  - For the supporting our participation in Phoenix and InSight

Imperial College London

Earth Observation Activities at Imperial

Dr Helen Brindley, Space and Atmospheric Physics

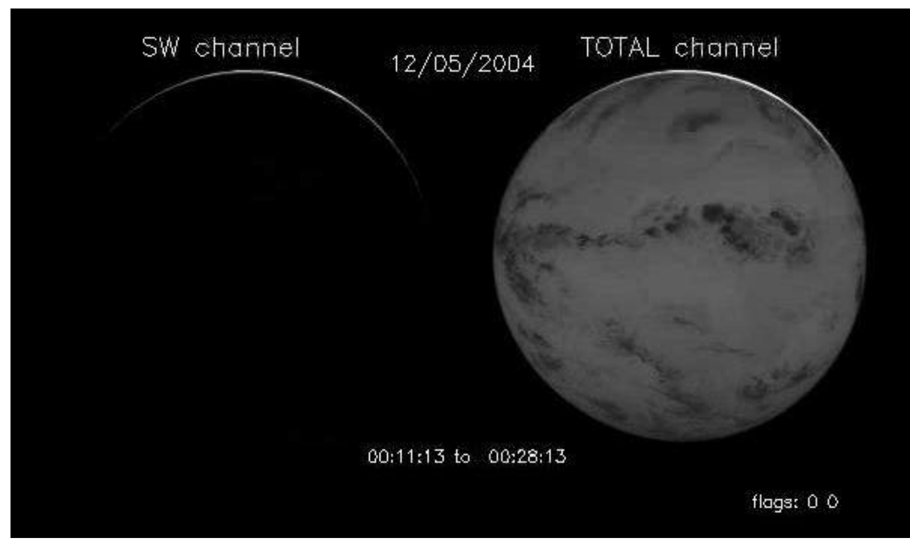
(with contributions from Professor Jo Haigh, Dr Apostolos Voulgarakis, Dr Jacqueline Russell, Dr William Ball, Dr Christopher Dancel, Professor Colin Prentice, Dr Jian-Guo Liu, Professor Cedo Maksimovic, Dr Li-Pen Wang, Susana Ochoa Rodríguez, Dr Ned Ekins-Daukes, Alvin Chan and Stefan Pfenninger)

J. Russell and H. Brindley

EO for climate applications

(i) Observing the variability in the Earth's outgoing energy at high time resolution from the Geostationary Earth Radiation Budget instrument (GERB): the world's only ERB instrument in geostationary orbit…

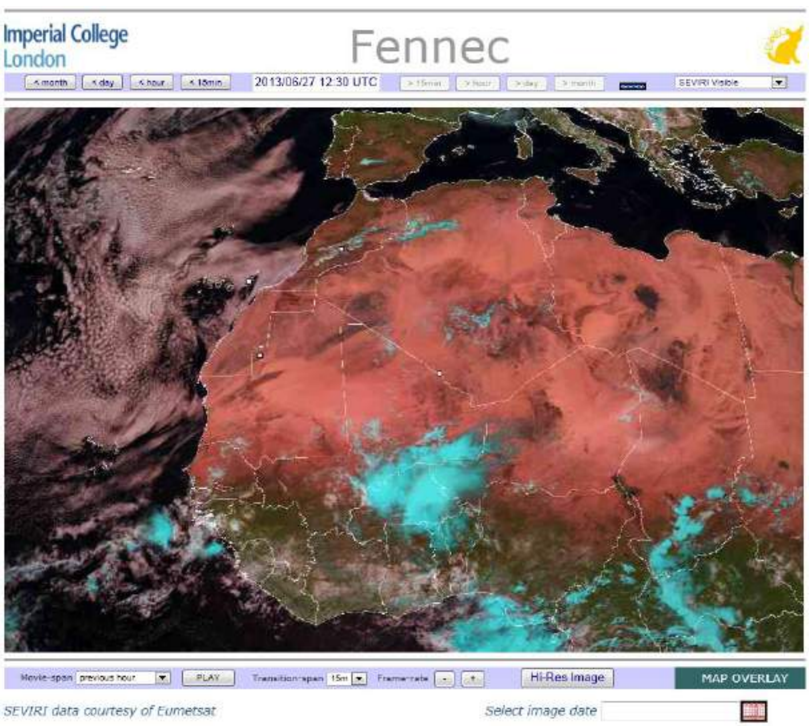
Earth Observation Calibration Facility

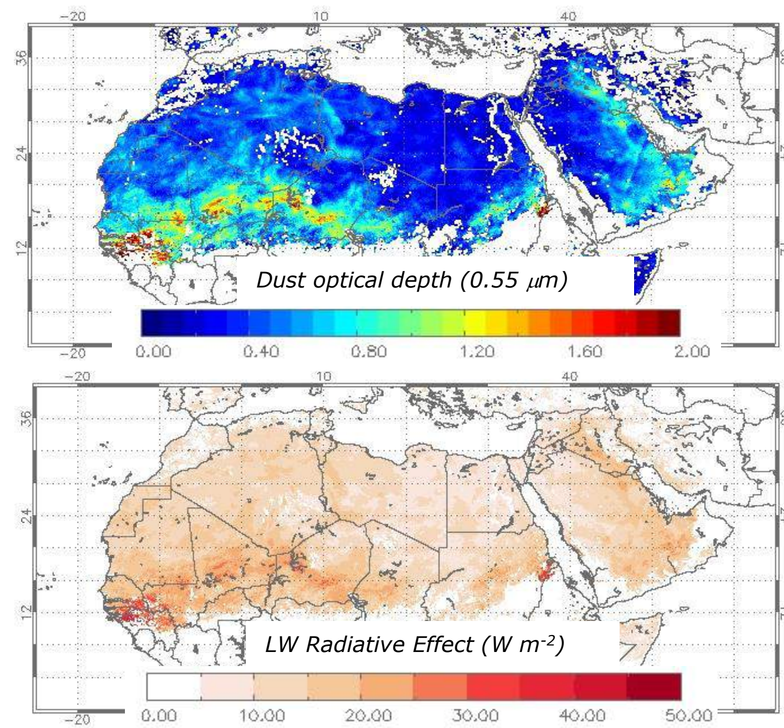


One day of Level 1.5 GERB data

EO for climate applications

(i) … and using co-located observations from the SEVIRI narrow-band radiometer to diagnose the atmospheric parameters causing the variability seen.





http://www.fennec.imperial.ac.uk/

Imperial College London

H. Brindley and C. Dancel

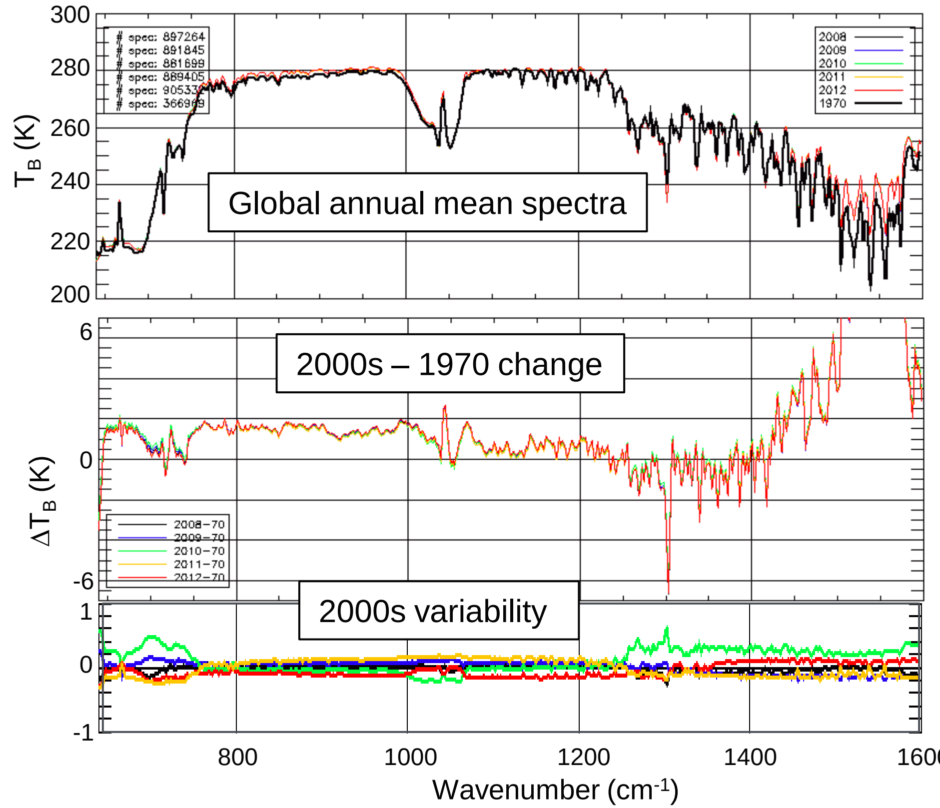
Space and Atmospheric Physics

EO for climate applications

(ii) Investigating drivers of climate variability and change: Spectral signatures

Instrument	IRIS	IMG	AIRS	IASI
Satellite	Nimbus 4	ADEOS	AQUA	METOP-A
Spectro-meter type	FTS	FTS	grating spectrometer	FTS
Data available	Apr 1970 – Jan 1971	Oct 1996 – Jun 1997	2002 - present	2007 - present
Spectral coverage (cm^{-1})	400 – 1600 cm^{-1} continuous	715 – 3030 cm^{-1} 3 bands	650 – 2700 cm^{-1} 2378 bands	645 – 2760 cm^{-1} 3 bands
Spectral resolution	2.8 cm^{-1}	0.1 cm^{-1}	0.4–1.0 cm^{-1}	0.5 cm^{-1}
Footprint (nadir)	95 km diameter	8km x 8km	13 km diameter	12 km diameter

In support of CLARREO and TRUTHS

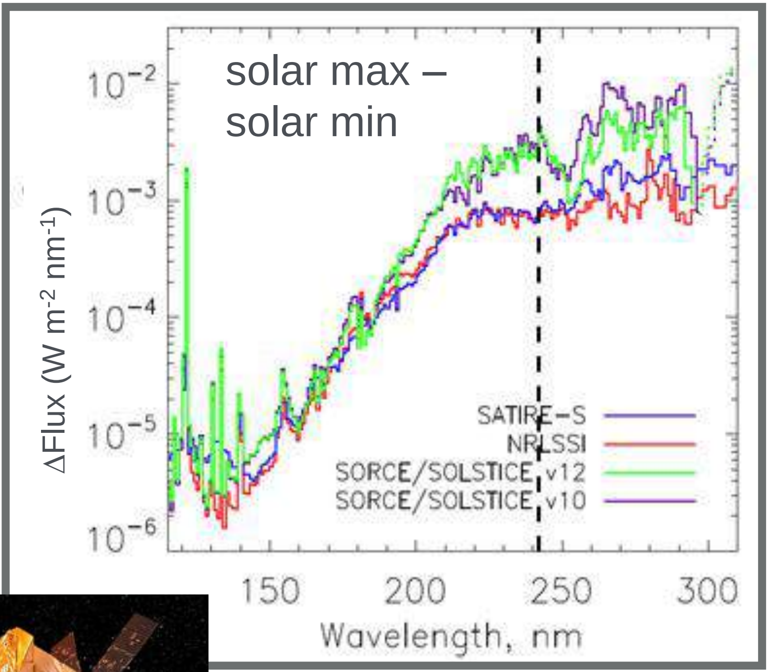


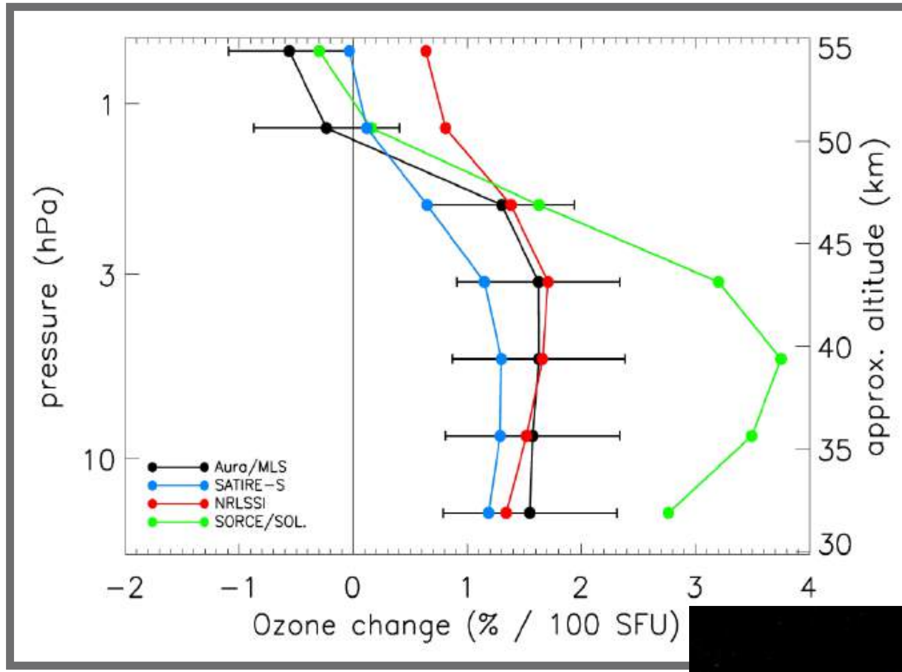
J. Haigh and W. Ball

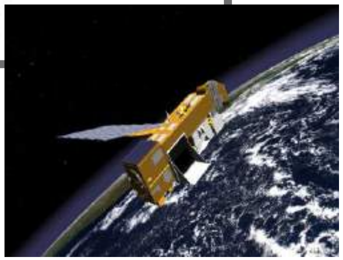
Space and Atmospheric Physics and Astrophysics

EO for climate applications

(ii) Investigating drivers of climate variability and change: Solar activity and ozone

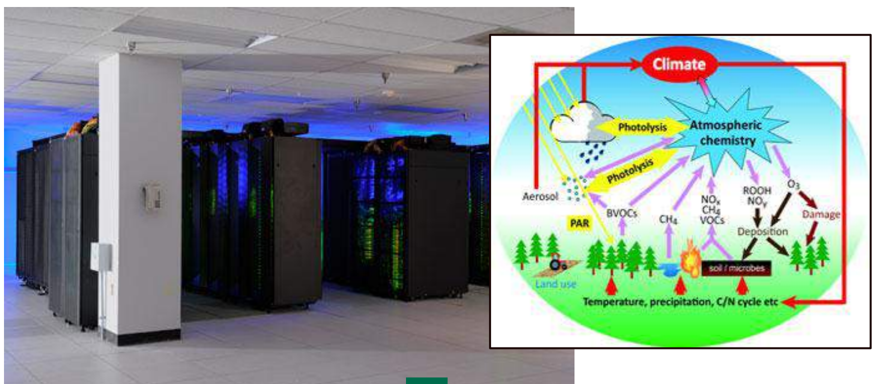




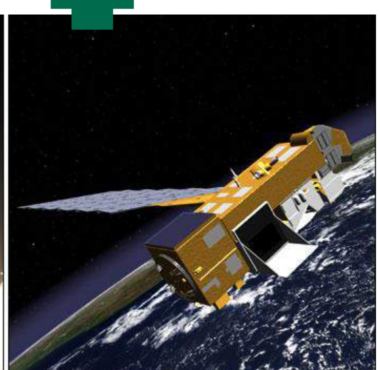


EO for climate applications

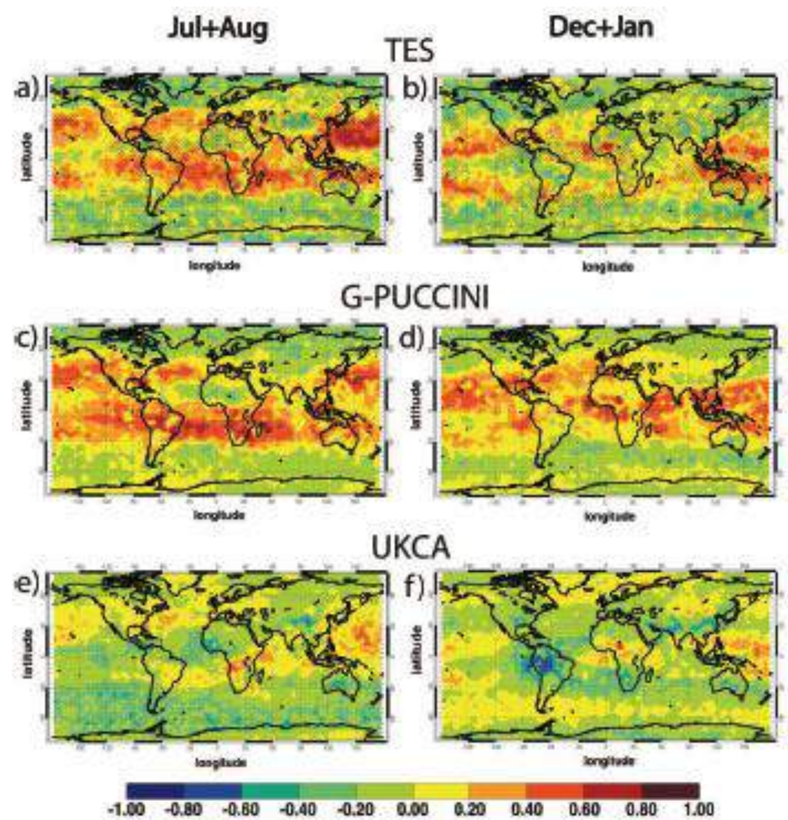
(iii) Improving our understanding of Earth System processes



Boeing Delta II Rocket



Artist's rendering of Aura in Orbit



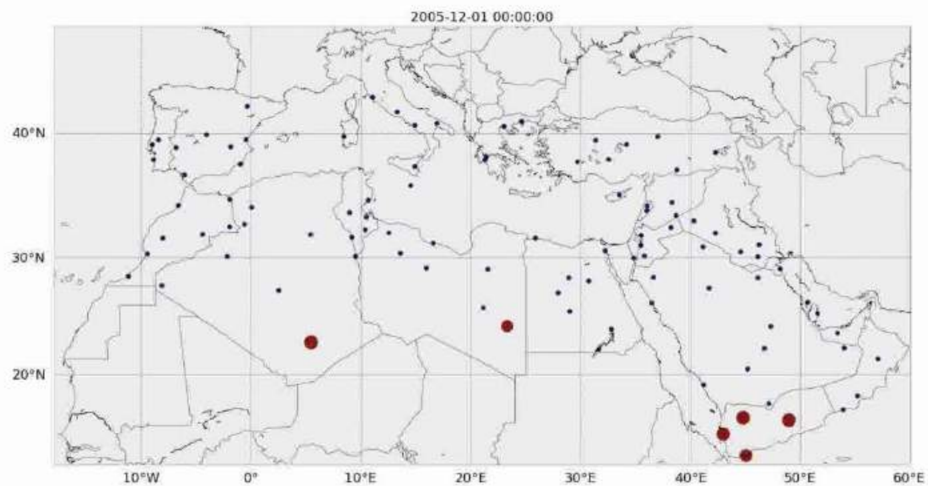
Imperial College London

S. Pfenninger, A. Chan,
N. Ekins-Daukes and H. Brindley

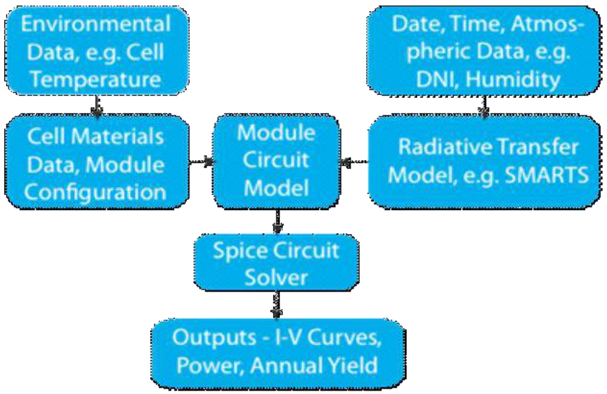
Civil and Environmental Engineering, Experimental Solid State Physics and Space and Atmospheric Physics

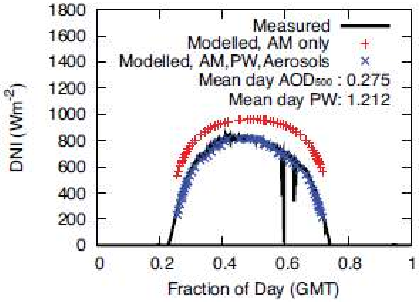
EO for green technology

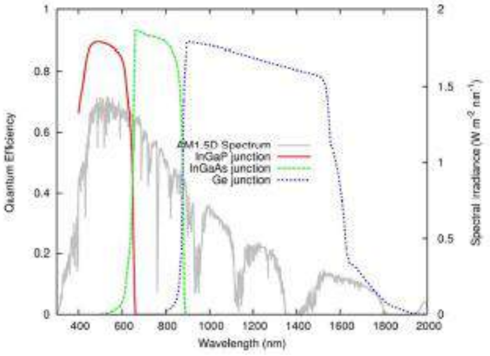
Using EO products to assess likely energy yield and to optimise solar cell design



Simulated output from CSP + thermal storage plants through one day in 2005







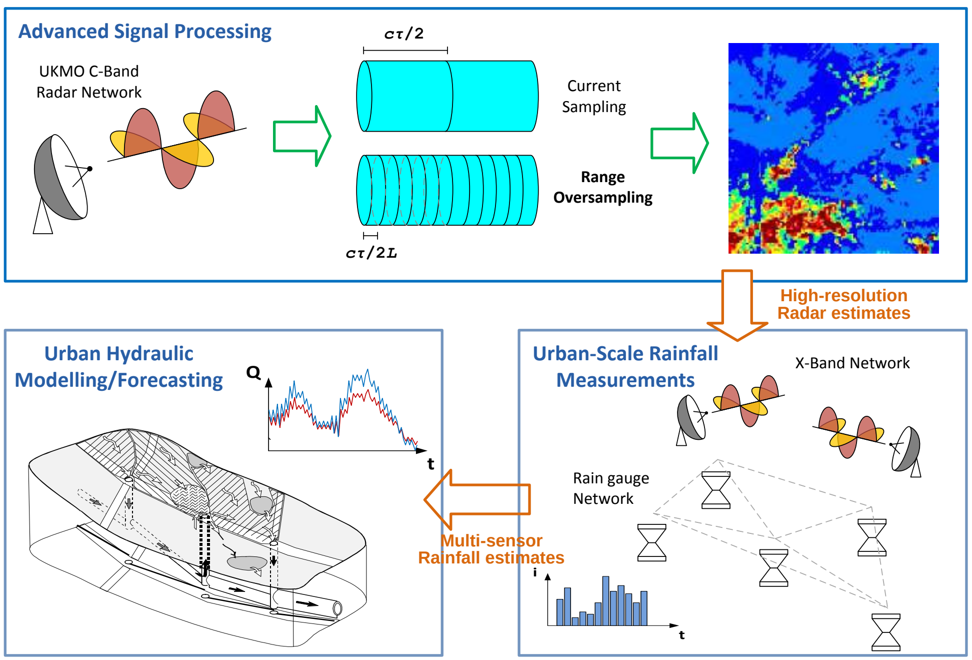
Imperial College London

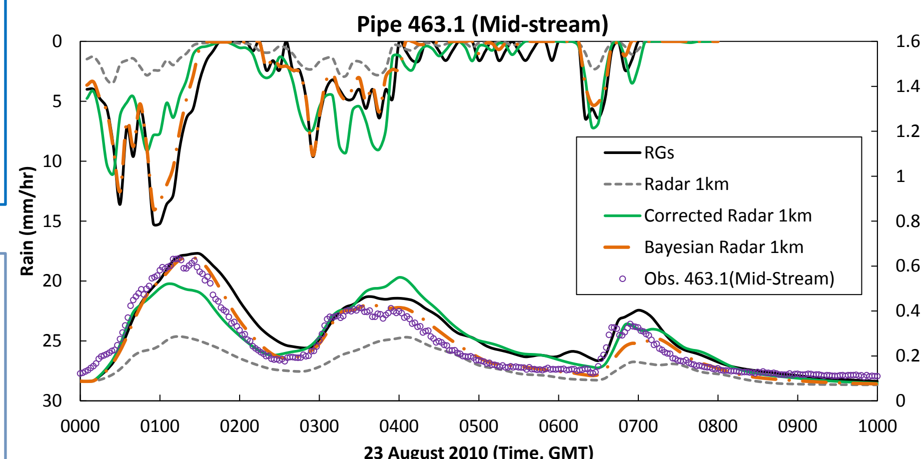
C. Maksimovic, L. Wang,
S. Ochoa Rodríguez

Civil and Environmental Engineering

EO for Water Resource Management (Urban Water Resources Group)

Improving operational radar rainfall estimates for use in urban hydrology (e.g. storm-water drainage modelling, surface water flood prediction etc.)

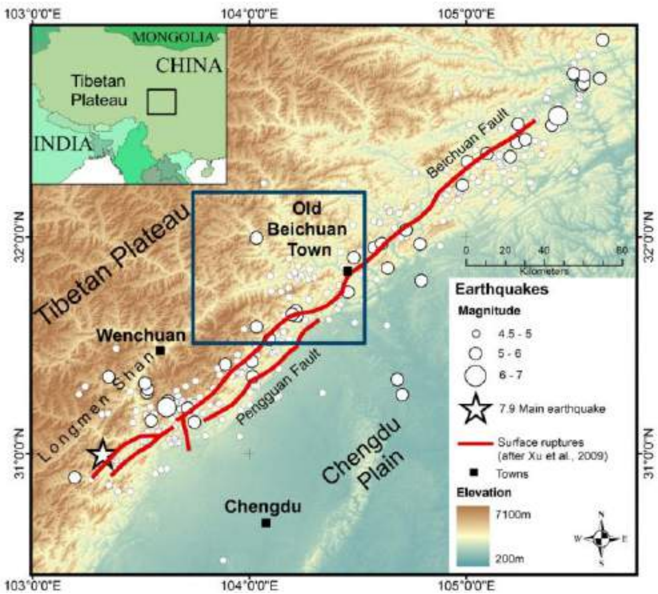




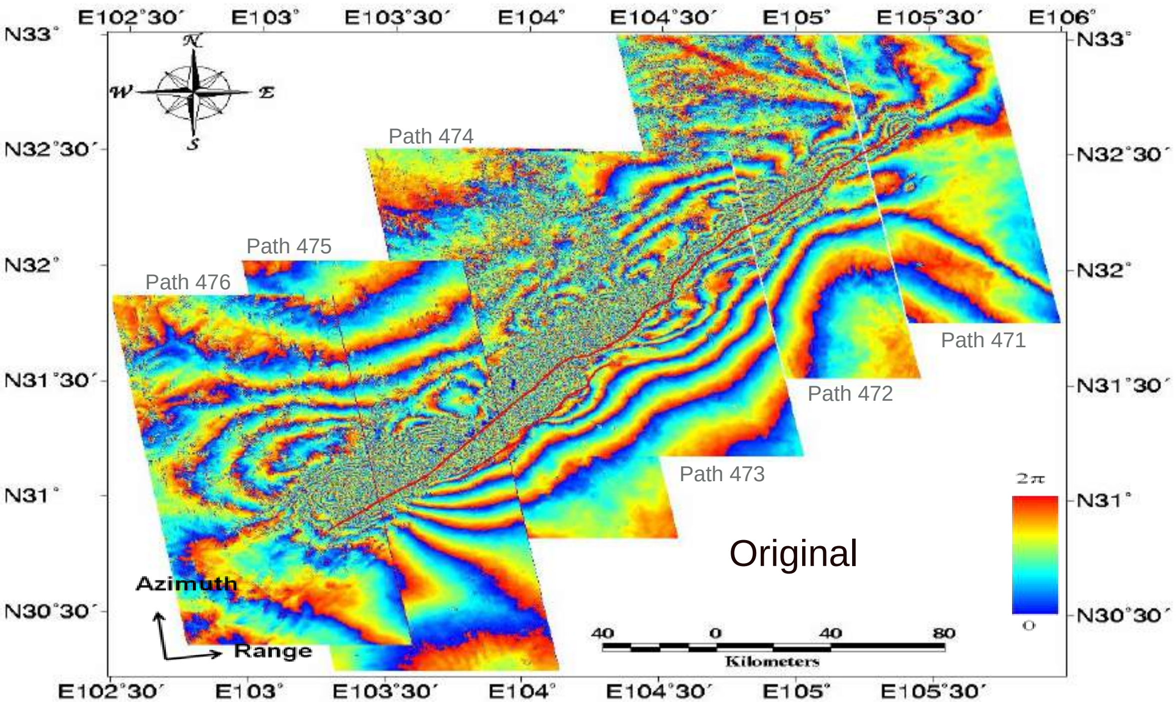
Methodology can also incorporate satellite radar observations

EO for geohazard assessment

Improving the information content of DInSAR imagery within earthquake fault zones



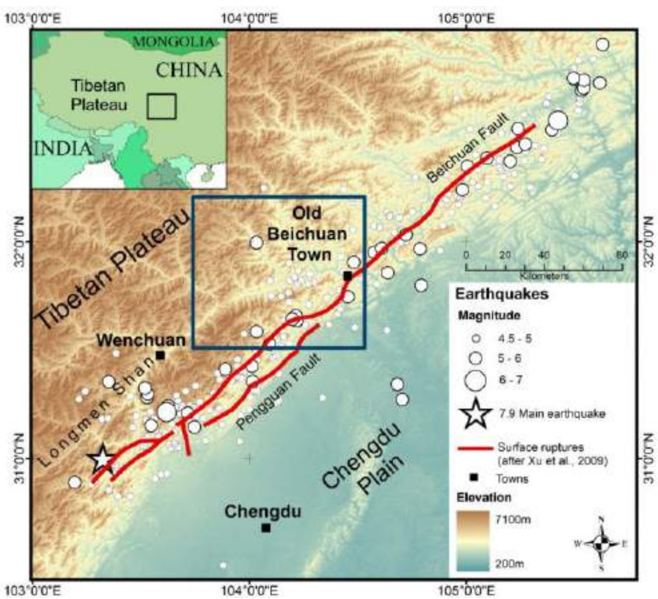
Wenchuan earthquake, Sichuan Province, China (12th May 2008)



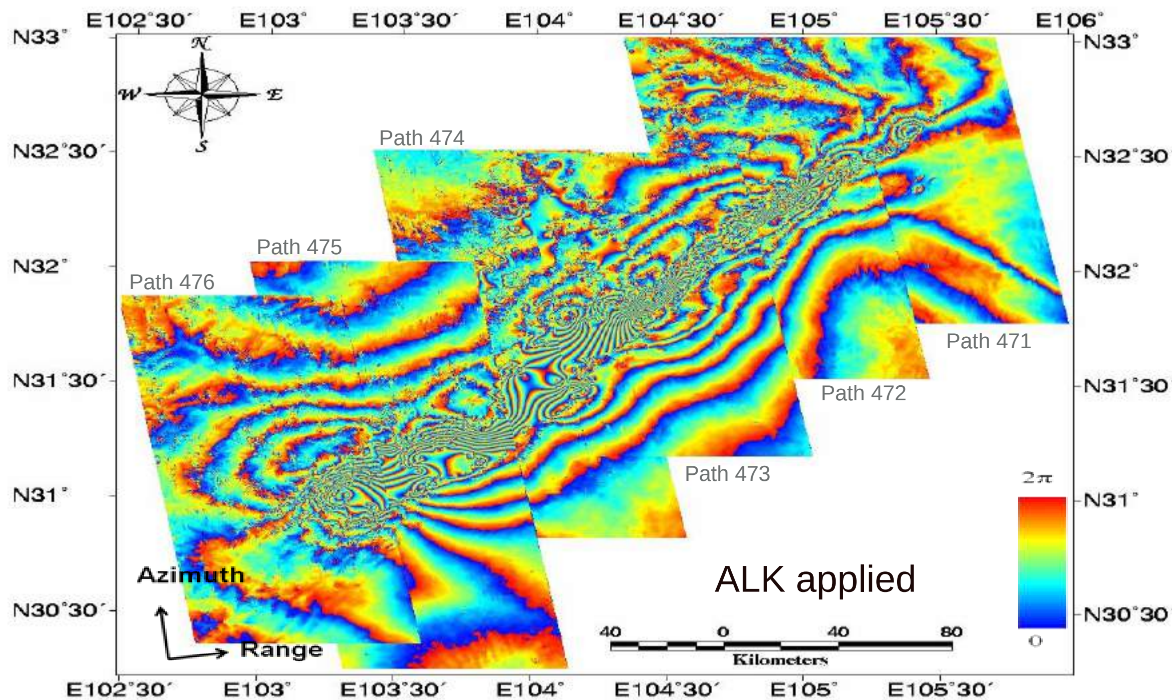
Earth Science and Engineering

EO for geohazard assessment

Improving the information content of DInSAR imagery within earthquake fault zones



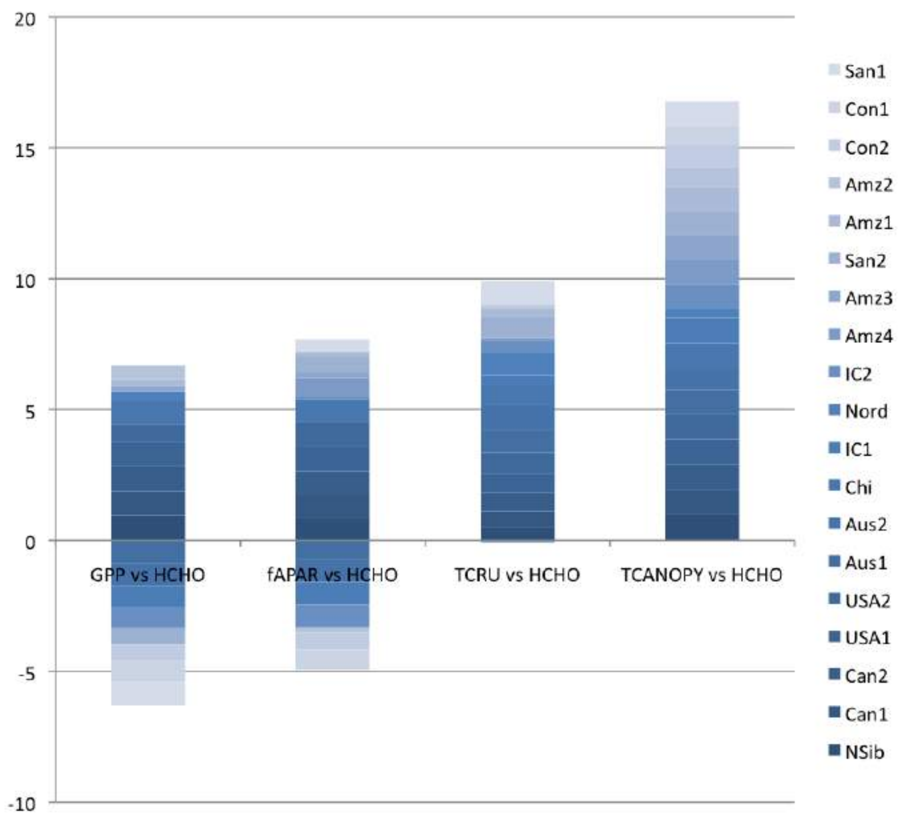
Wenchuan earthquake, Sichuan Province, China (12th May 2008)



Ecology and Evolution

EO for understanding and modelling of the terrestrial biosphere

Using satellite products to investigate controls on emissions of biological volatile compounds



Stacked correlation between seasonal variation in remotely sensed column formaldehyde (HCHO) and selected vegetation parameters at selected worldwide locations

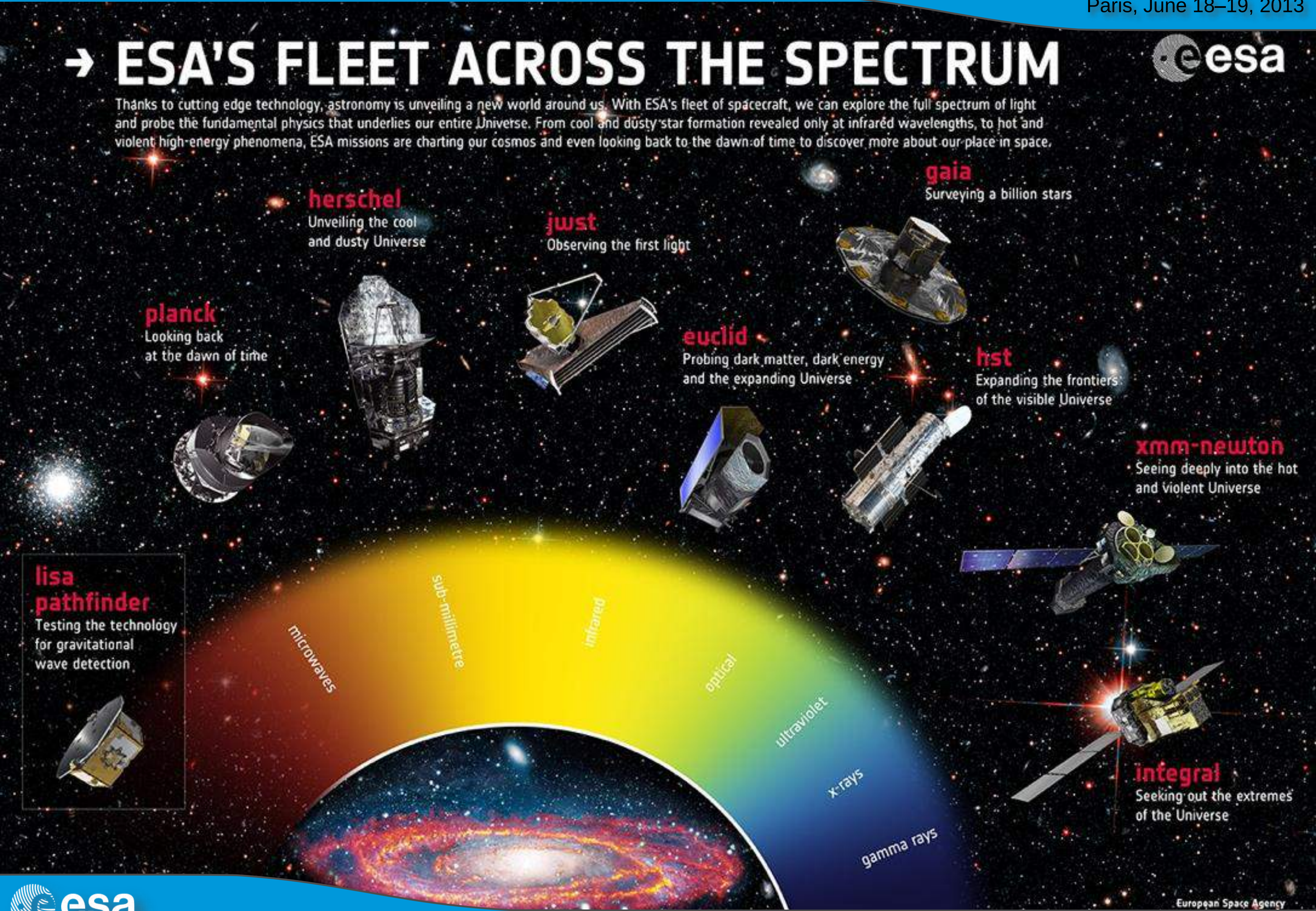
Some highlights of 2013…

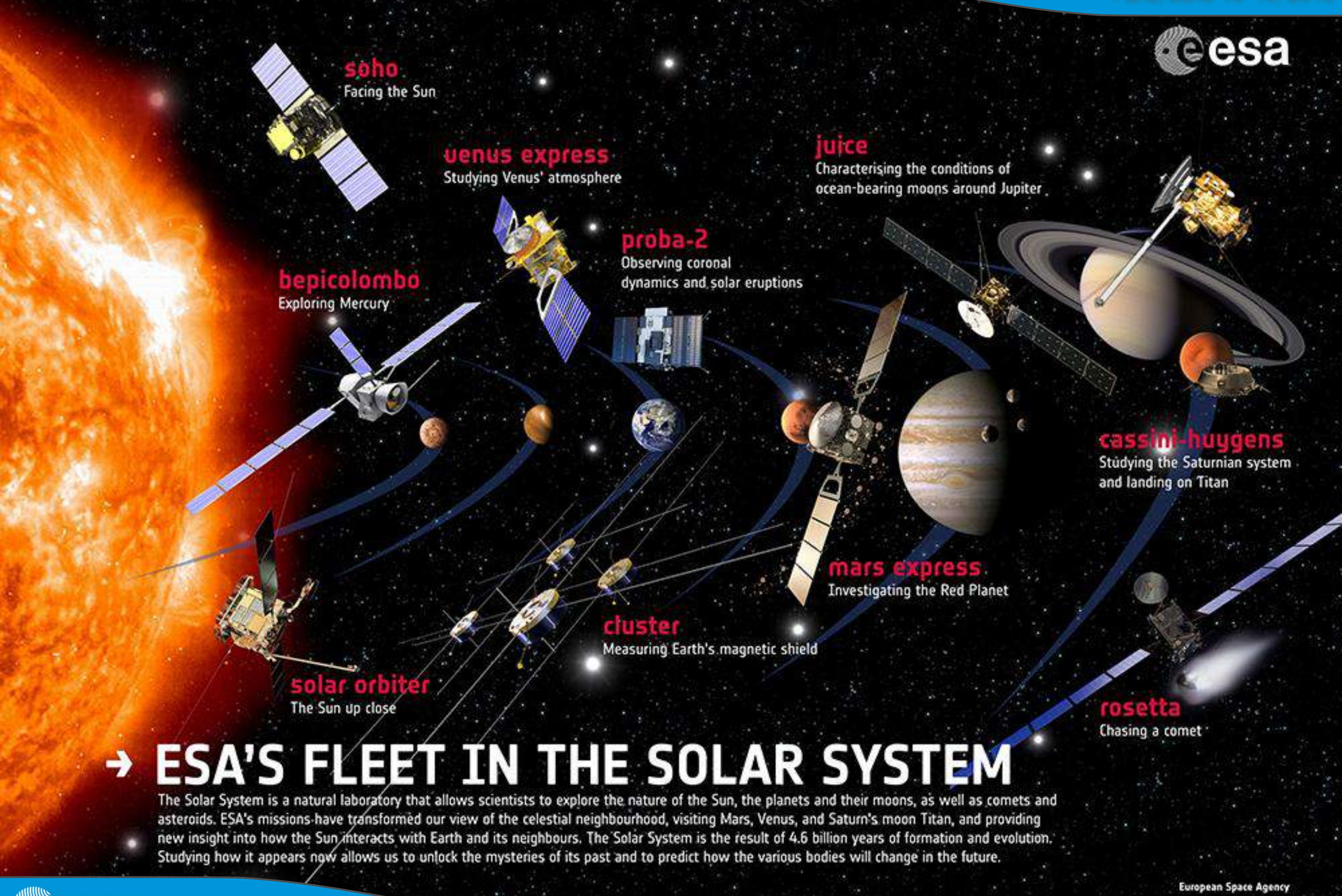
and beyond

M. Vaissiere

Head of ESA-ECSAT

Director Telecommunication and Integrated Applications


→ ESA'S FLEET ACROSS THE SPECTRUM
esa
Thanks to cutting edge technology, astronomy is unveiling a new world around us. With ESA's fleet of spacecraft, we can explore the full spectrum of light and probe the fundamental physics that underlies our entire Universe. From cool and dusty star formation revealed only at infrared wavelengths, to hot and violent high-energy phenomena, ESA missions are charting our cosmos and even looking back to the dawn of time to discover more about our place in space.
gaia
Surveying a billion stars
herschel
Unveiling the cool and dusty Universe
jwst
Observing the first light
planck
Looking back at the dawn of time
euclid
Probing dark matter, dark energy and the expanding Universe
hst
Expanding the frontiers of the visible Universe
xmm-newton
Seeing deeply into the hot and violent Universe
lisa pathfinder
Testing the technology for gravitational wave detection
microwaves
sub-millimetre
infrared
optical
ultraviolet
x-rays
gamma rays
integral
Seeking out the extremes of the Universe
European Space Agency


esa
soho
Facing the Sun
venus express
Studying Venus' atmosphere
juice
Characterising the conditions of ocean-bearing moons around Jupiter
proba-2
Observing coronal dynamics and solar eruptions
bepicolombo
Exploring Mercury
cassini-huygens
Studying the Saturnian system and landing on Titan
mars express
Investigating the Red Planet
cluster
Measuring Earth's magnetic shield
solar orbiter
The Sun up close
rosetta
Chasing a comet
→ ESA'S FLEET IN THE SOLAR SYSTEM
The Solar System is a natural laboratory that allows scientists to explore the nature of the Sun, the planets and their moons, as well as comets and asteroids. ESA's missions have transformed our view of the celestial neighbourhood, visiting Mars, Venus, and Saturn's moon Titan, and providing new insight into how the Sun interacts with Earth and its neighbours. The Solar System is the result of 4.6 billion years of formation and evolution. Studying how it appears now allows us to unlock the mysteries of its past and to predict how the various bodies will change in the future.
European Space Agency

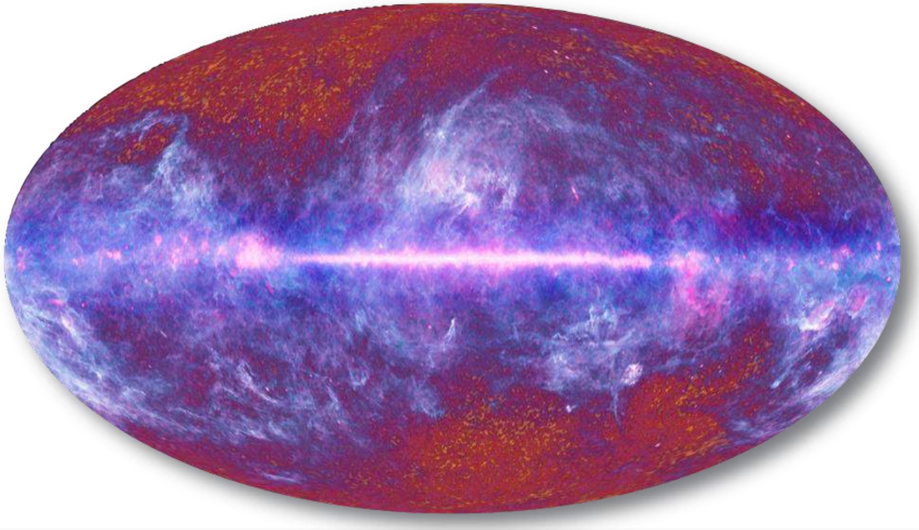
Ending HERSCHEL and PLANCK

Herschel – 2009

- Far infrared
- End of operations 29 April 2013
- Final command 17June 2013
- Excellent science
- Technology bonus

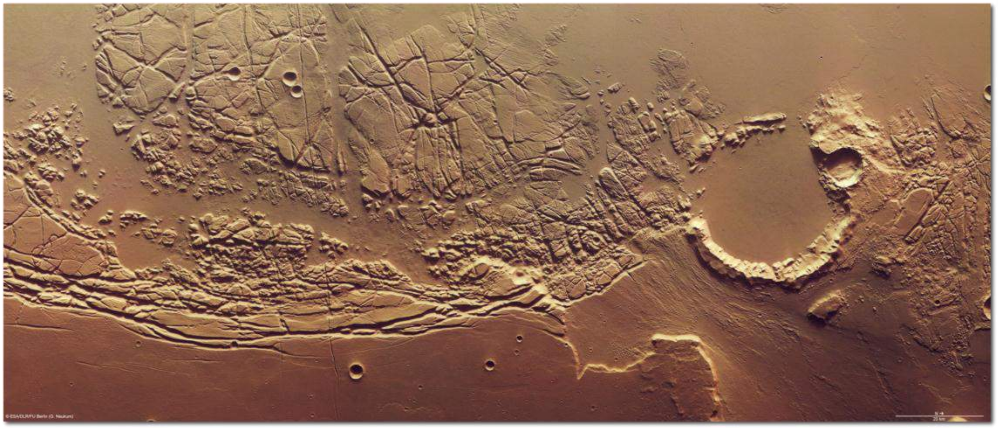
Planck – 2009

- Cosmic Microwave Background
- First all-sky image of CMB Mar13
- Most precise picture early Universe
- Still providing data until Aug 13



MarsExpress – 10 years!

- New global mineralogical maps released
- Maps will help determine future landing site, science sites etc



Return to Mars …. ExoMars

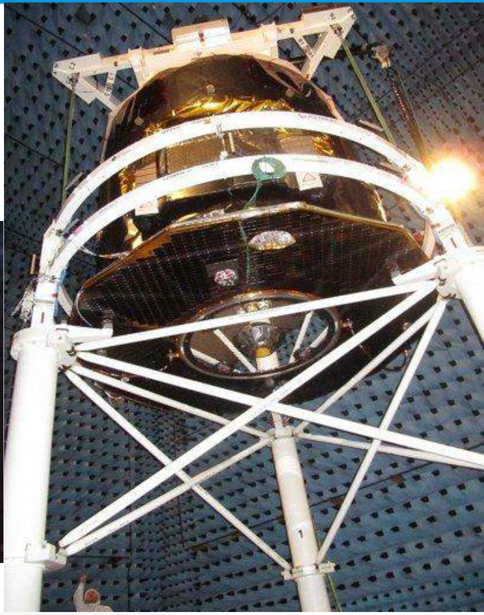
- 2 missions 2016 (orbiter) & 2018
- Cooperation with Roscosmos
- Investigate Martian environment
- Demonstrate new technologies for planetary exploration, with long-term view of Mars Sample Return mission
- 2016 mission entered final construction stage with contract signature @ Le Bourget

Tim PEAKE – into space

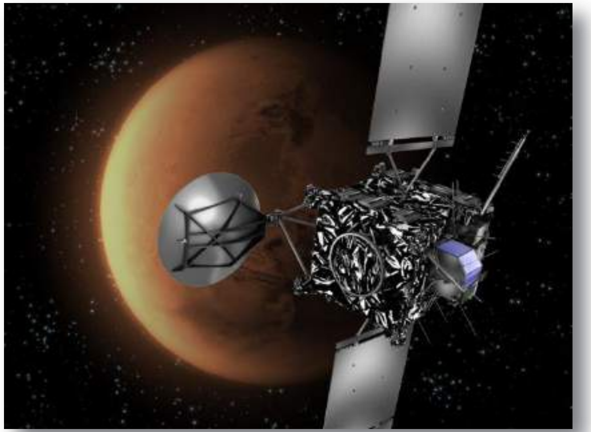
- Selected for 6-month mission to ISS in 2015
- Scientific and Engineering Programme
- Telecom technologies for ISS
- Outreach and Education

To come ....

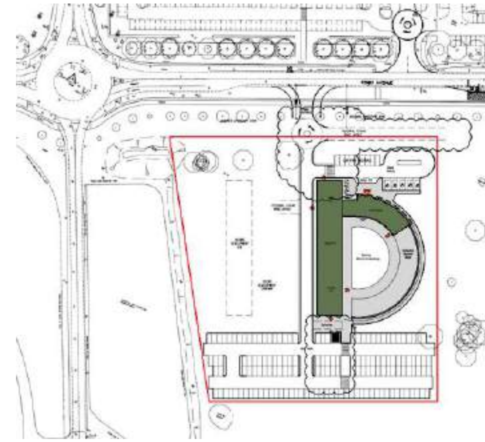
- **GAIA launch – Q3/2013**
  - Create high accuracy 3D map of Milky Way
  - Preparing for launch
  - Launch window > 19Oct13



- **Rosetta**
  - Wake up 20Jan 2014
  - Arrival comet spring
  - Deploy Philae lander Nov 2014
  - Escort comet until end 2015



ECSAT Building, Harwell



Building available in 2015

100 people by end 2015

The Harwell model

ECSAT

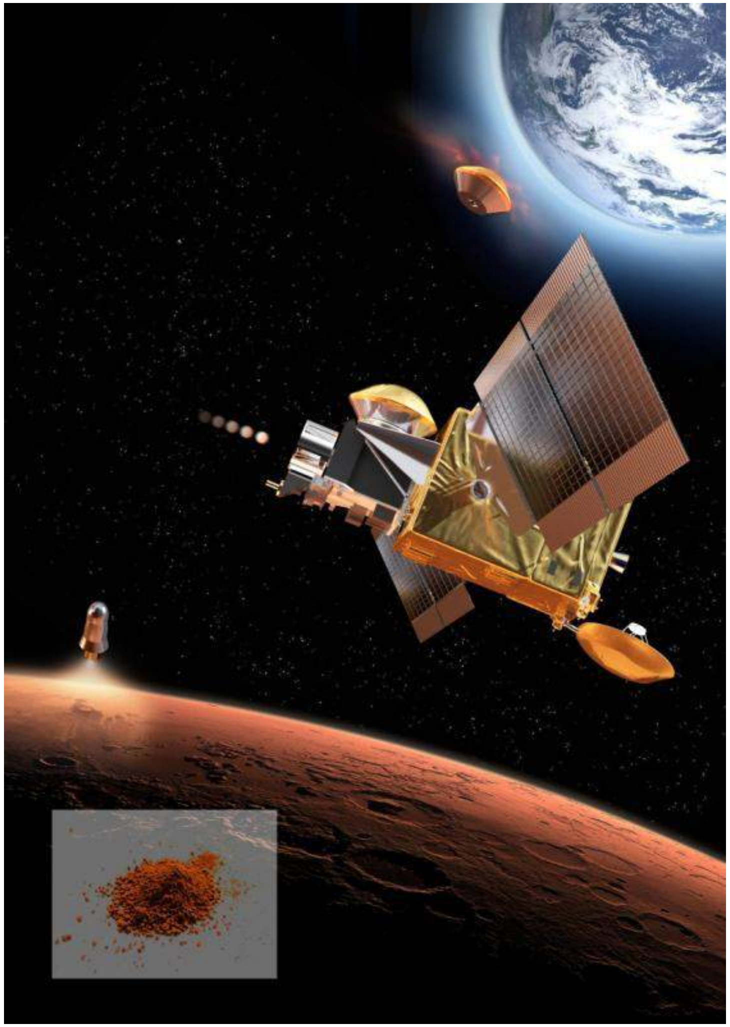
- **An ESA Centre**
  - Knowledge, Competitiveness and Growth
- **A member of the Harwell Campus “Family”**
- **A node of the UK network (scientific community, industry, UKSA, TSB,…)**
- **A gateway to the rest of Europe and beyond**

ECSAT – Robotic Exploration

Future Exploration Missions

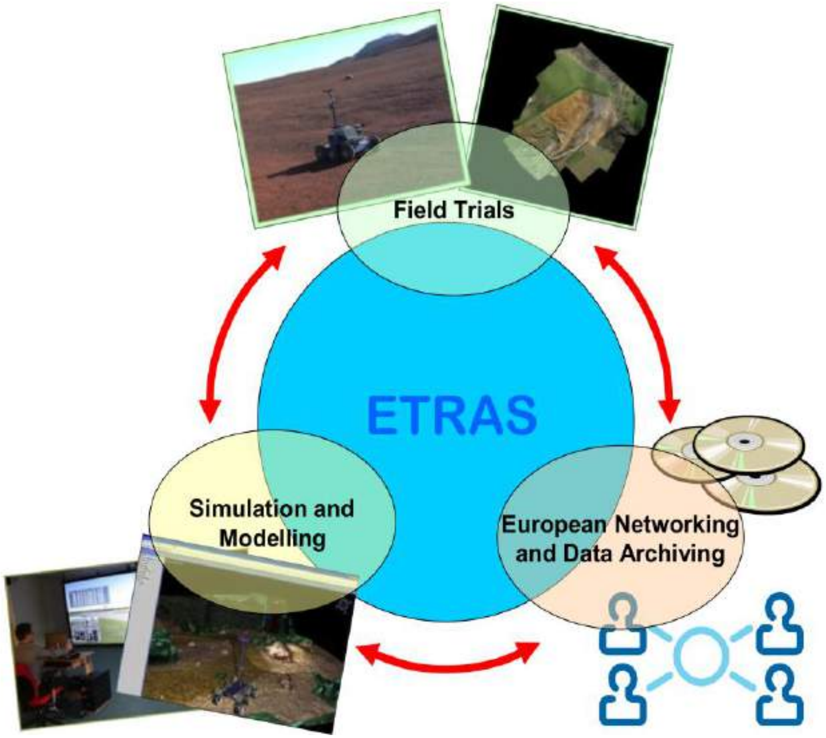
Key Enabling Technologies

- ***Autonomy***
- ***Sample Curation***
- ***Nuclear Power Systems***



ECSAT – Robotic Exploration

Autonomy – Harwell Robotics and Autonomy Facility



- Verification and Validation of Autonomous Systems
- Correlation between field trials and simulation throughout whole lifecycle of Autonomous System

ECSAT – Robotic Exploration

Planetary Analogue Samples

- Simulants of target body material
- Can be used for verification of exploration engineering technologies
- Preparation of sample curation methodologies and techniques

Tissint Meteorite © NHM

© NHM

The ARTES programme

- **ARTES is an R&D programme**
  - First objective : to support the worldwide competitiveness of the European telecommunications satellite industry
  - Second objective : to support the development of new space based applications for the benefit of the European society and economy;
- **More than 85 % of the projects funded under ARTES are implemented in partnerships with private entities through co-funding schemes;**
- **ARTES programme is being implemented by teams across the two ESA centres : ESTEC and ECSAT;**

Integrated Applications Promotion

- **Developing operational services for a wide range of users by combining different space and terrestrial systems.**

  Key characteristics:

  - User driven (responding to defined needs);
  - Engages with a wide range of stakeholders;
  - Combining multiple existing space assets with terrestrial systems;
  - Exploring the capacity of space assets beyond the current state-of-the-art;

- Focus on *sustainable* applications and services.

- Over 120 current activities and demo projects.

- Imperial Business School handle the business case for "Earth Rider".
  - This delivers mass-market edutainment via multi-media shows developed with the UK National Space Centre and Space Synapse.
  - Delivered via planetariums and the "Ovei" by McClaren (a pod that provides an all-encompassing sensory experience).
  - Aims to give audiences an experience similar to that of being in space, using material from Earth Observation and Human Space Flight (notably the ISS).
- ESA is keen to engage in additional IAP projects with Imperial.

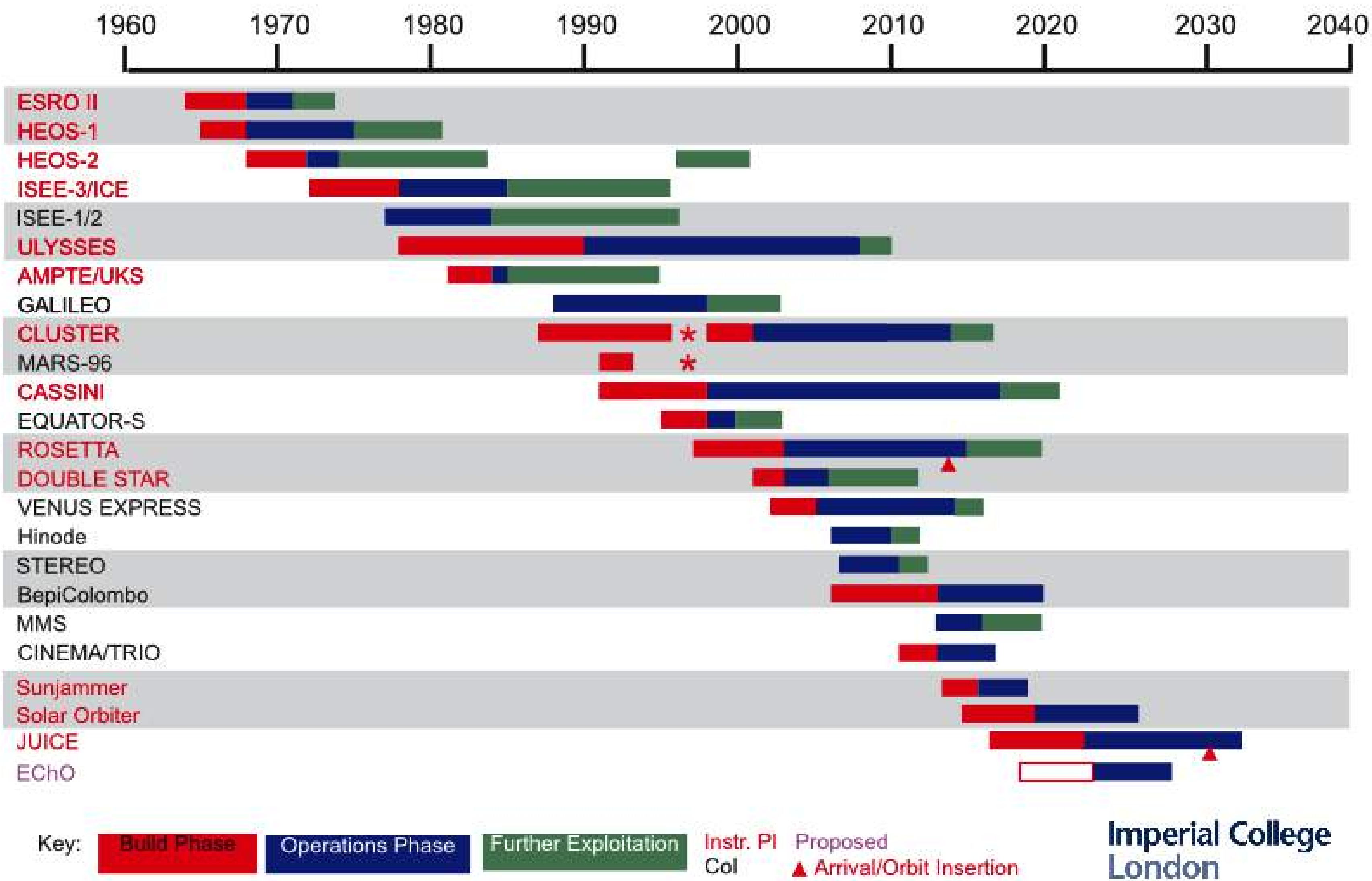
Alphasat

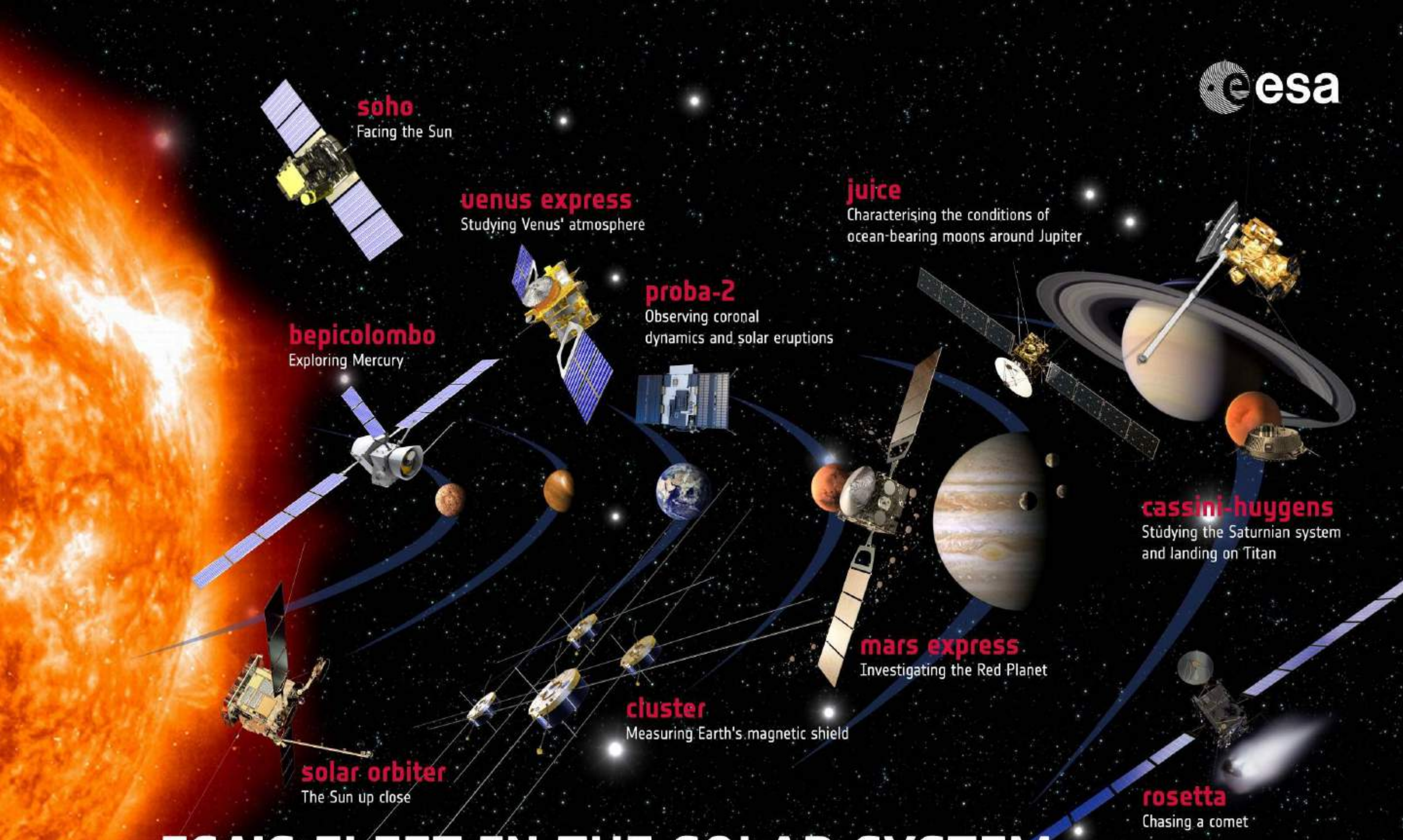
Imperial College London

Space Physics: Instrumentation and Industrial Partnerships

Chris Carr and Patrick Brown
c.m.carr@imperial.ac.uk
patrick.brown@imperial.ac.uk

Space Physics: Mission timeline





→ ESA'S FLEET IN THE SOLAR SYSTEM

The Solar System is a natural laboratory that allows scientists to explore the nature of the Sun, the planets and their moons, as well as comets and asteroids. ESA's missions have transformed our view of the celestial neighbourhood, visiting Mars, Venus, and Saturn's moon Titan, and providing new insight into how the Sun interacts with Earth and its neighbours. The Solar System is the result of 4.6 billion years of formation and evolution. Studying how it appears now allows us to unlock the mysteries of its past and to predict how the various bodies will change in the future.

Imperial College London

Fluxgate Magnetometer Instrument for the Cluster mission:

Imperial College (PI), IGeP Braunschweig, IWF Graz, NASA-GSFC

Radiation hard

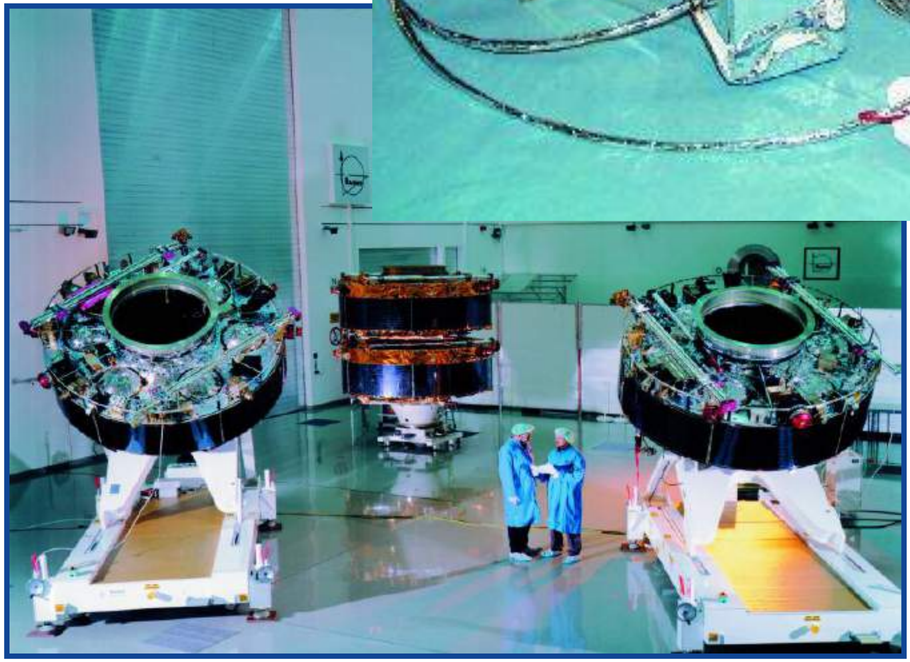
Hi-Reliability

Dual-redundant bus architecture

Fault-tolerant by design

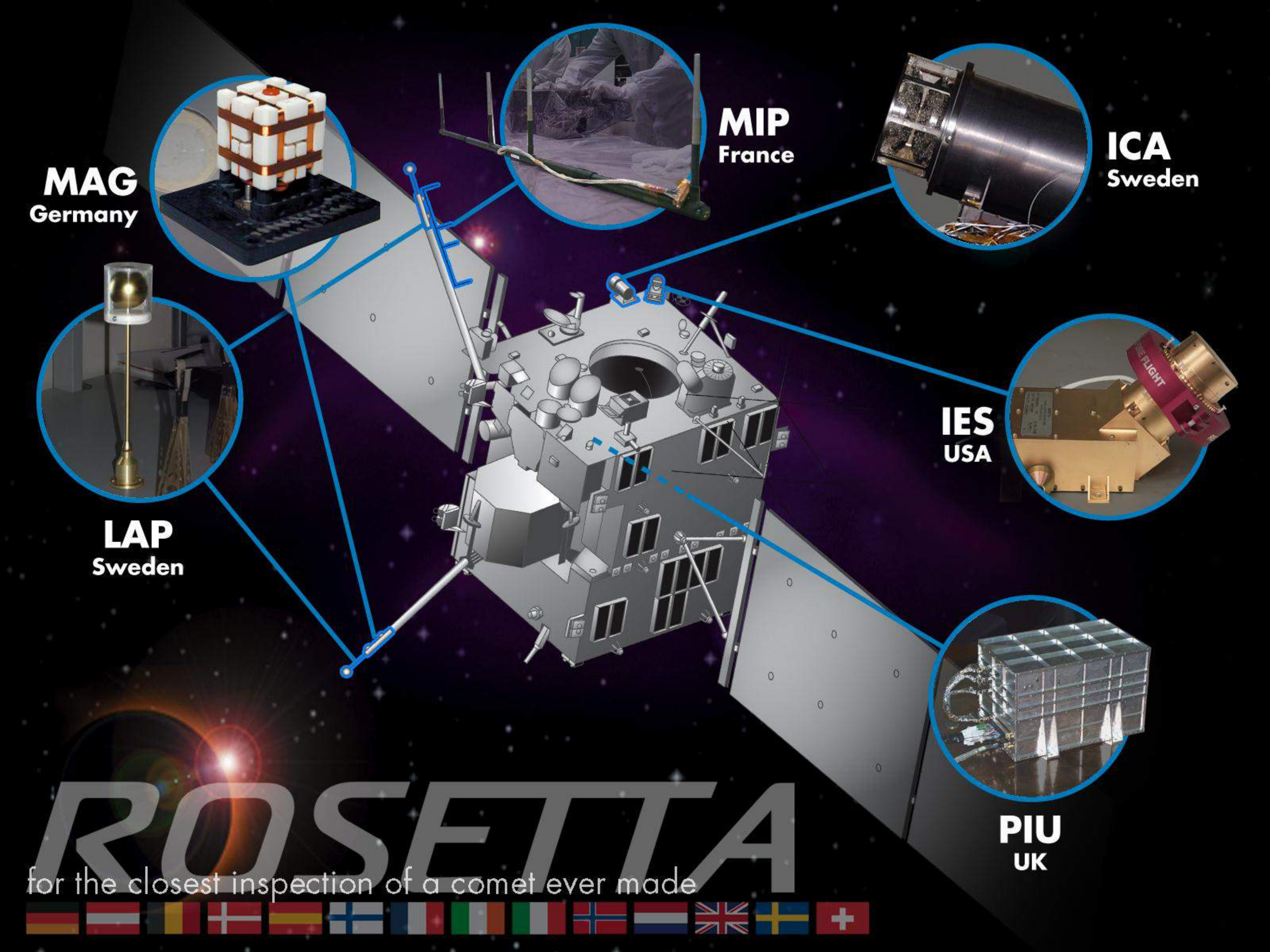
12-years continuous operation (4 instruments)

- No degradation



Imperial College
London

Cluster, 4th June 1996

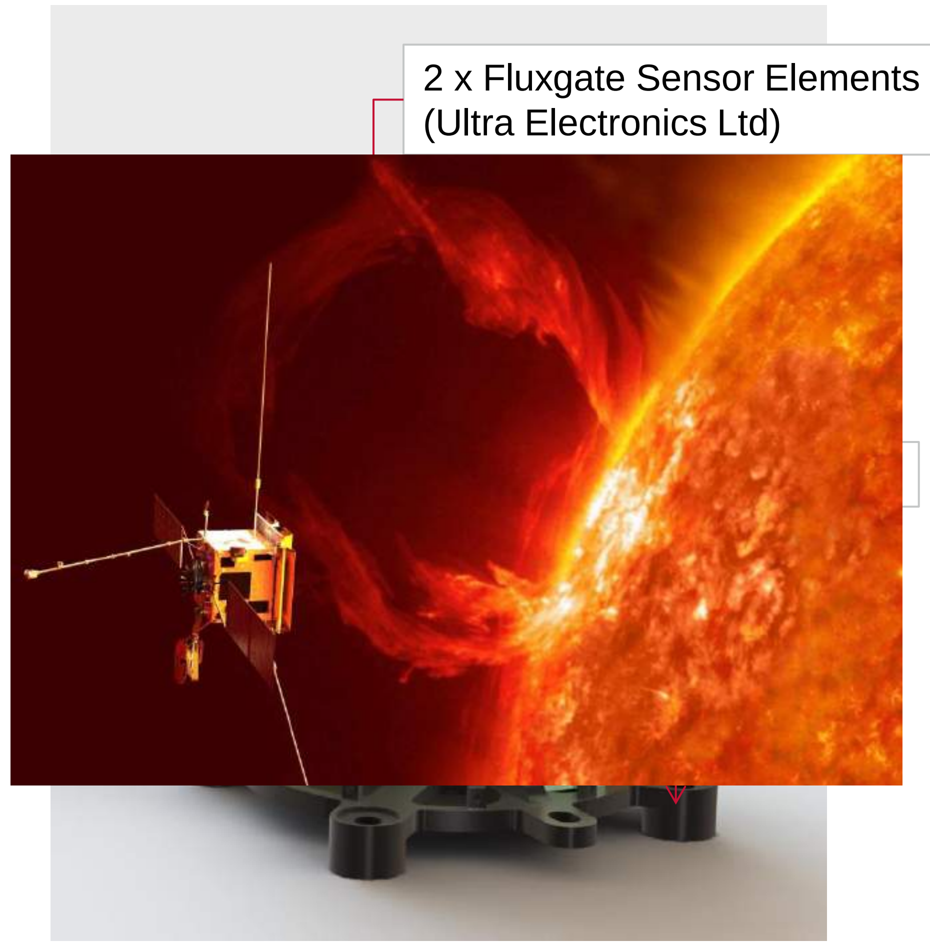

MAG
Germany
MIP
France
ICA
Sweden
LAP
Sweden
IES
USA
PIU
UK
ROSETTA
for the closest inspection of a comet ever made

Imperial College London

Solar Orbiter Magnetometer

- Solar Orbiter’s trajectory goes to less than 0.3 AU
  - Closer to the Sun than Mercury
- Spacecraft behind heat-shield
  - Boom-mounted sensor in permanent shadow
- Extreme thermal environment for the magnetometer
  - Maximum +80 °C
  - Minimum -190 °C

- In-house mechanical, thermal design and simulation

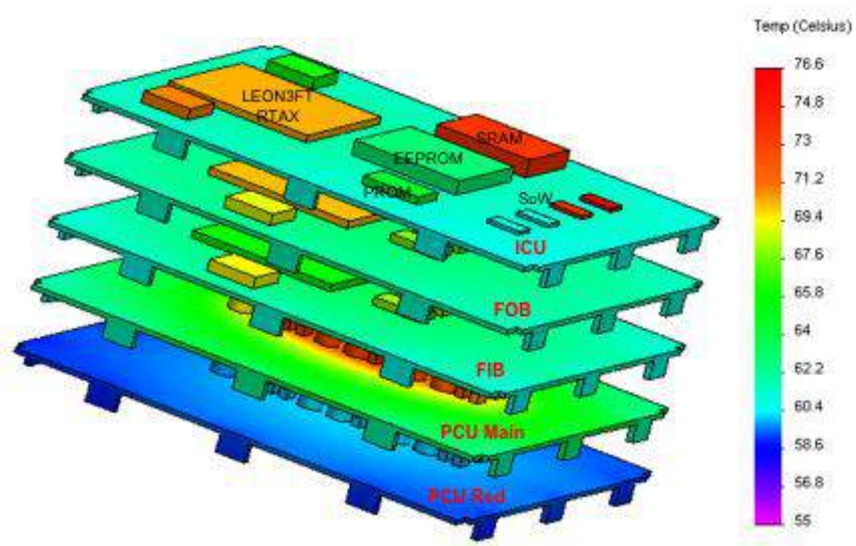


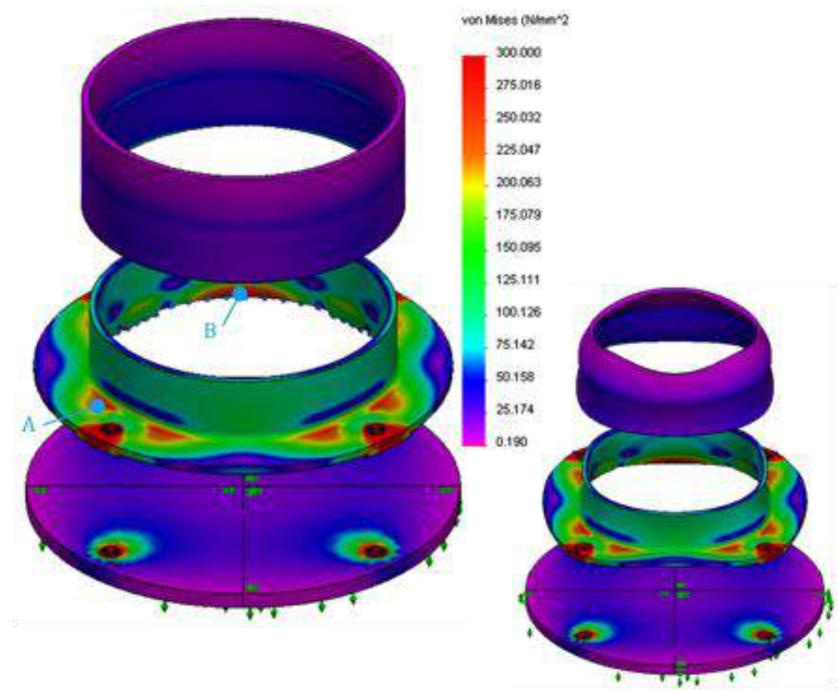
Imperial College London

Mechanical and Thermal FEM Analysis

SolidWorks Simulation plus ThermXL

In accordance with ECSS-E-ST-32

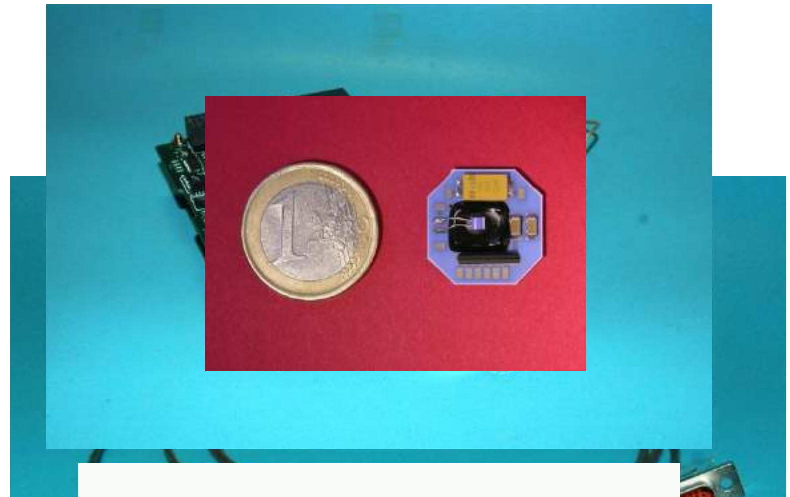




Emanuele Cupido (e.cupido@imperial.ac.uk)

Magnetoresistive Sensor

- Miniaturised magnetic field sensor
  - Developed for use on very small satellites (e.g. CubeSat)
  - Honeywell magnetoresistive sensor
- First flown on the US ‘CINEMA’ CubeSat
  - 2 new launches in 2013
  - Selected for Sunjammer
  - ESA SSA ‘SOSMAG’
- Technology licensed to Satellite Services UK Ltd as an attitude sensor
  - 8 flight units sold
  - Through Imperial Innovations plc



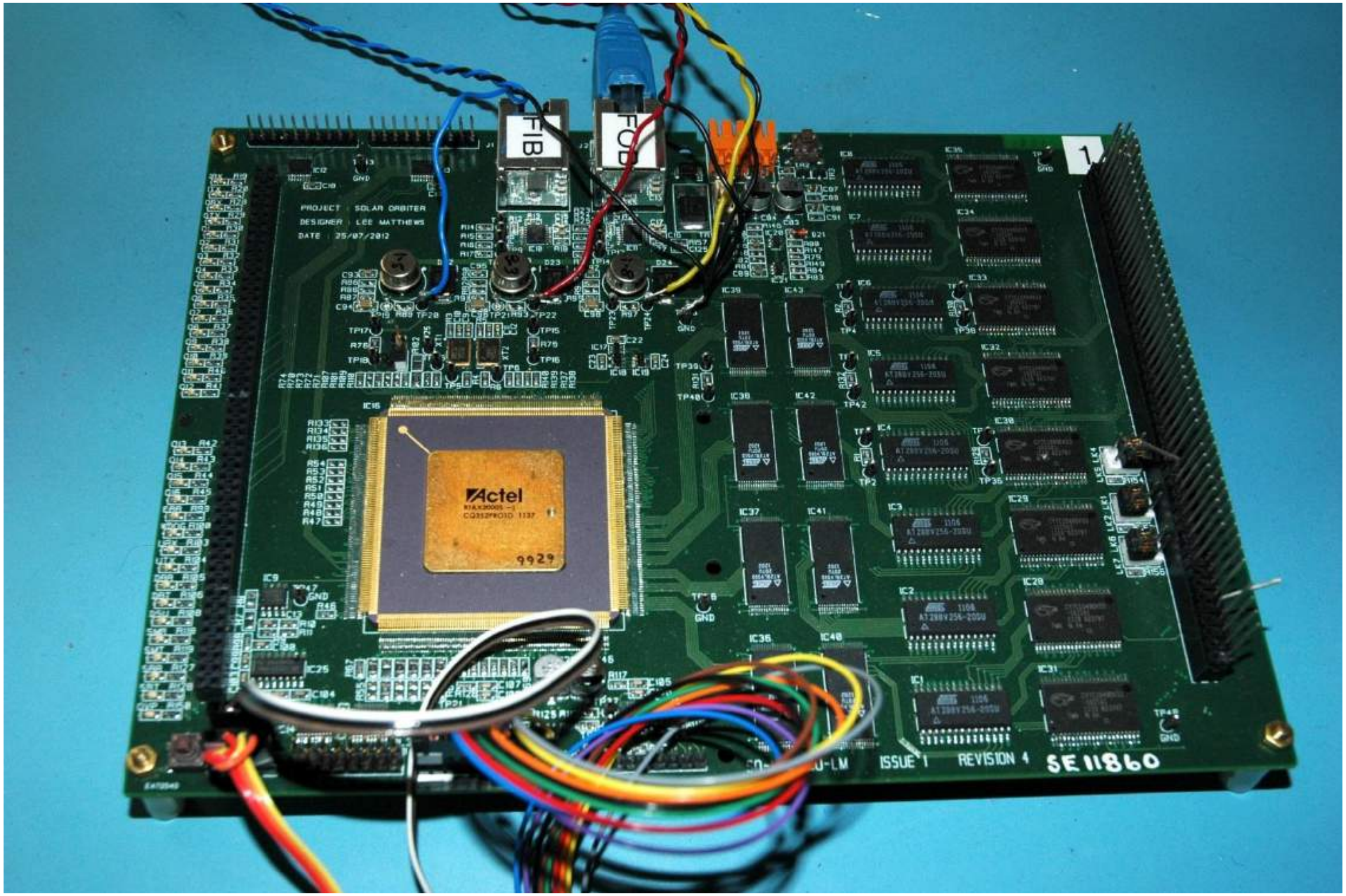
SSBV
Space & Ground Systems UK

Patrick.Brown@imperial.ac.uk

Imperial College
London

Payload data processor

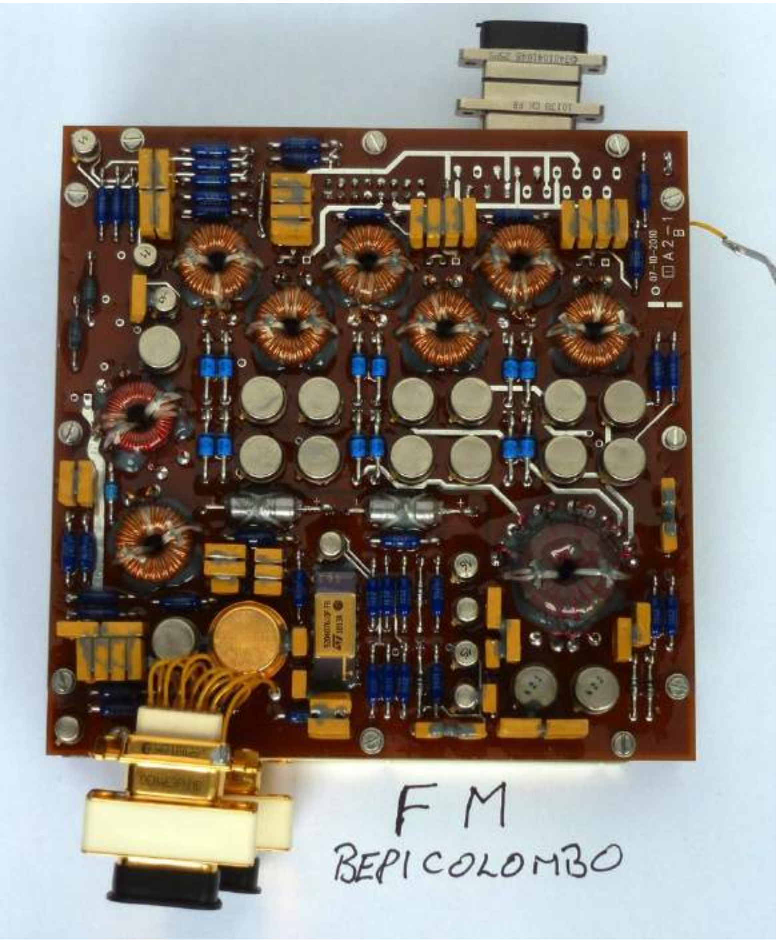
Leon3FT Processor



Prototype for Solar Orbiter

Low-voltage DC/DC power converters

- Flight model for BepiColombo
  - High efficiency
  - Multiple output voltages
  - Modular redundancy
  - Recent heritage:
    - » Cluster
    - » Double Star
    - » Venus Express etc.
- Potential for commercialisation
- We have a ‘pump-priming’ research contract from Lockheed Martin

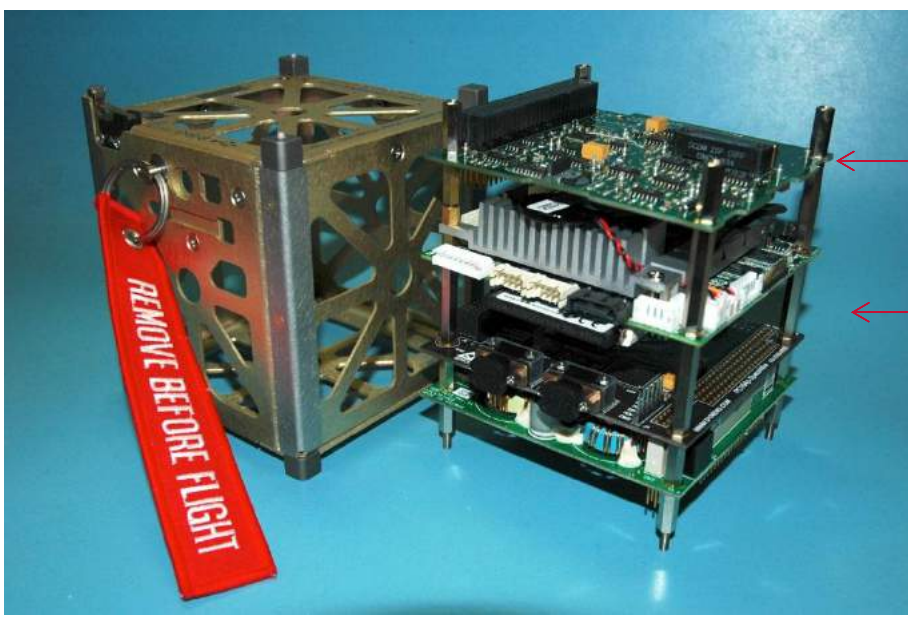


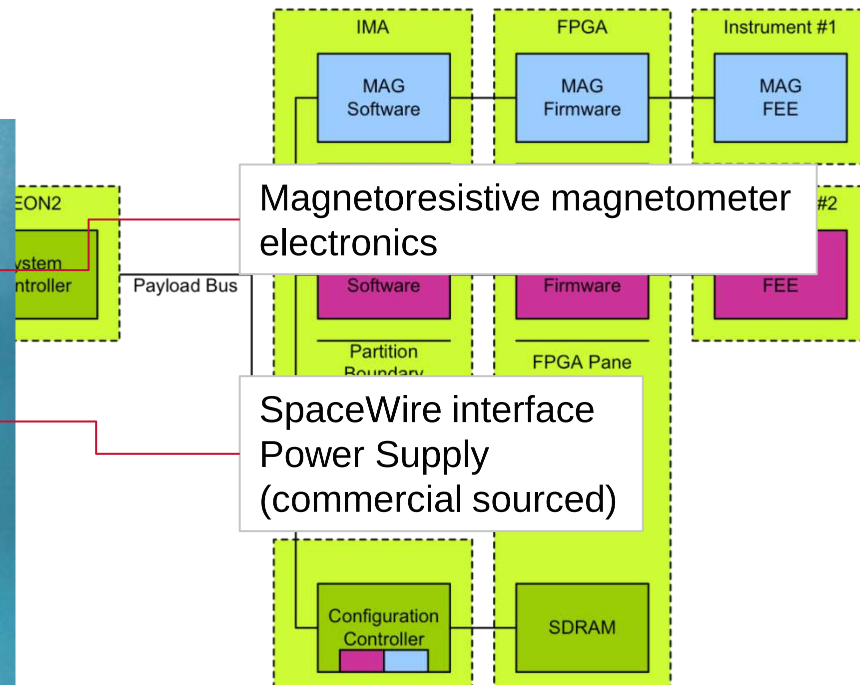
Imperial College London

Integrated Payload Data Handling Systems (I-PDHS)

- Astrium lead with SciSys
- Imperial and RAL payload
- Demonstrate new onboard data handling architectures
  - Reduced mass, power and complexity

I-PDHS is a NSTP Space-CITI project hosted by the Catapult





Magnetoresistive magnetometer electronics

SpaceWire interface
Power Supply
(commercial sourced)

Industry Collaborations

Ultra Electronics (UK)
Fluxgate Sensors R&D
Magnetic test facility
(available through **Imperial Consultants Ltd**)

Lockheed Martin (USA)
Power converters (research contract)

Astrium (UK)
CASE-funded postgraduate student
and magnetometer ASIC development

ESA/MST Aerospace (Germany)
Technology transfer contract (2010/11)

MAGSON (Germany)
Magnetometer prototype for ESA
SSA (Space Situational Awareness) programme

Satellite Services BV Ltd (UK)
Licensed by **Imperial Innovations plc** to sell our magnetoresistive magnetometer

Satellite Applications Catapult
Imperial Space Lab

Paul Febvre

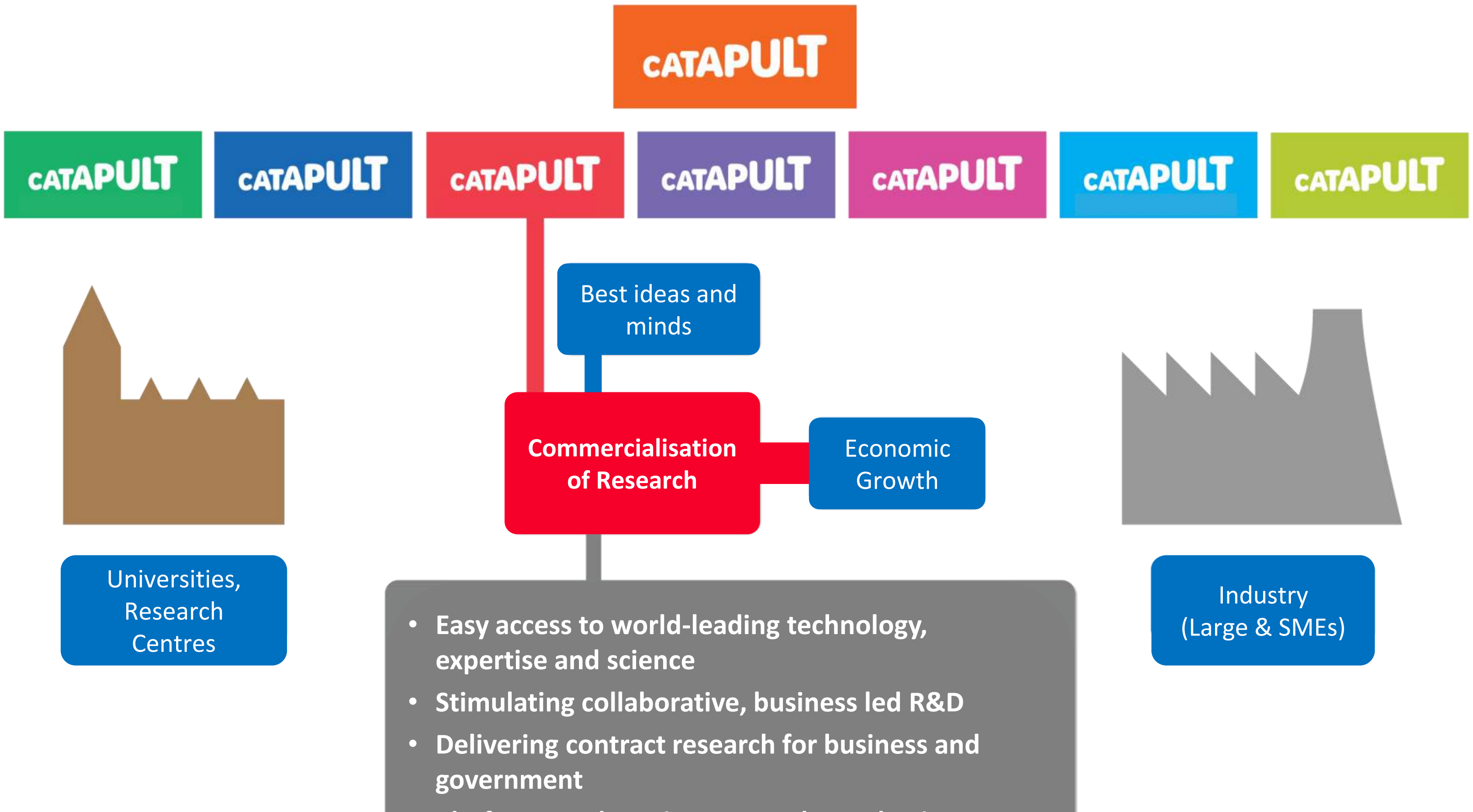
Chief Technology Officer

01st July 2013

Catapult is a Technology Strategy Board programme

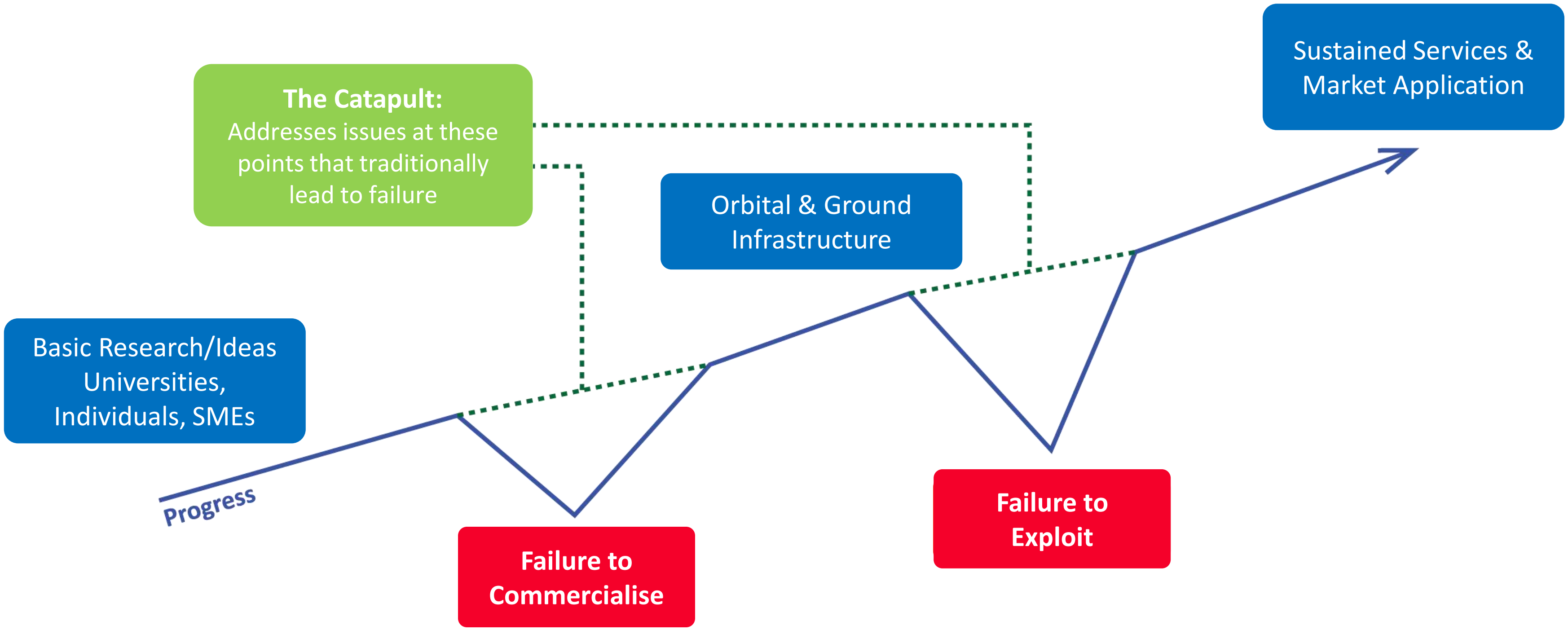
cATAPULT
Satellite Applications

The Catapult



CATAPULT Satellite Applications

Background and Mission



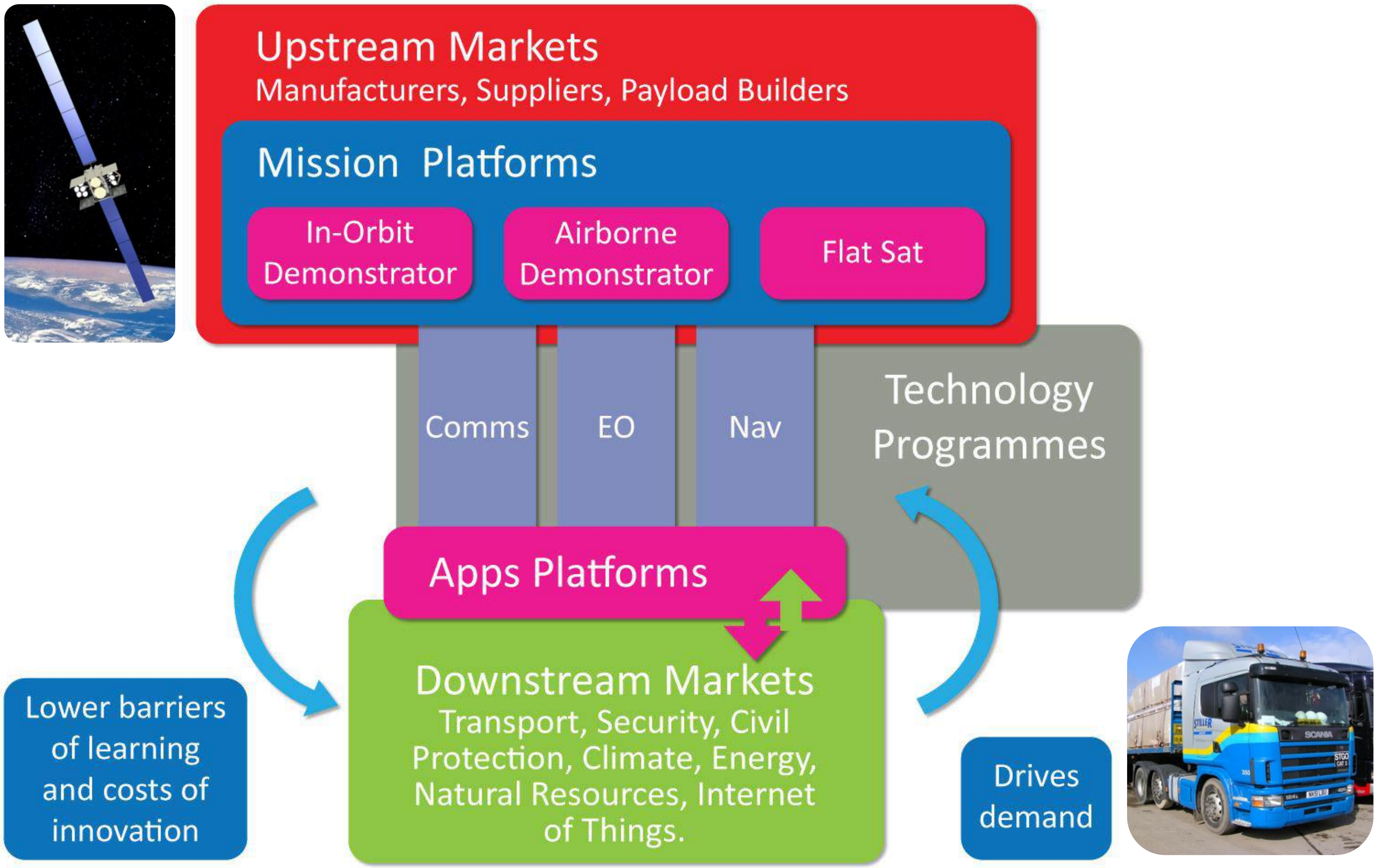
£40bn Market by 2030

10%pa Growth

Major growth in satellite applications but significant barriers for new businesses

Catapult Satellite Applications

Overview



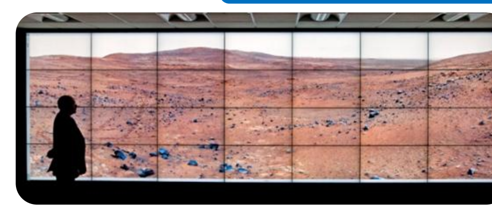
Upstream Markets
Manufacturers, Suppliers, Payload Builders
Mission Platforms
In-Orbit Demonstrator
Airborne Demonstrator
Flat Sat
Comms
EO
Nav
Technology Programmes
Apps Platforms
Downstream Markets
Transport, Security, Civil Protection, Climate, Energy, Natural Resources, Internet of Things.
Lower barriers of learning and costs of innovation
Drives demand

Facilities

Applications Innovation Centre

Operations Centre

Visualisation

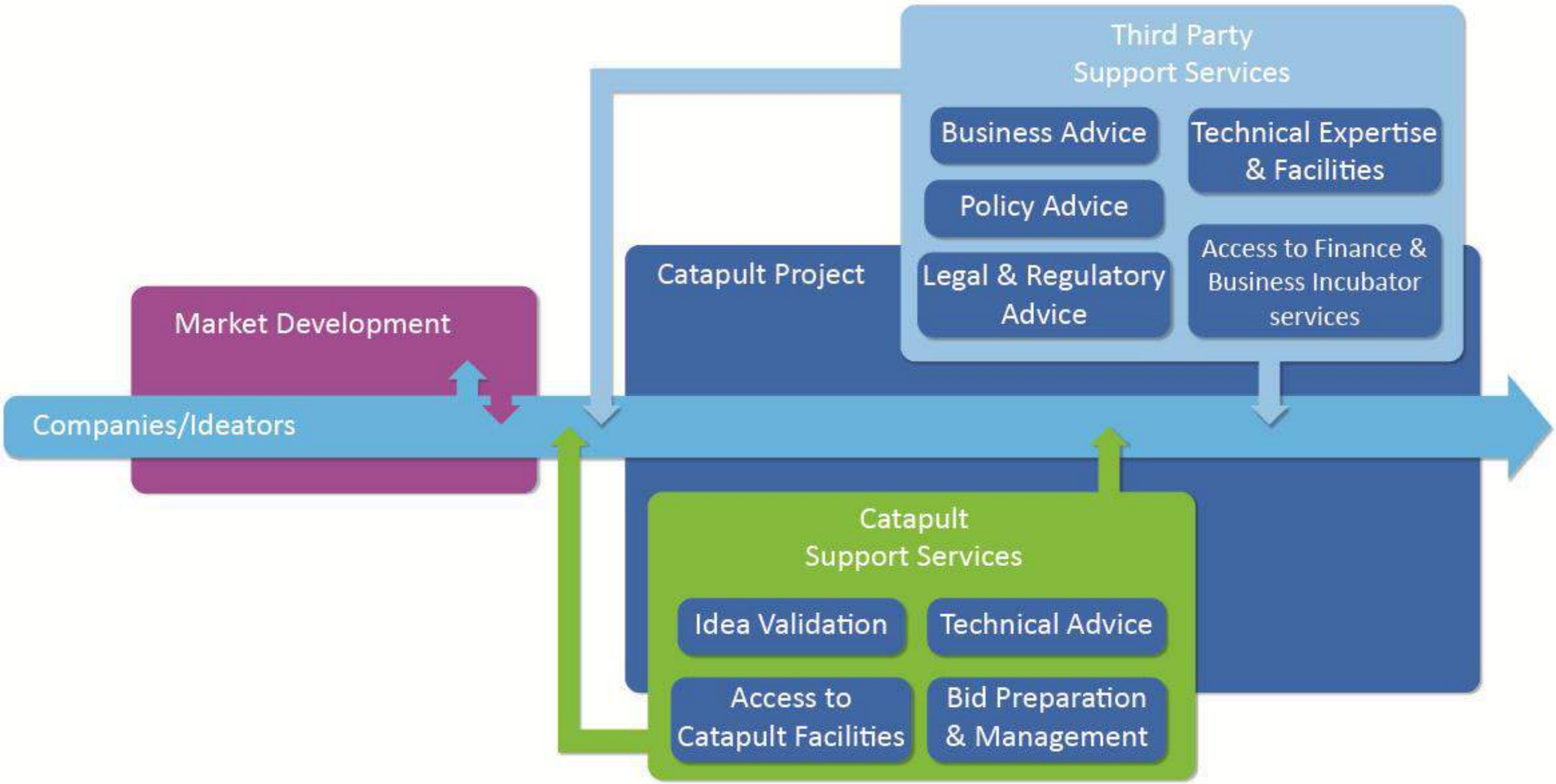


Security & Resilience Unit

Public Regulated Service

Concept Requirements Design Development Integration Verification Validation Operation Showcasing

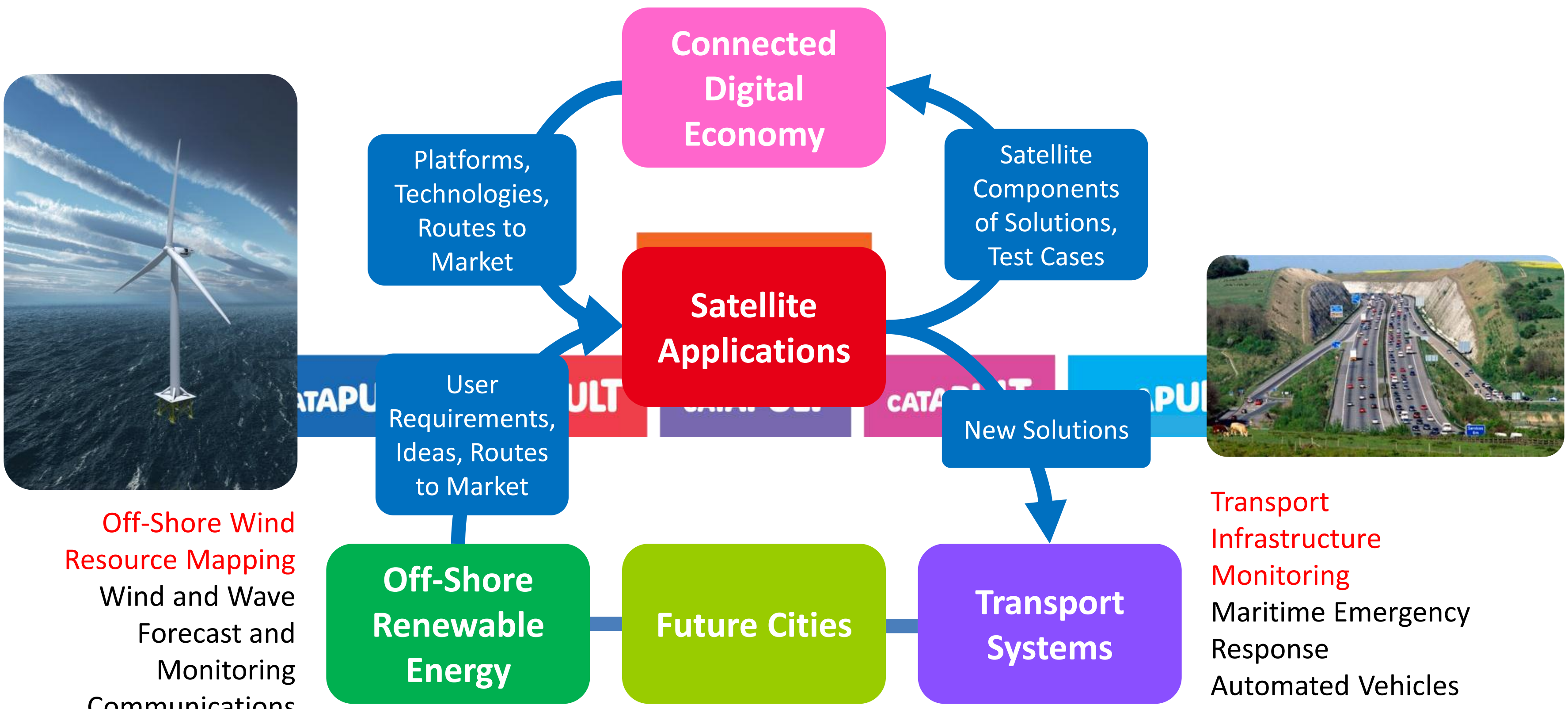
Integrated Support



CATAPULT Satellite Applications

The Catapult Network

Big Data -> CEMS
M2M -> Satcomms
and IoT



Off-Shore Wind
Resource Mapping
Wind and Wave
Forecast and
Monitoring
Communications
and Positioning

Urban Planning
inc Heat islands
Monitoring
Building Usage
Precision Farming

Transport
Infrastructure
Monitoring
Maritime Emergency
Response
Automated Vehicles
Communications and
Positioning

Satellite Applications Catapult

Satellite Technology Trends

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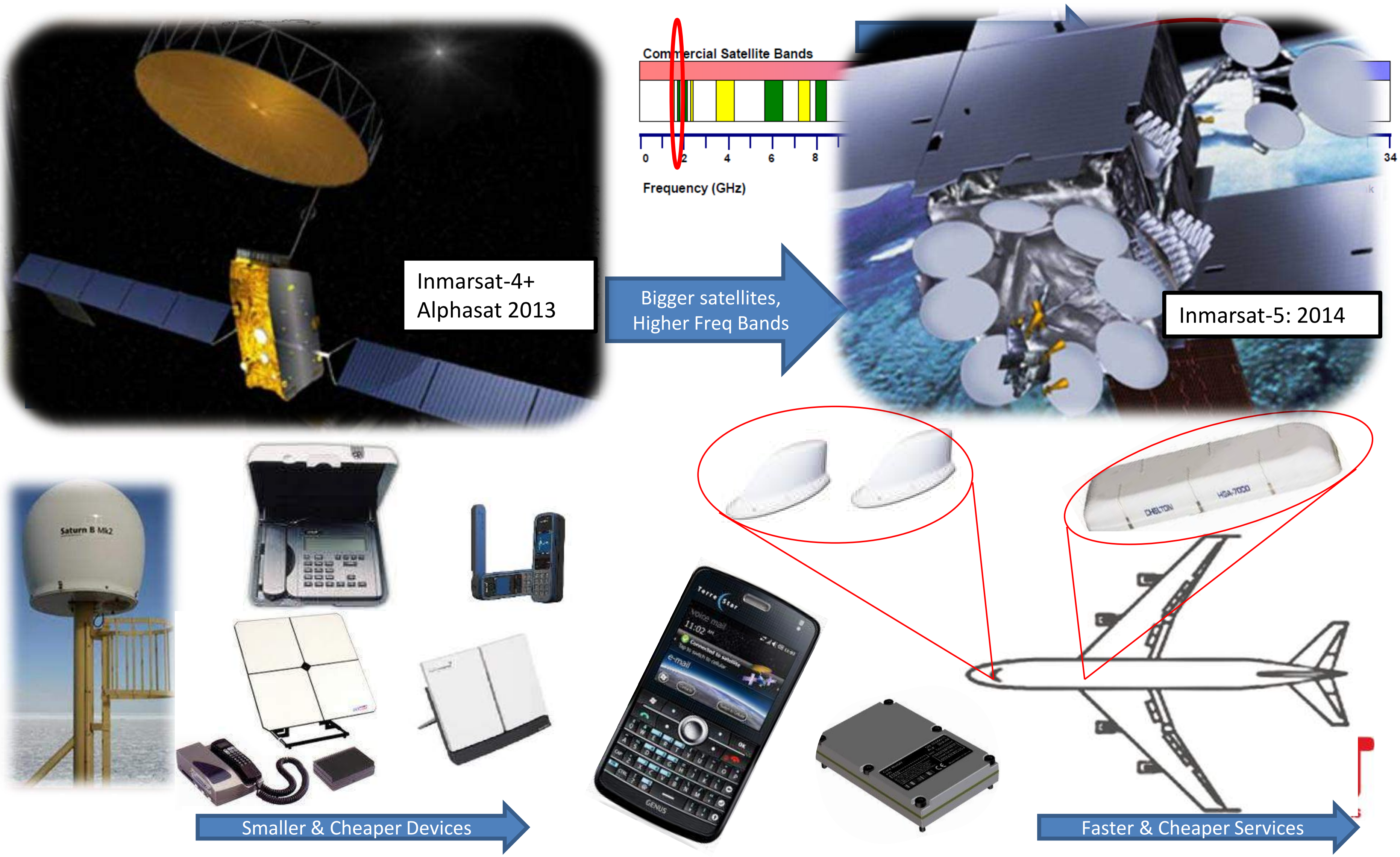
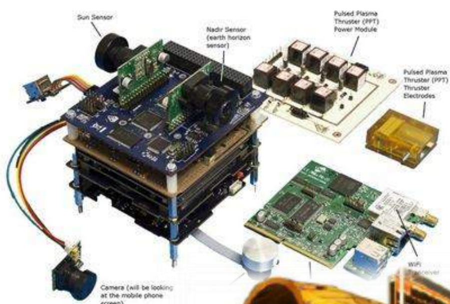
Satellite Applications

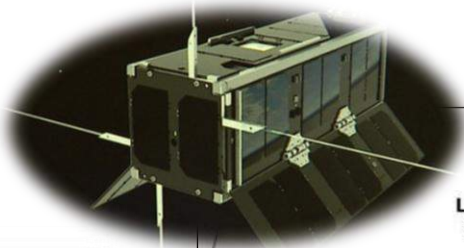
Technology Innovations and Trends in Telecommunications

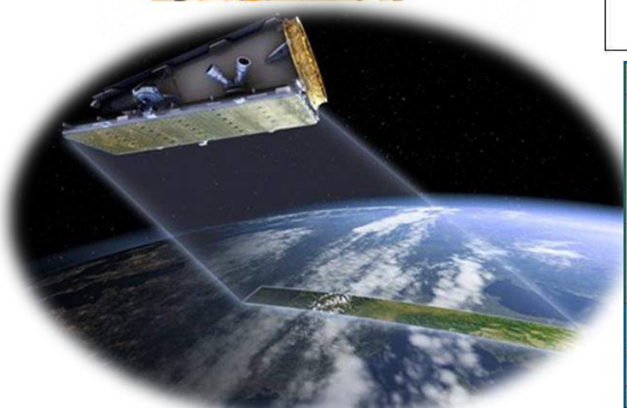


Technology Innovations in Earth Observation

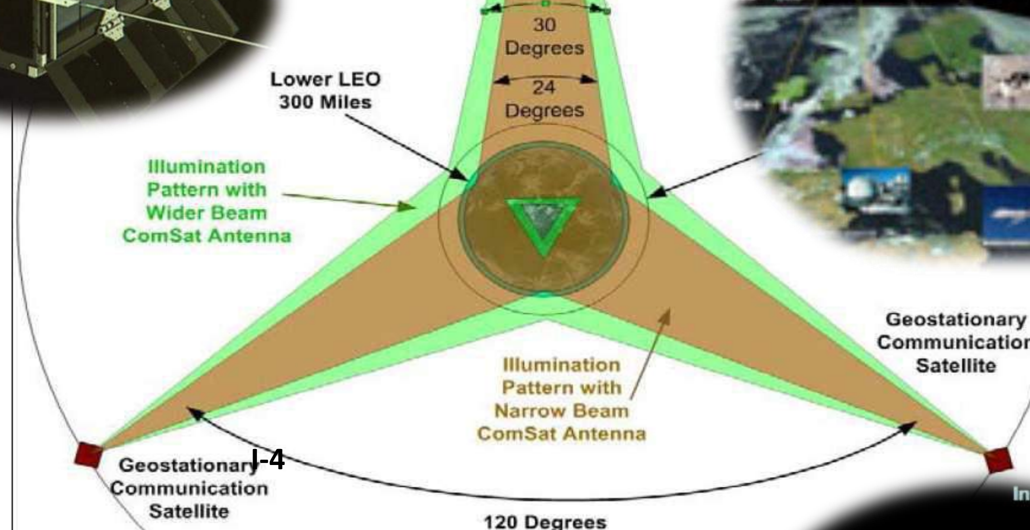
Smaller Lower-cost satellite constellations

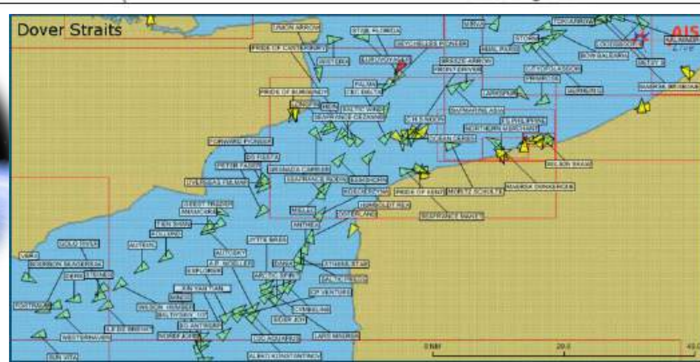


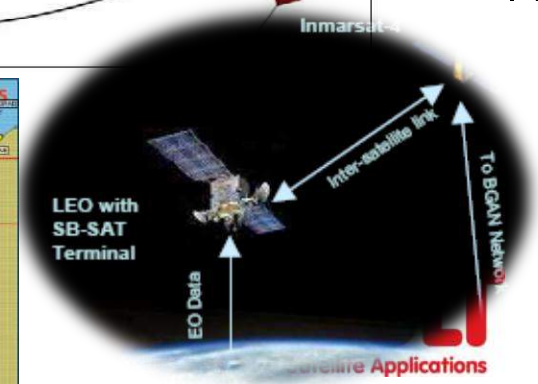




Data relay satellites for real-time access





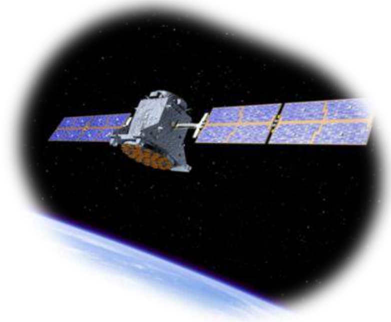


Other Key Technology Innovations and Trends

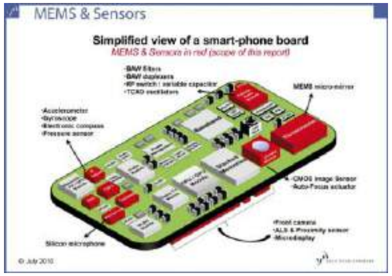
Galileo Public Regulated Service + Commercial services

Trust, Accuracy, Resilience

→ Autonomous systems



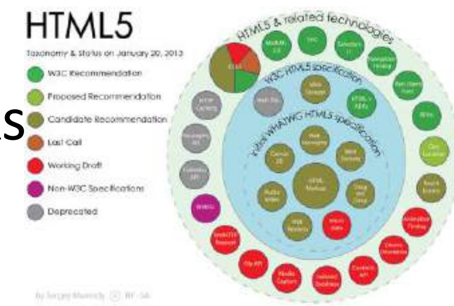
Ubiquity of smart-phones



Positioning, Sensors, Processing + Storage

Crowd sourcing…Location Based Services and Applications

→ *Trust* and security models required



Emergence of rich open app development frameworks

Standardisation + speed of development

→ Lower cost of entry and support

CATAPULT
Satellite Applications

Future Missions Technologies…

MEMS, smart materials, deployable structures,

Additive manufacturing

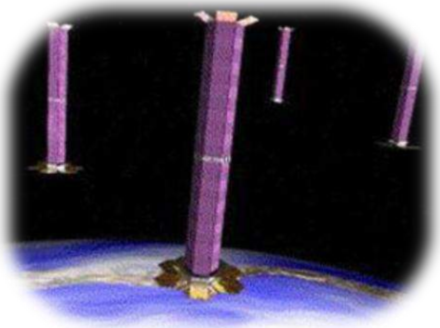
Massive advances in laser technologies

New propulsion and power technologies

→Airborne-platforms → "Stratellites"

→ Novel orbits and architectures/ Formation flying

→ Repairable/ reusable satellites



CATAPULT Satellite Applications

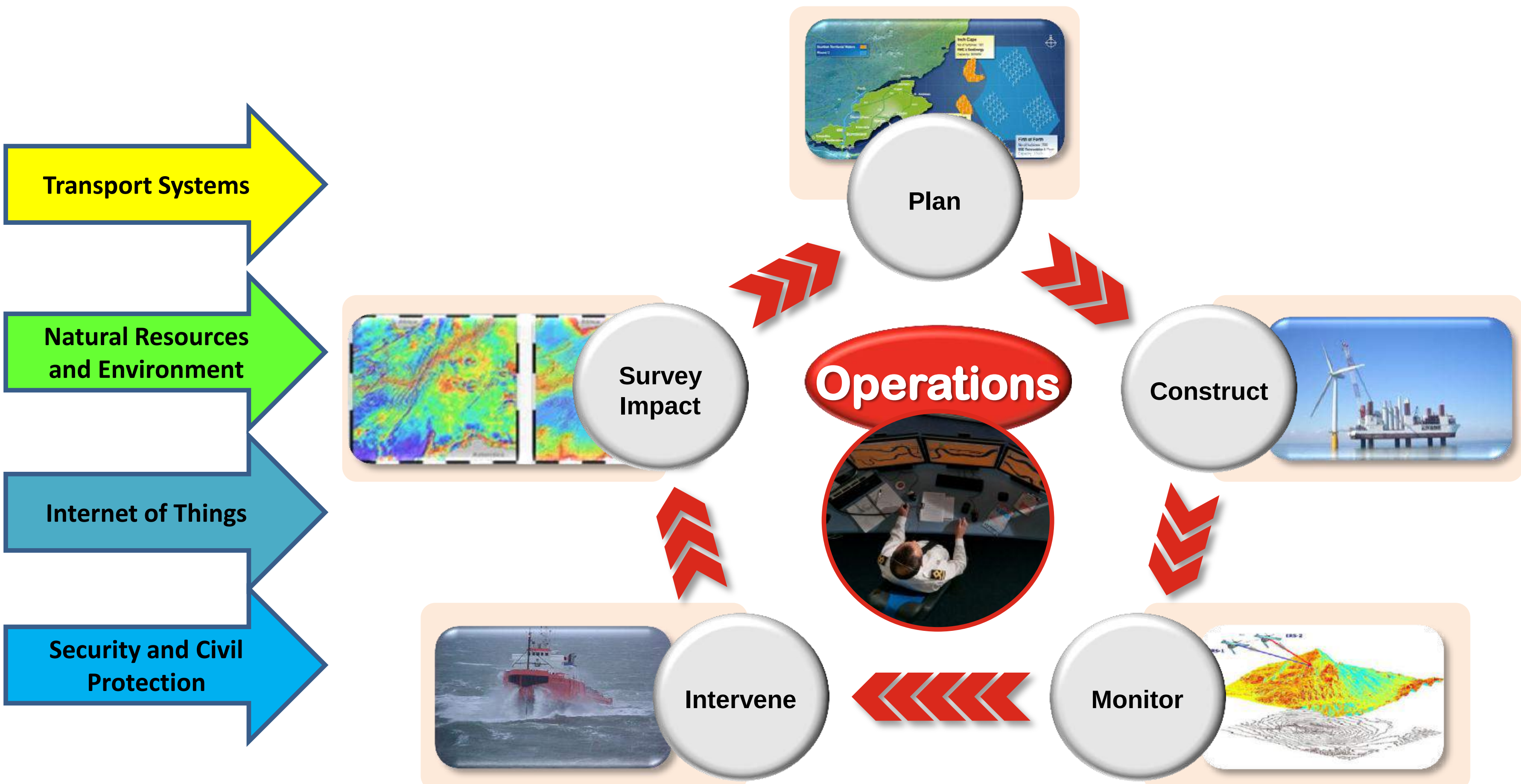
Satellite Applications Catapult

Example Use-cases

Application of Satellite technologies

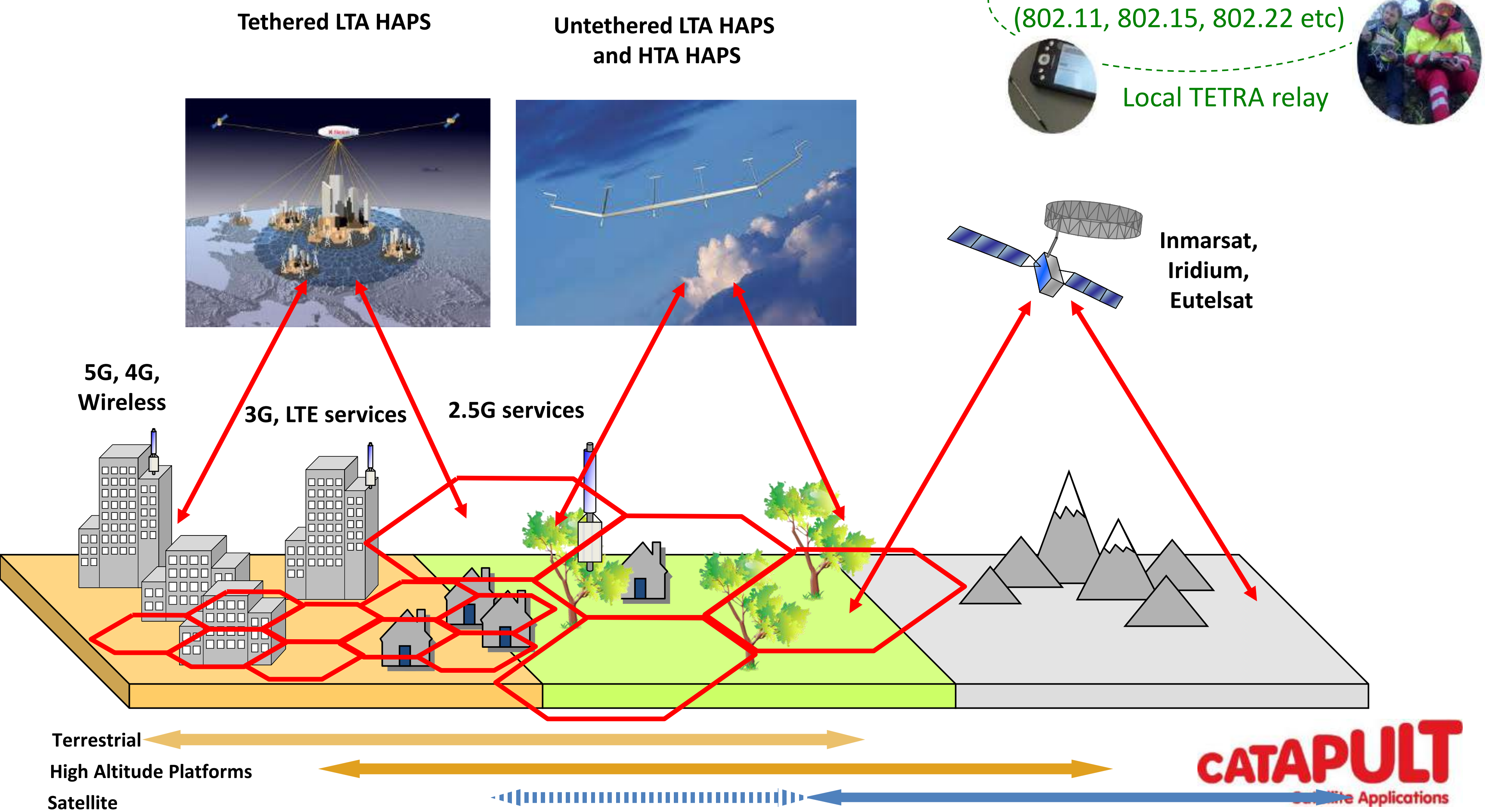
CATAPULT Satellite Applications

Example: Maritime Operations → Situation Awareness & Information

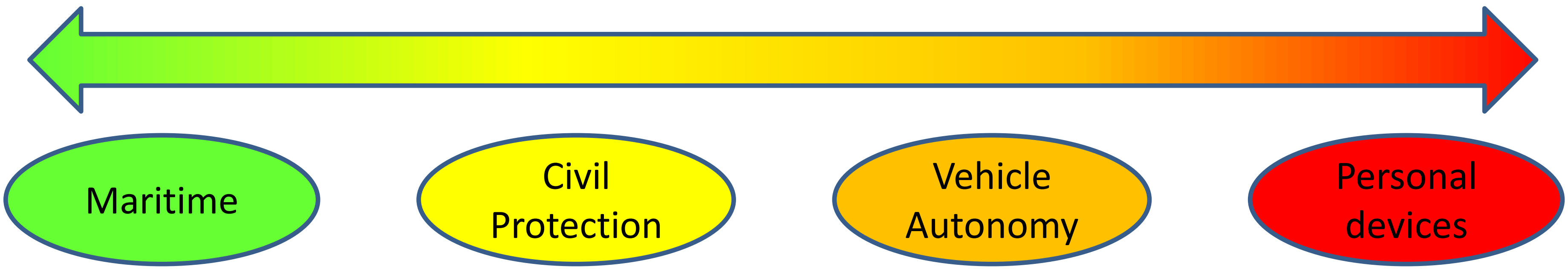


Catapult Satellite Applications

Example: Future Public Services



Spectrum of Risk/Opportunity



Incremental	Disruptive
High value/ margin	Low margin
Small scale	Massive scale
Institutional	Consumer
Existing Business Models	New Business Models
Limited opportunities	Significant opportunities

CATAPULT Satellite Applications

Conclusions

- Emerging Satellite Services and Technologies offer huge potential for Satellite Applications
- Extraordinary benefits arise from collaborating in an open innovation environment
- The Satellite Applications Catapult provides
  – A conduit for exploitation of research
  – Facilities and Services for development of Applications
- What does the Catapult need from Imperial?
  – Coordinated direction of research activities
  – Joint collaboration on proposals with a research element
  – A framework for knowledge exchange activities

CATAPULT Satellite Applications

Satellite Applications Catapult

Thank You

Paul Febvre
CTO

Paul.Febvre@sa.catapult.org.uk

Imperial College London

Geochemistry, Meteorites & Missions

Professor Mark A. Sephton, Earth Science & Engineering

Imperial College London

Presentation Outline

The Planetary Geologist

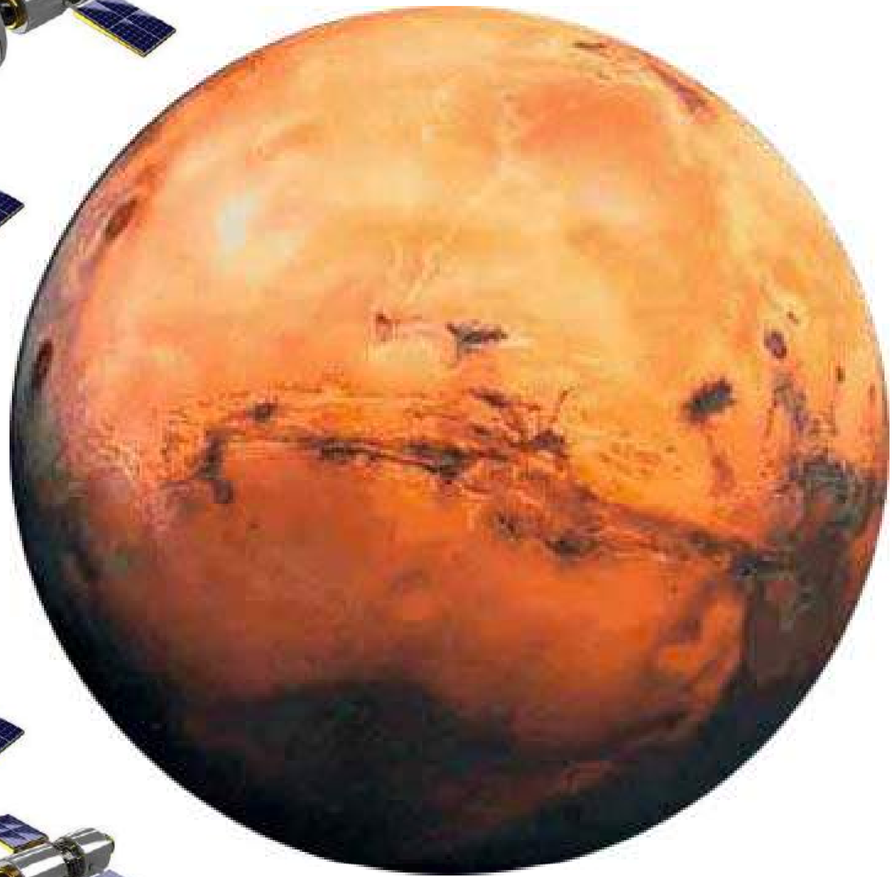
E.g. - The Life Marker Chip

Knowledge Transfer

Use of Analogues

Organic Matter

Minerals



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Rise of the Planetary Geologist

Mariner 9 was an Orbiter that reached Mars in 1971, becoming the first spacecraft to orbit another planet

"Mariner 9 cameras took thousands of pictures. A whole new world was taking shape. NASA called in a new type of scientist – Planetary Geologists ."

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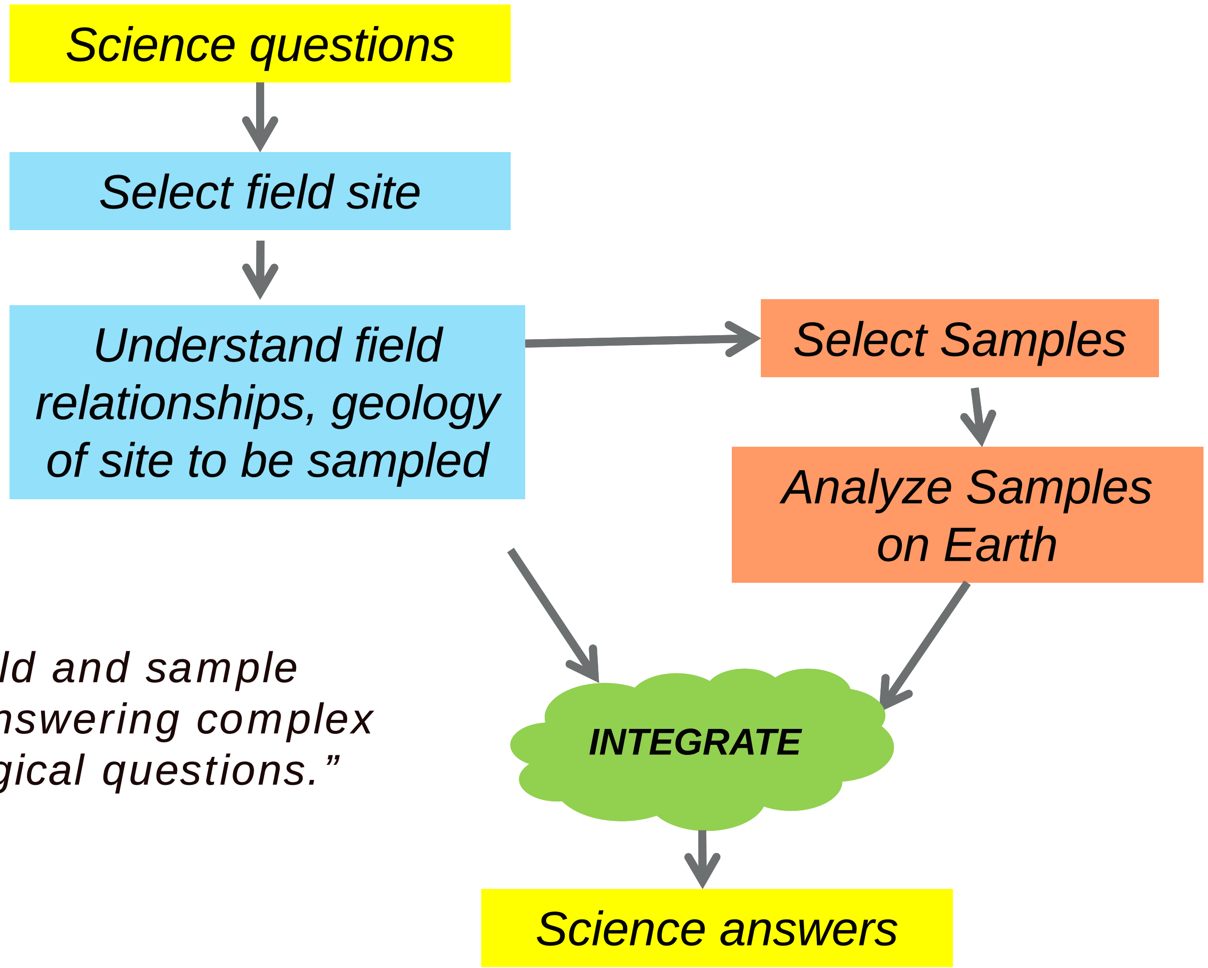
Integrating field and sample science



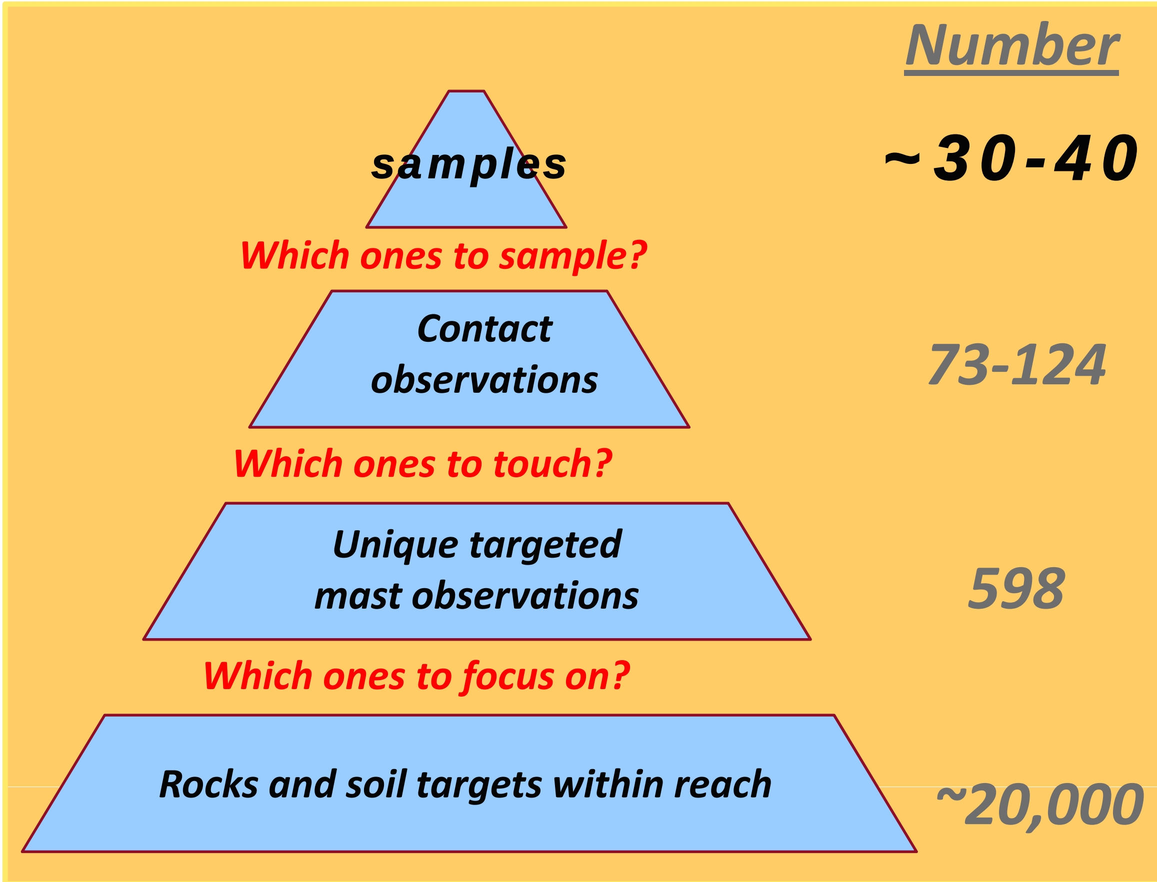
"The integration of field and sample science is critical to answering complex geological/ astrobiological questions."

McLennan et al. 2012. Astrobiology, 12, 175-230

Hierarchical need for information

Putting together effective sample suites requires collecting information in the field on many more rock and soil candidates than the number eventually collected.

Example:
Counts from first Mars year of Spirit's exploration of Gusev Crater, 2004-2006.



McLennan et al. 2012. Astrobiology, 12, 175-230

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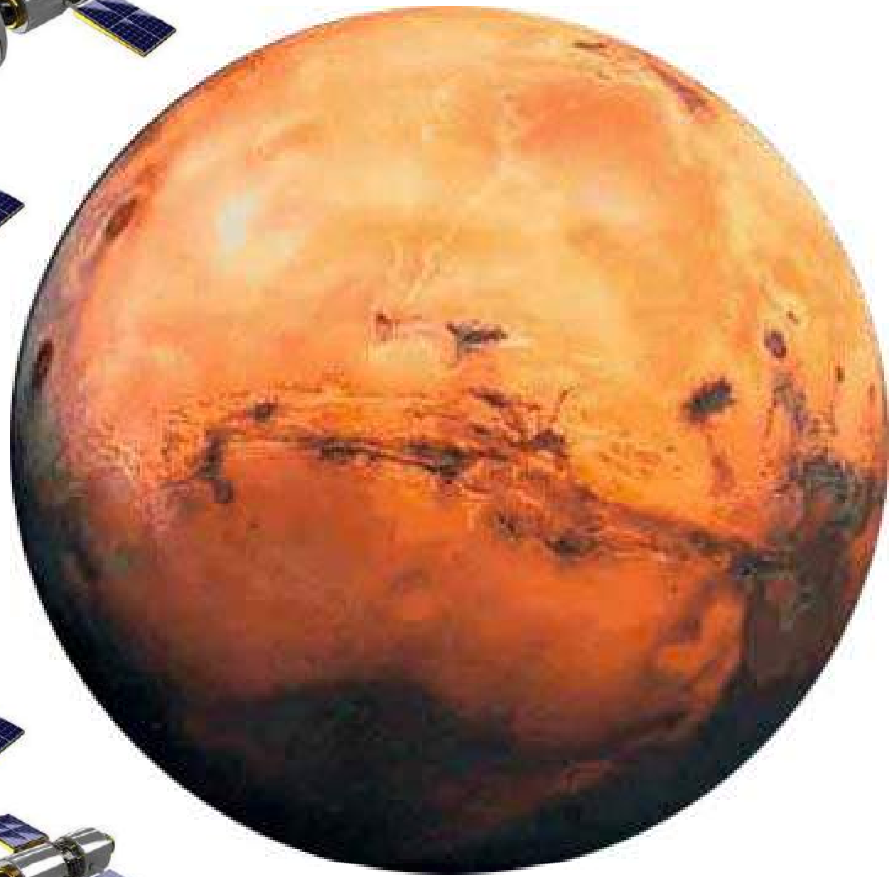

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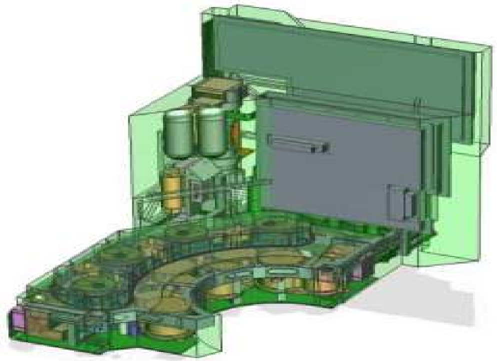
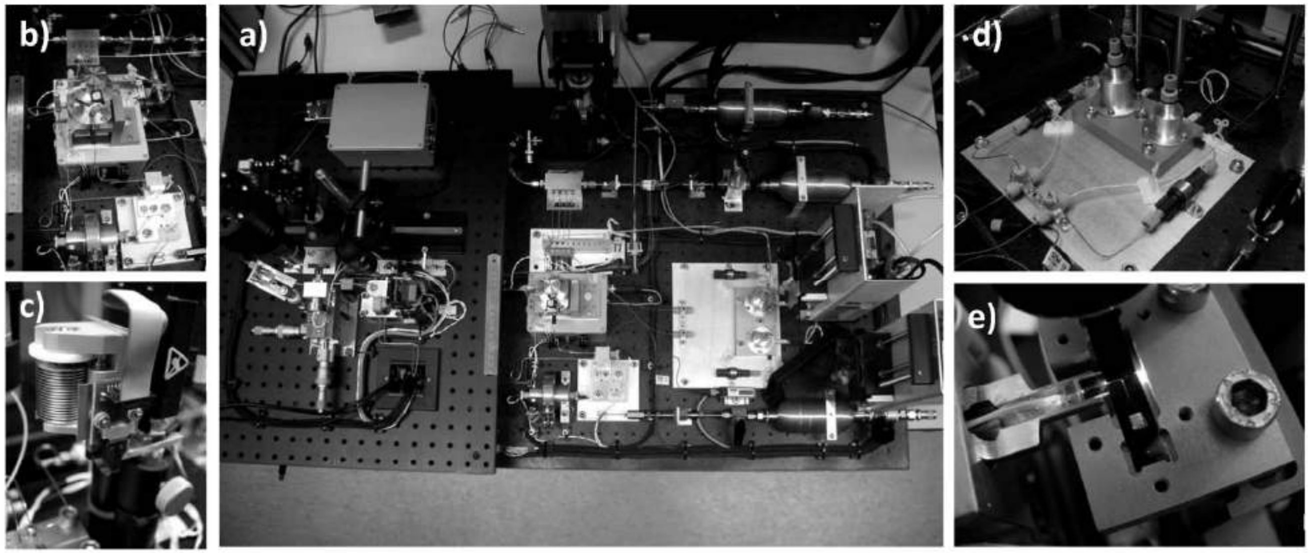
The Life Marker Chip

Thanks to Mark Sims, Dave Cullen, Richard Court

Life Marker Chip

- Detects organic compounds
- Uses an antibody array
- Specific and sensitive





(a) End to End demonstrator at Uni. Leicester
(b) SPS system, flight-like inlet volume (top), waste chamber (bottom),
(c) flight-like bellows pump from AS,
(d) flight-like fluid cartridges,
(e) proof of concept silicon nitride waveguide.

Sephton et al. 2013. Planet Space Sci, doi: 10.1016/j.pss.2013.04.016.

Conventional geochemistry

Conventional organic geochemistry extraction

- Eglinton 1969

Remove surface

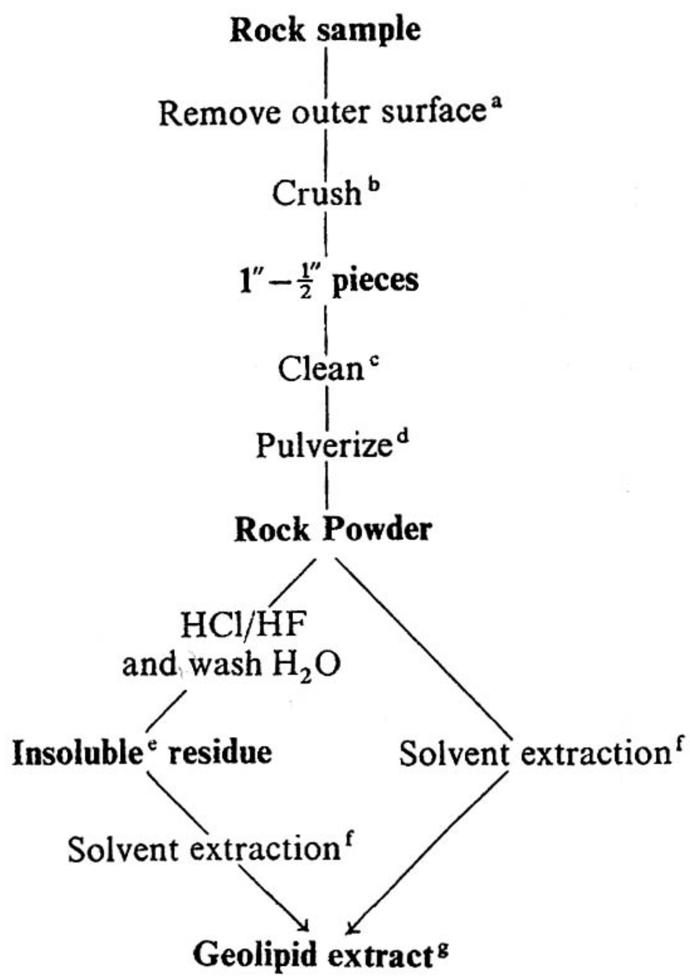
Powder

Organic solvent

- Free compounds
- “Like dissolves like”

Demineralizing acids

- Kerogen



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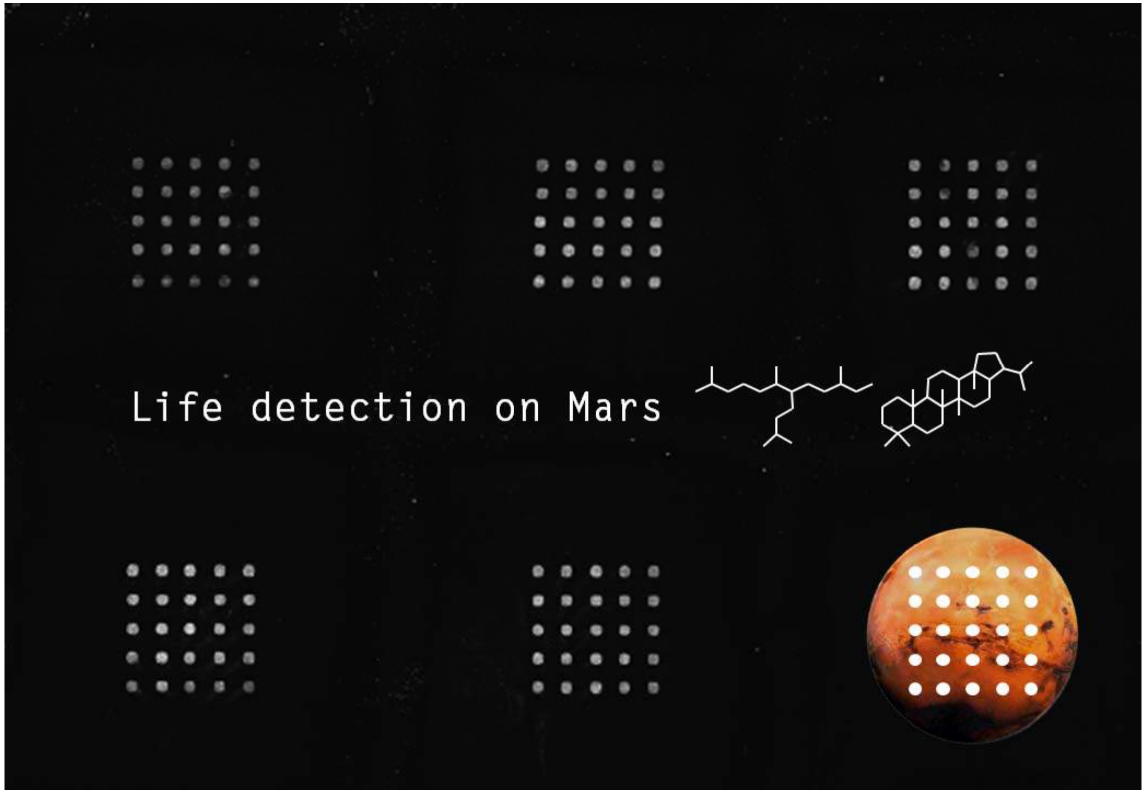
Unconventional geochemistry

Life Marker Chip Detector relies on **antibodies** which are proteins so new water-based solvents are needed



Sephton et al. 2013. Planet Space Sci, doi: 10.1016/j.pss.2013.04.016.

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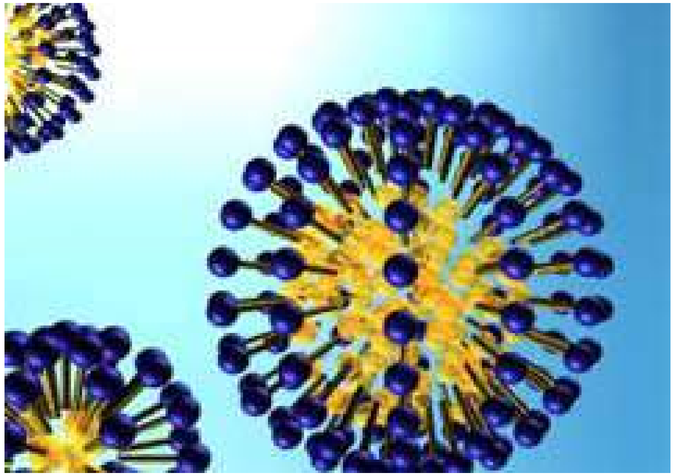
New solvents

Surfactant solutions

- Organic additives with water loving and water hating parts
- Spontaneously form spheres with analyte inside
- Polysorbate 80 for Mars - Court et al. 2010

Subcritical Water

- Polarity changes with temperature and pressure
- Polar compounds at low temperatures
- Hydrocarbons at high temperatures
- Tuneable for selective extraction



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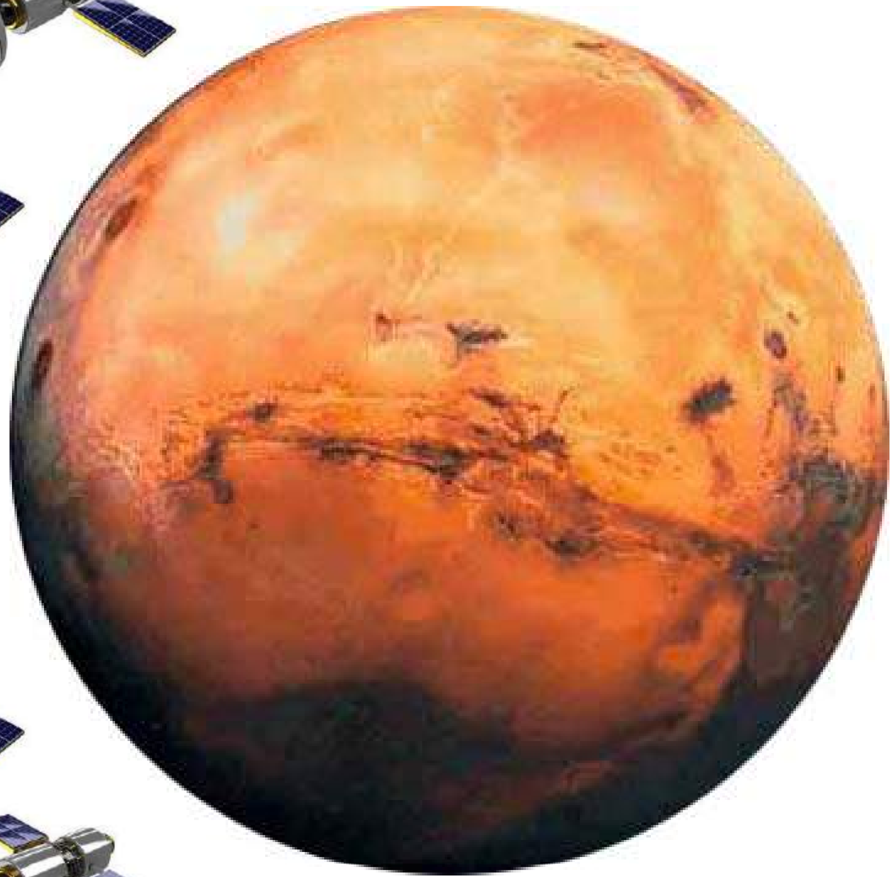
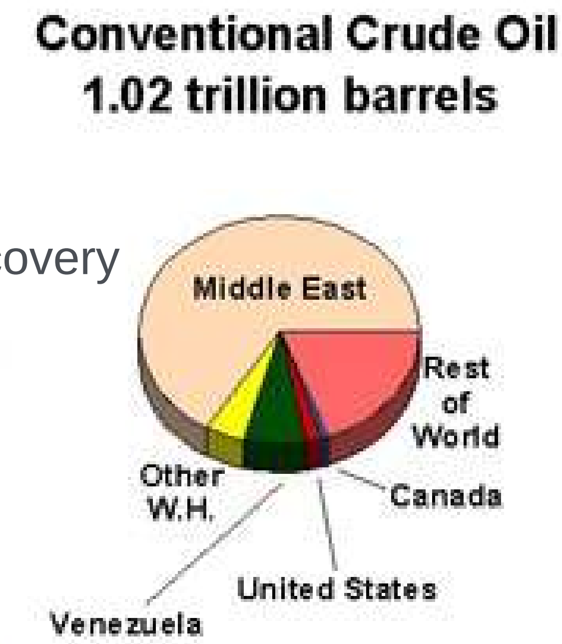
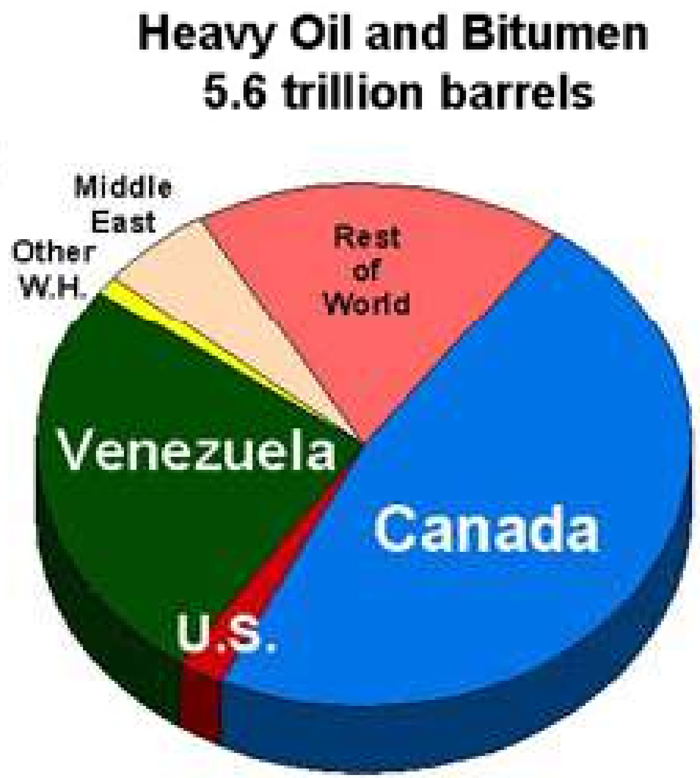


Unconventional solutions to unconventional oil

- Global resources.
- Dominated by heavy oil.
- Politically stable.
- Difficult to extract.

- Water use
- Steam assisted recovery





Meyer, R.F. and W. De Witt. 1990. U.S.G.S. Bulletin.

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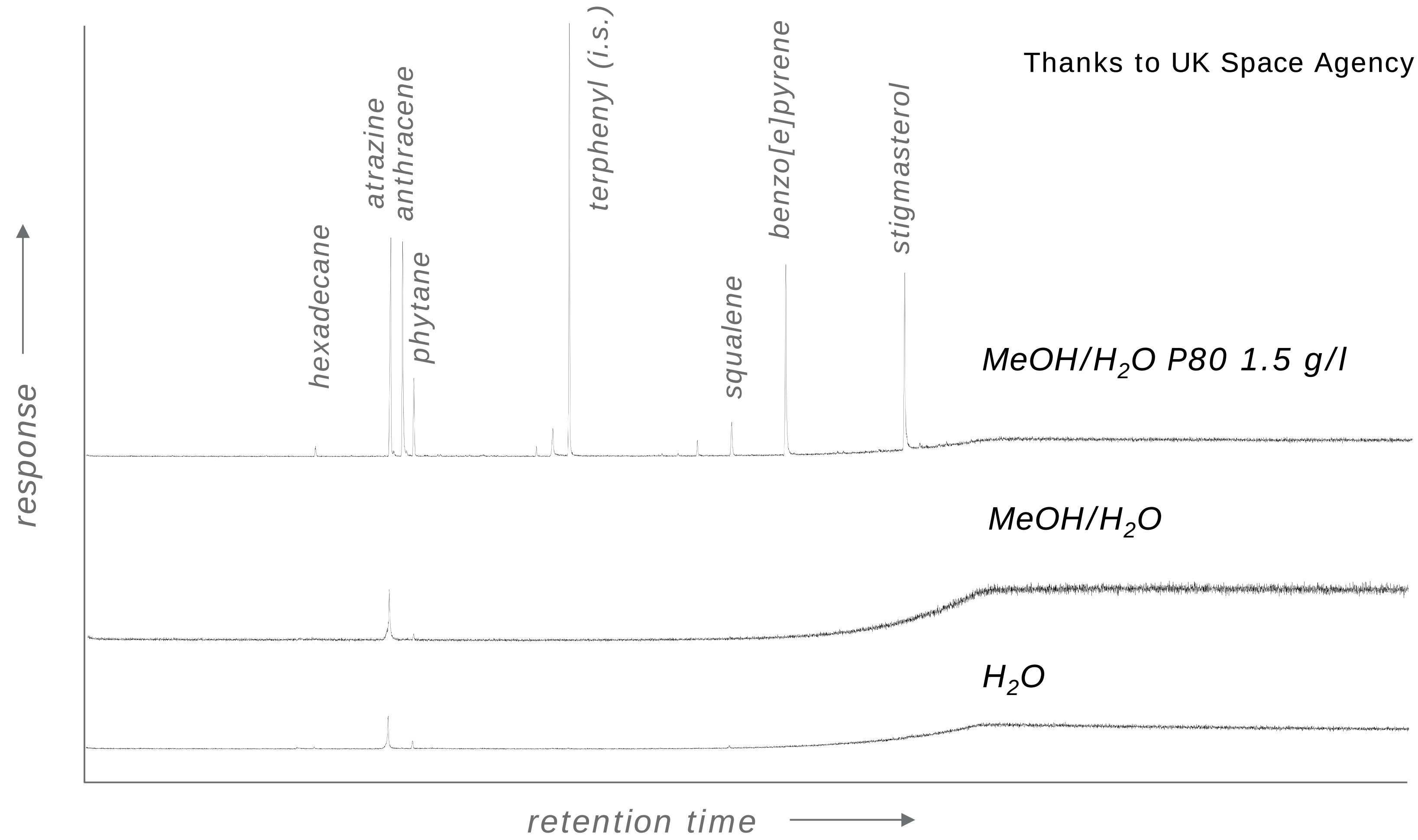
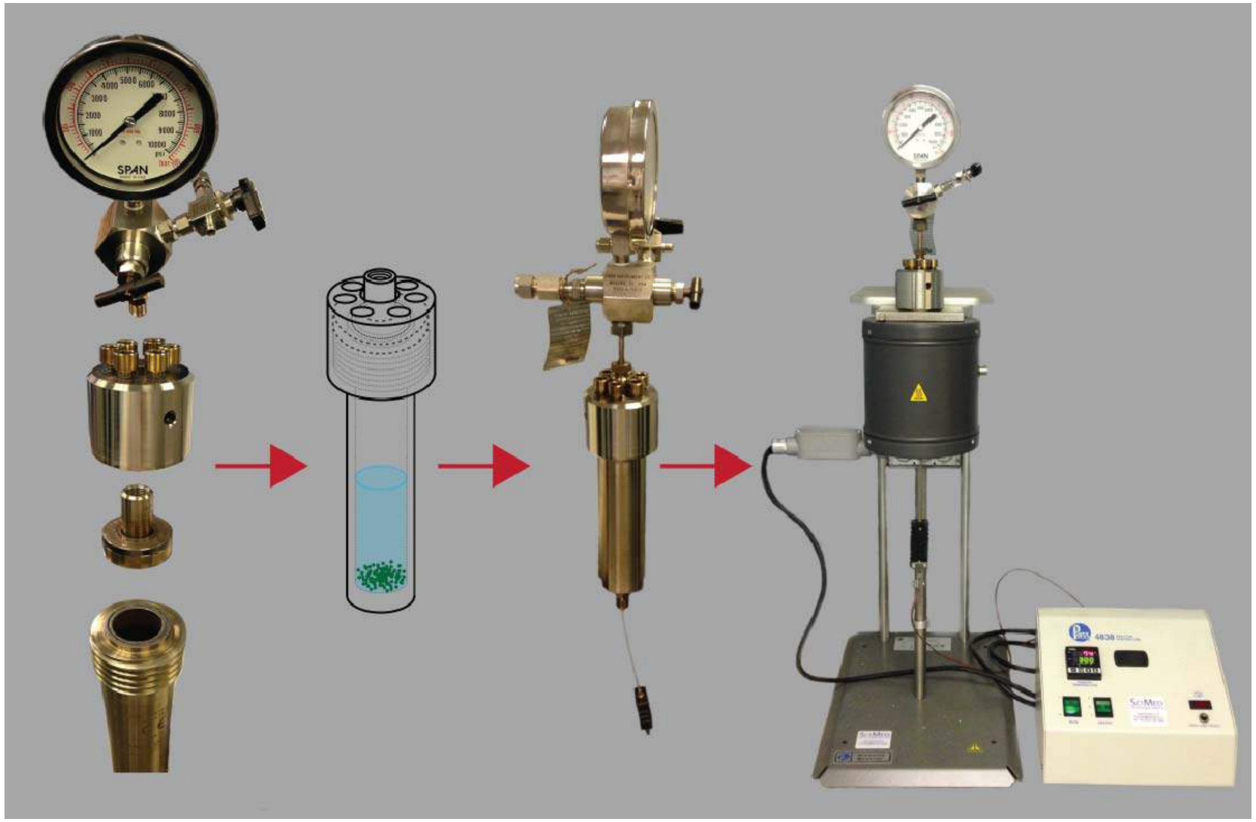
Aqueous vs surfactant solvents



Court et al. 2010, Planet Space Sci 58, 1470–1474

Subcritical Water

Thanks to UK Space Agency



Montgomery et al. 2013, Fuel 113, 426-434

(James Lewis – Figure)

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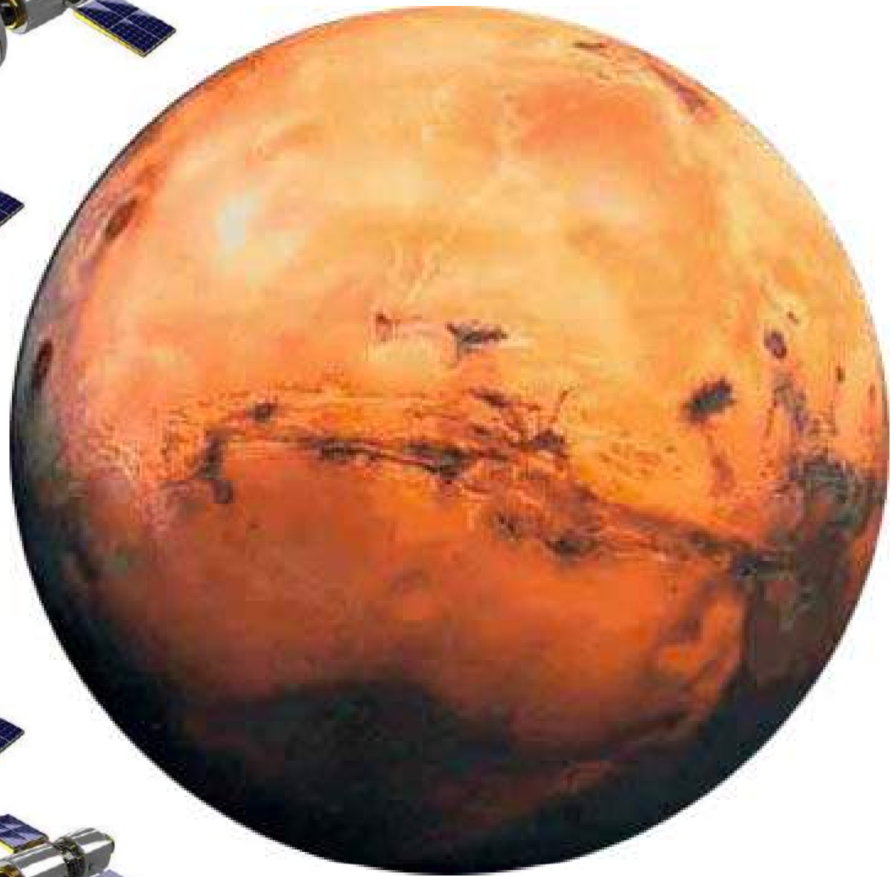

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The use of analogues

EMBARGOED

BBC - Mission to Mars (2013)

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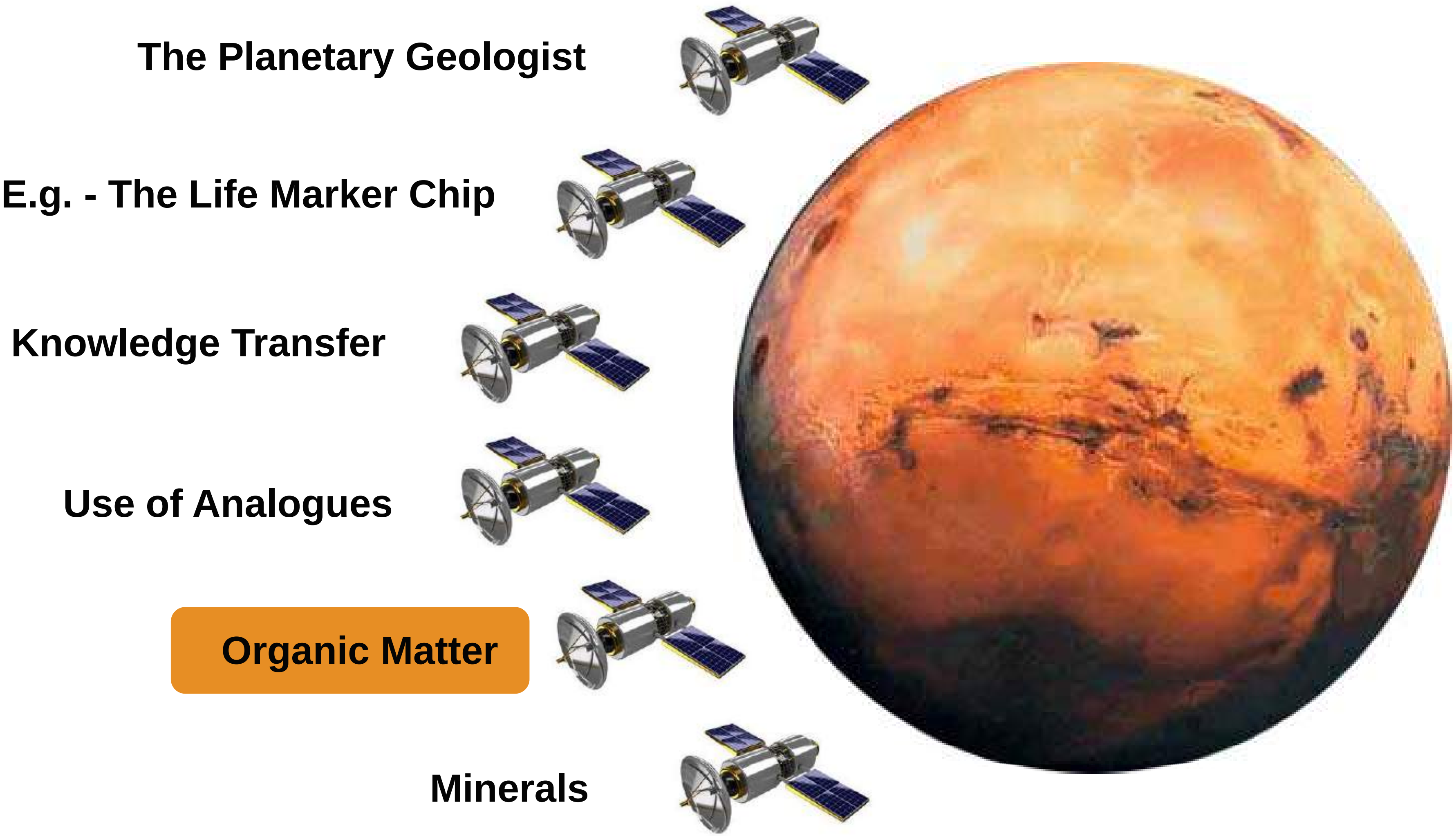
Presentation Outline



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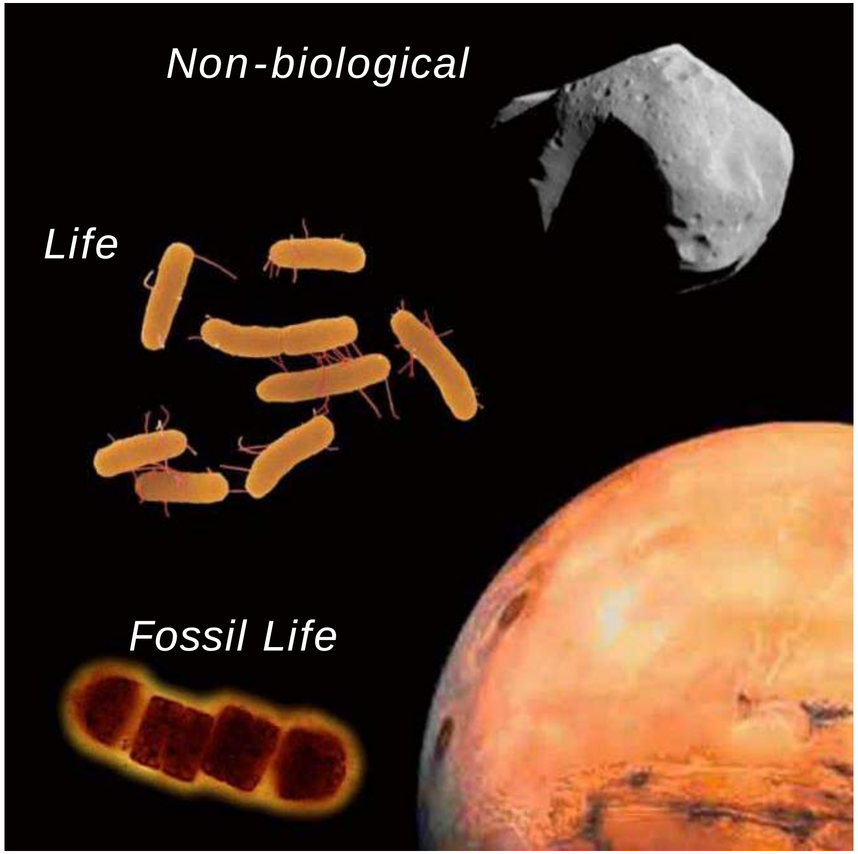
Organic Matter on Mars

- Non-biological
  - Life's precursors
  - Diverse structures
- Life
  - Biological
  - Delicate
  - Specific structures
- Fossil life
  - Robust remnants
  - Degraded and metamorphosed
  - Stable structures



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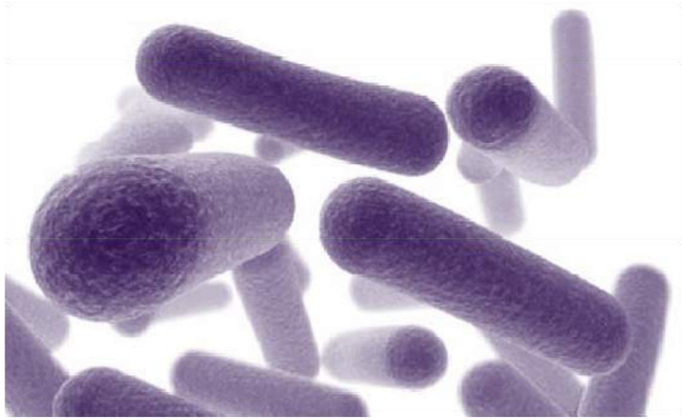
Life constitution

Bacterium	% wt	No types of each molecule
Water	70	1
Inorganic ions	1	20
Small organic molecules	6	750
Very large organic molecules	22	5 000



Most of the molecules in a living system

- Very large organic molecules
- Macromolecules

Macromolecules can be subdivided into four different types:

- Lipids
- Carbohydrates
- Proteins
- Nucleic acids

Macromolecules are products of combining many individual organic units

- Hydrocarbon-dominated units
- Sugars or polyols
- Amino acids
- Nucleobases, etc.

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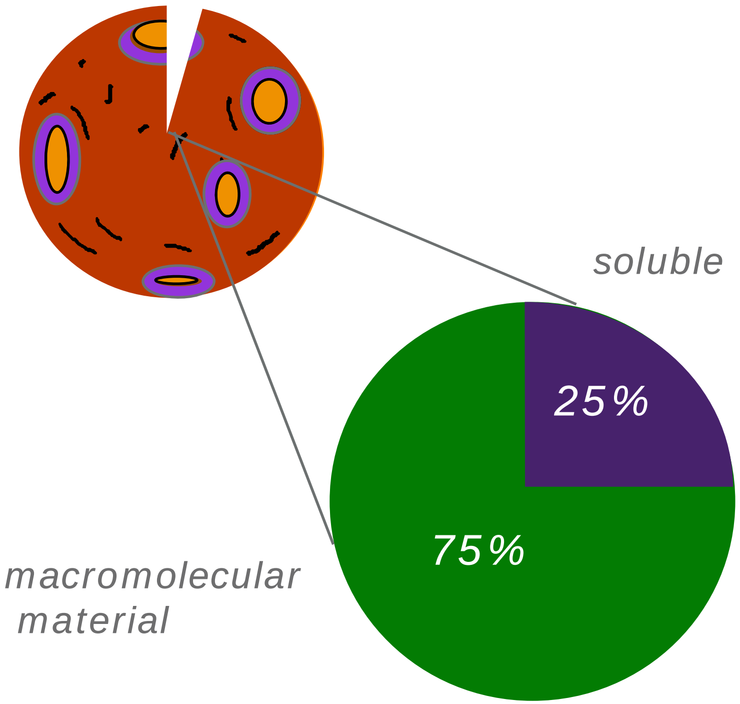
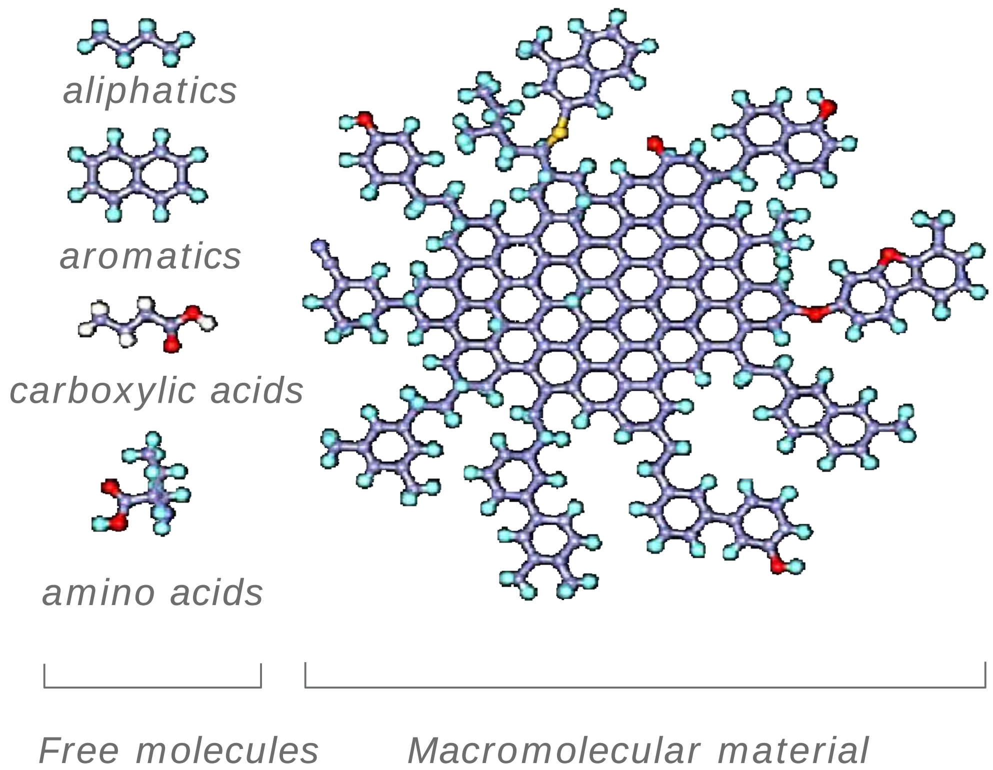
Meteorite constitution

Carbonaceous chondrites
- *Up to 5% organic matter*



Meteoritic organic matter
- *25% solvent soluble or "free"*
- *75% insoluble, macromolecular*
- *$C_{100}H_{71}O_{12}N_3S_2$ (Hayatsu et al. 1977)*



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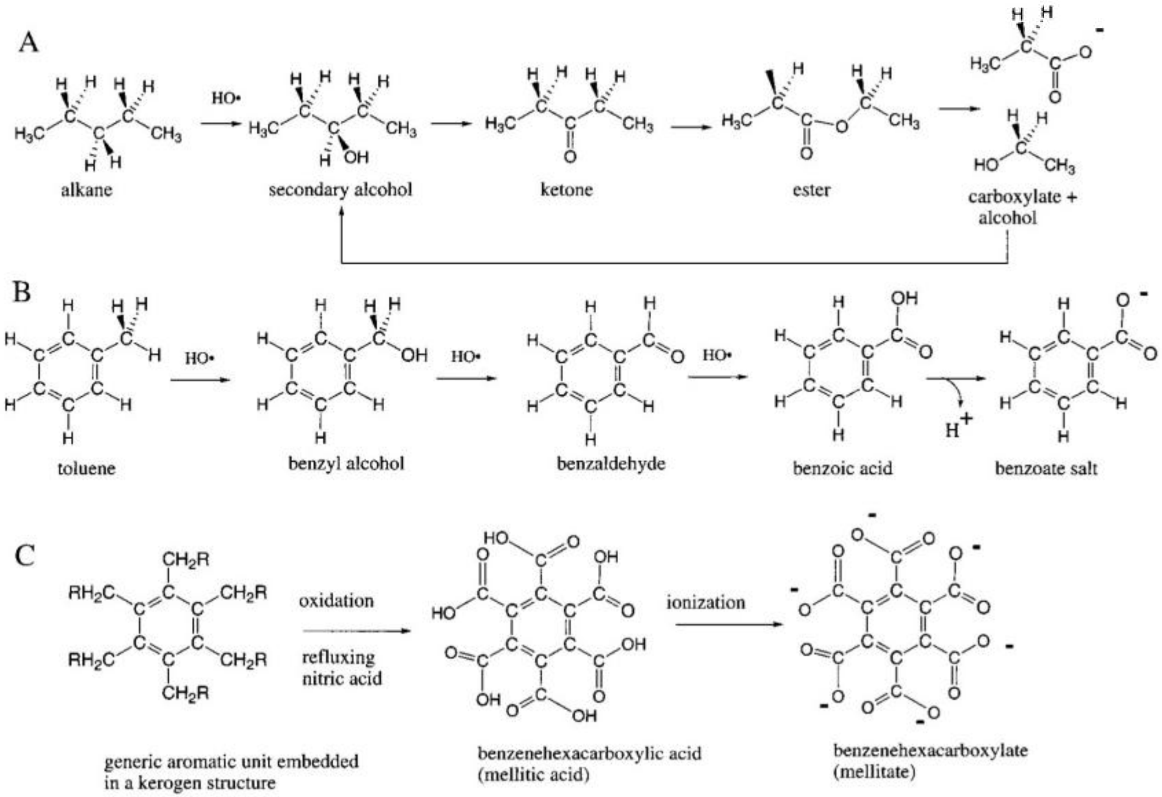
Mars & degradation



No organic molecules detected by Viking GC-MS

2.4 x 10^8 g carbon comes to Mars each year via meteorites

Oxidative degradation

- Units lost, residues produced

Benner et al. 2000 PNAS 97, 2425–2430

- A) pentane, B) toluene, C) kerogen

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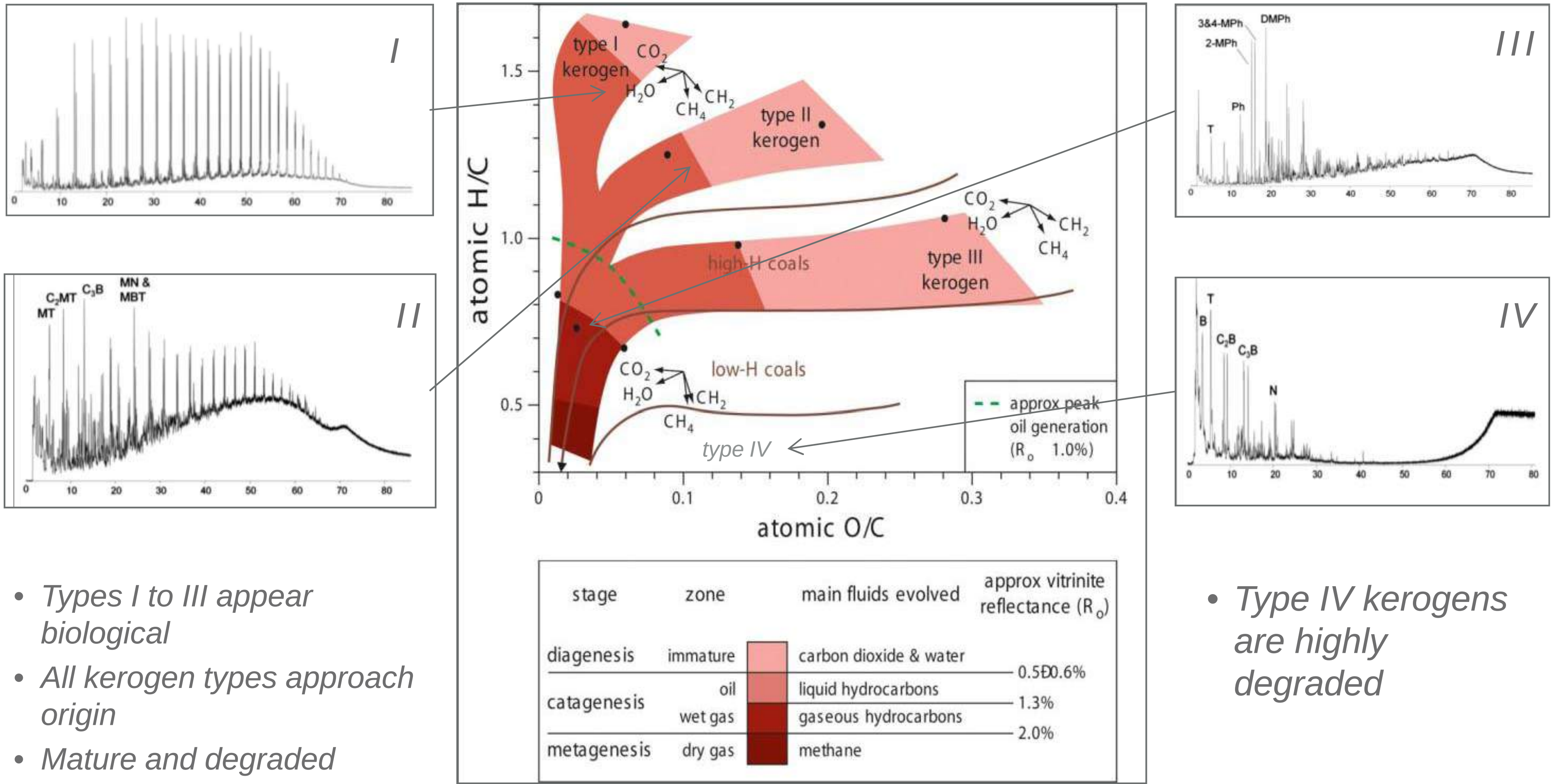
Kerogen Evolution



- *Types I to III appear biological*
- *All kerogen types approach origin*
- *Mature and degraded kerogens less faithful*

- *Type IV kerogens are highly degraded*

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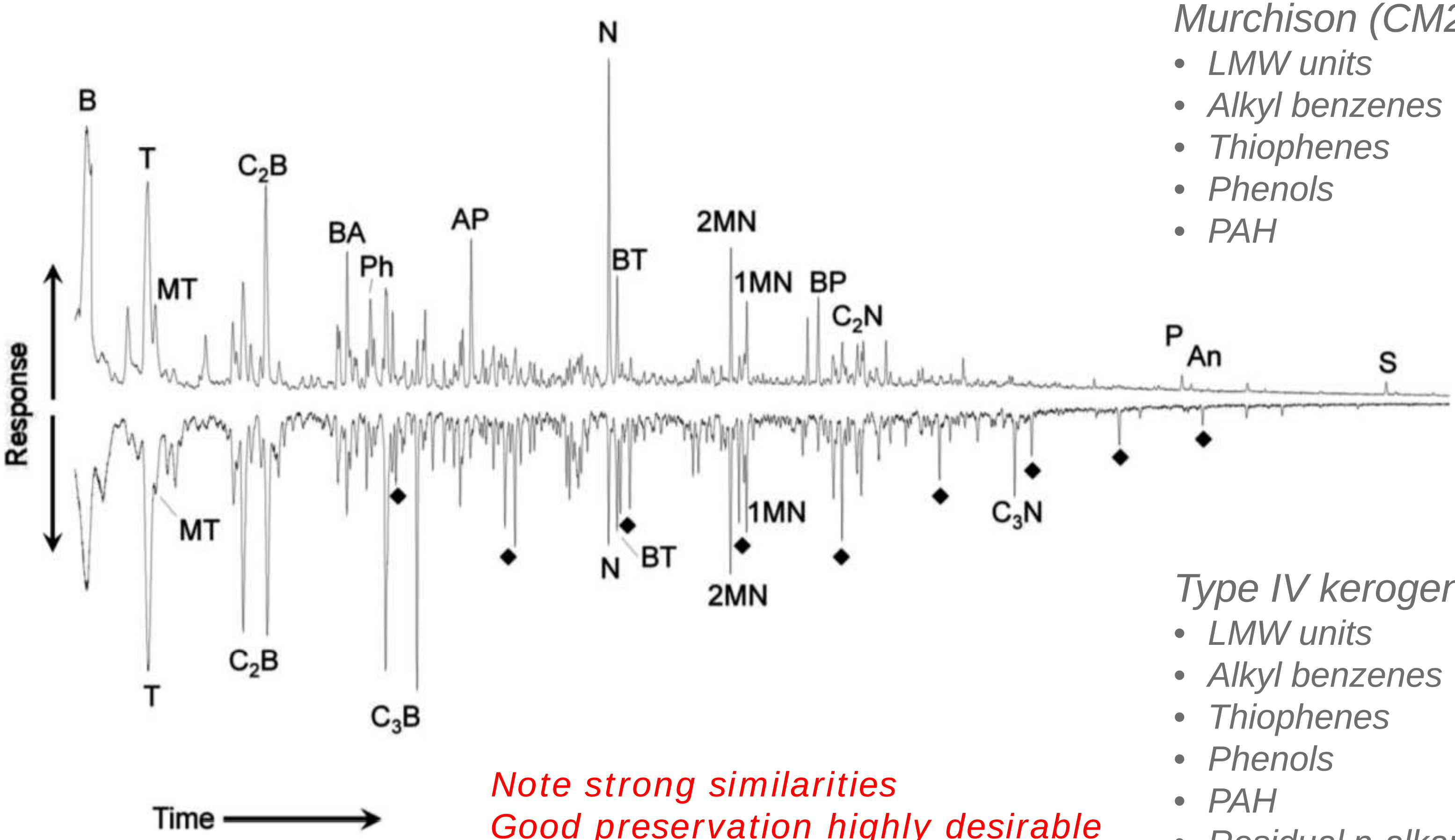
Meteorite & type IV organic matter



Murchison (CM2)
- *LMW units*
- *Alkyl benzenes*
- *Thiophenes*
- *Phenols*
- *PAH*

Type IV kerogen
- *LMW units*
- *Alkyl benzenes*
- *Thiophenes*
- *Phenols*
- *PAH*
- *Residual n-alkanes*

Note strong similarities
Good preservation highly desirable

Matthewman et al. 2012 Astrobiology 13, 324-333

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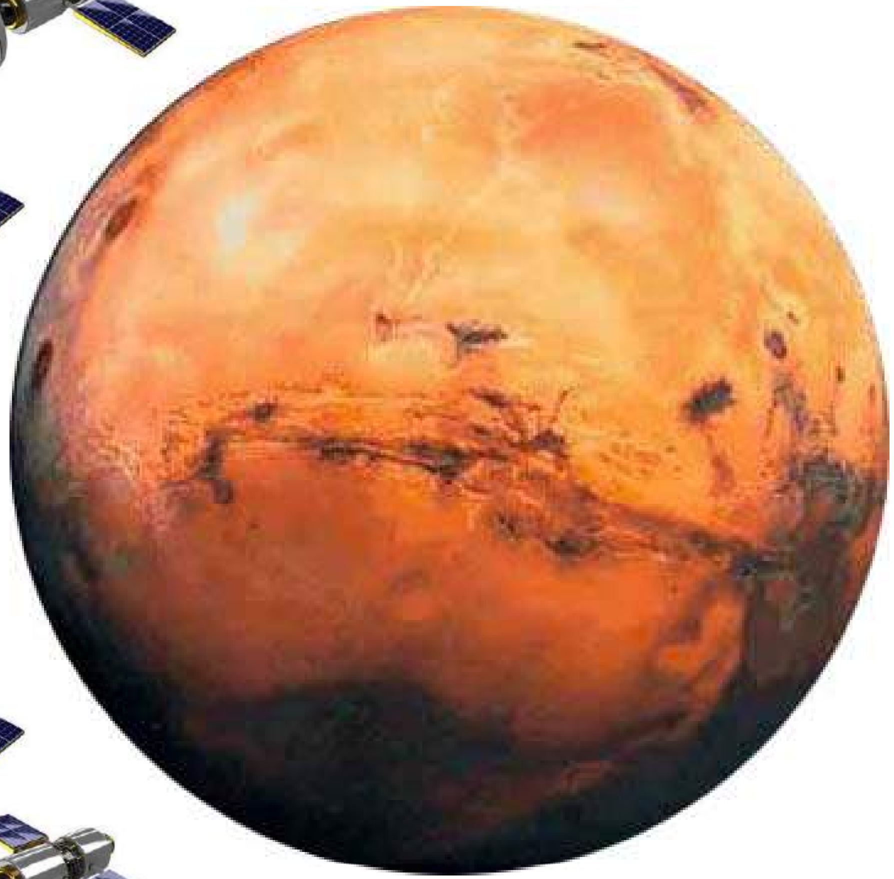


Earth's organic matter and minerals

Earth's organic matter

- 90% of that accumulating is in coastal margins
- Intimately associated with mineral surfaces

Mineral hosted organics

- 83% organic matter on minerals is irreversibly adsorbed
  - » Hedges & Keil 1995
- Organic content directly related to minerals surface area
- Equivalent to a monolayer coating (0.86 mgCorg m^{-2})
  - » Meyer 1984

Minerals

Mineral	Surface area m^2/g	Organic coating mg/g	Irreversible mg/g
Ferrihydrite	134	120.6	76.3
JSC Mars-1	106	95.4	96.5
Smectite	52.7	47.4	37.9
Dunite	2.8	2.6	2.0
Volcanic tuff	13.7	12.3	9.9
Volcanic tuff & Mg sulfate (1:3)	11.3	10.2	8.1

- Surface areas of Martian mineral analogues calculated by Pommerol et al. (2009).
- Data can be used to predict monolayer organic contents.
- Phyllosilicates are particularly important minerals for the entombment and preservation of organic matter. Phyllosilicate formation requires water and therefore conditions that are conducive to life.
- Such deposits are important targets for life search missions.

Sephton et al. 2013. Planet Space Sci, doi: 10.1016/j.pss.2013.04.016.

Mars minerals in time

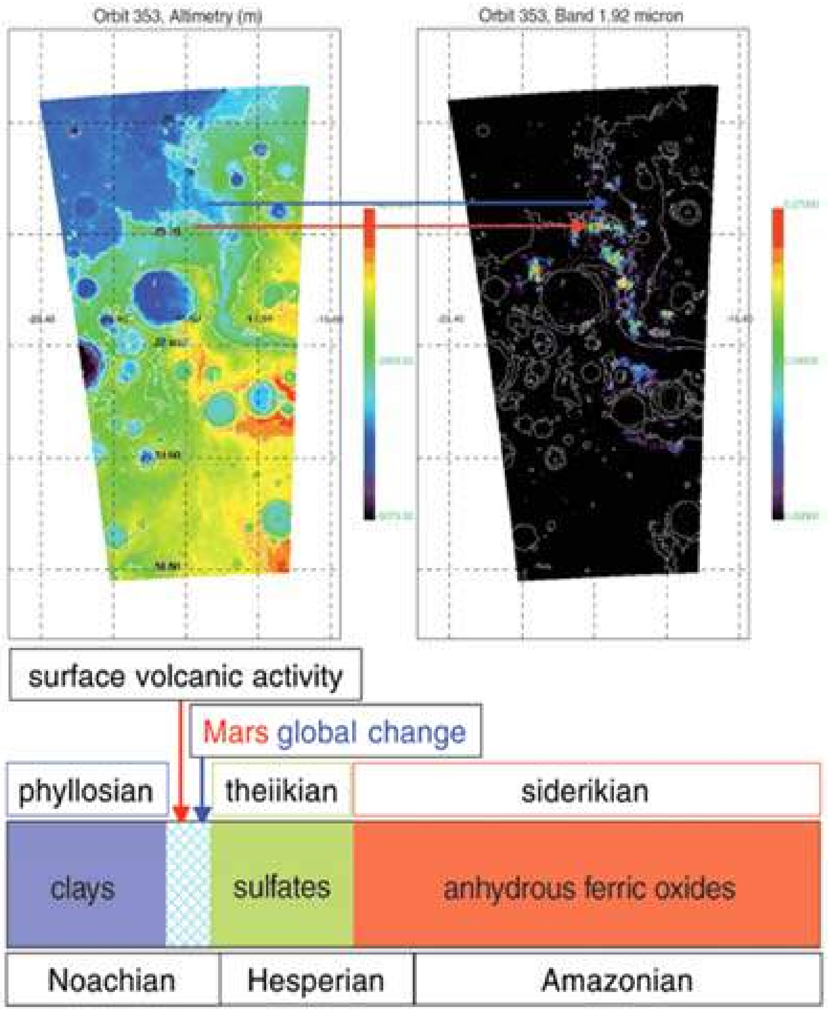
The OMEGA/Mars Express imaging spectrometer

- Bibring et al. 2006, Science 312, 400 - 404

Recognized mineralogically and temporally-distinct areas on Mars

- Phyllosilicates
- Sulfates
- Ferric oxides

Will organic contents be directly related to mineral surface as on Earth?



Earth Science & Engineering

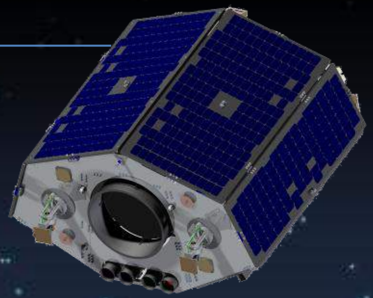
Name	Area
Dr Gareth Collins	Impact Cratering
Dr Richard Court	Astrobiology
Dr Matthew Genge	Meteoritics
Prof Sanjeev Gupta	Surface processes
Prof Joanna Morgan	Geophysics
Dr Adrian Muxworthy	Magnetics
Dr Zita Martins	Astrobiology
Prof Mark Rehkamper	Geochemistry
Prof Mark Sephton	Organic Geochemistry

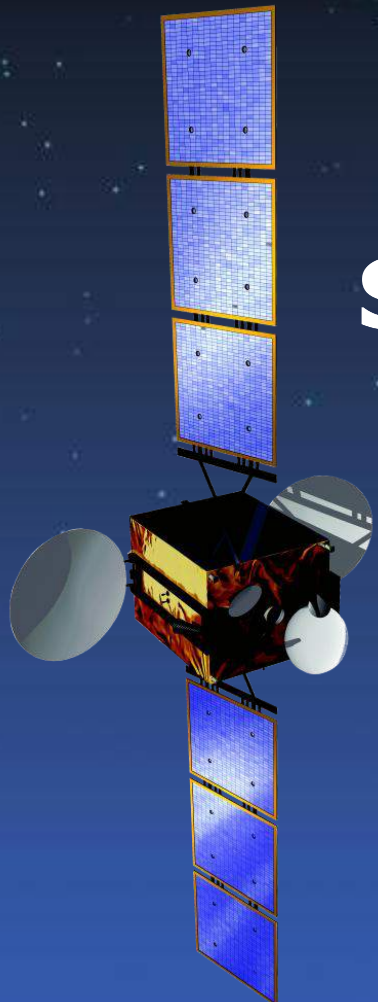
IARC
Impacts &
Astromaterials
Research Centre

Mars Extracts

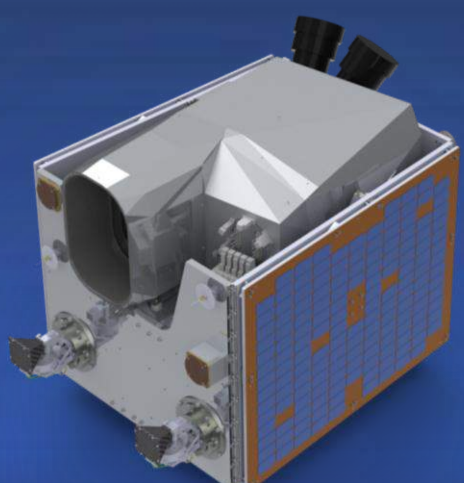
Thank you ...

SURREY SATELLITE TECHNOLOGY LTD *Changing the economics of space*





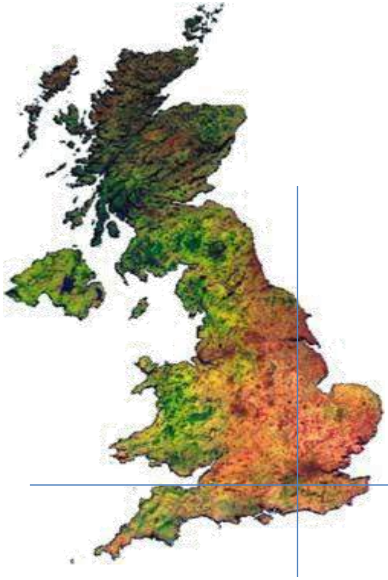
SSTL – British Innovation in Space

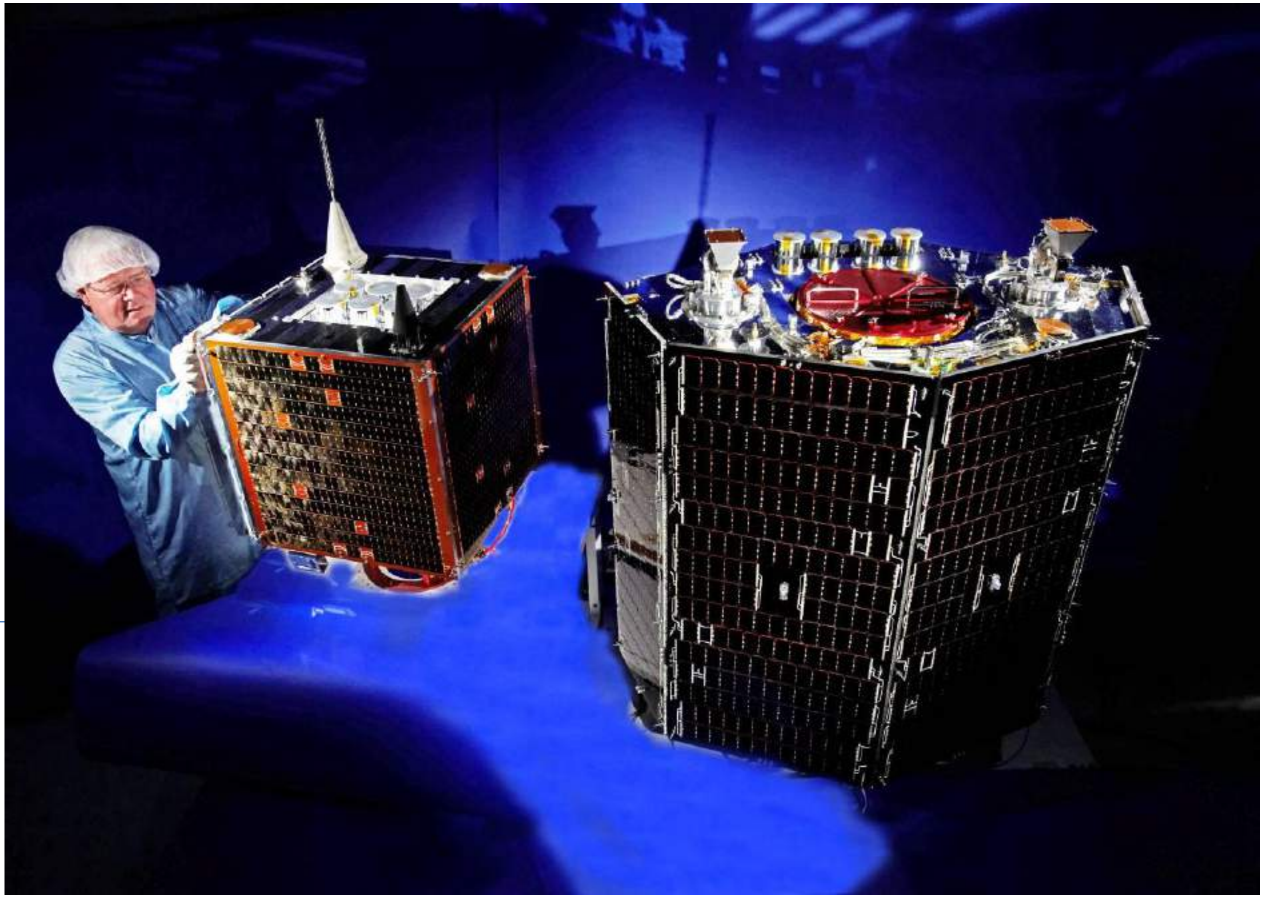


Philip Davies
Business Development Manager
1st July 2013

Changing the Economics of Space

This is achieved through:
Rapid-response small-satellites using advanced terrestrial technology

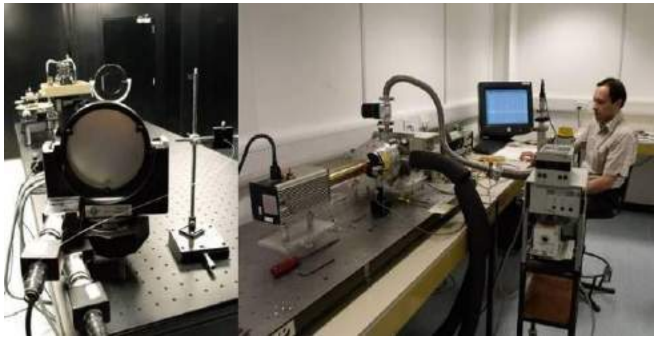




SSTL - The Company

UK satellite manufacturer is owned by
99% EADS Astrium 1% University of Surrey

Since 1985, employing ~600 staff
Facilities in Surrey, Kent, Hampshire & Colorado

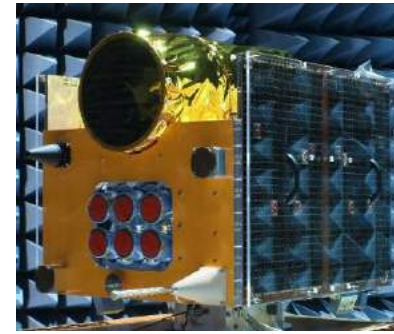


A History of Success

41 Satellites completed

27 payloads in progress

13 Further satellites in progress

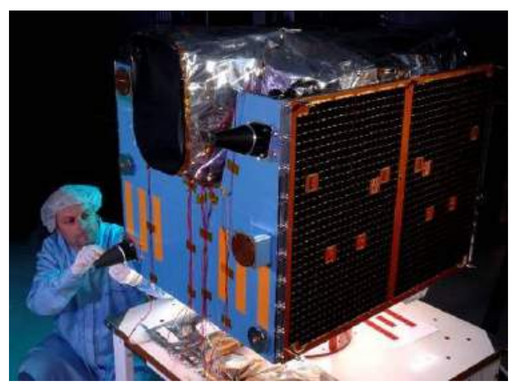


HERITAGE

Flight proven – low risk

RESULTS

All projects, fixed price, on-time and on-budget



UK SPACE AGENCY · esa · deimos imaging · MDA · Los Alamos National Laboratory · EADS astrium · ThalesAlenia Space · OHB System An OHB Technology AG Company · COM DEV

Ground Systems, Operations and Launch

- Minimal resources required
- Largely autonomous
- COTS based ground systems
- Low-cost launches

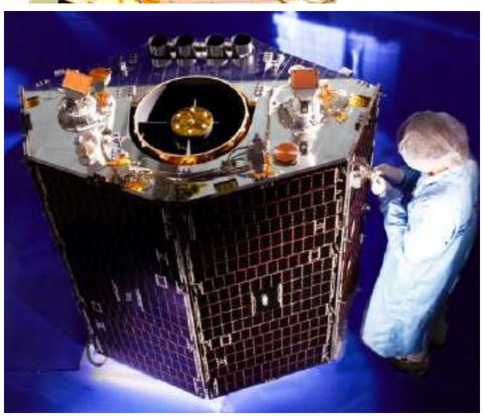
SSTL's Products & Services

SSTL 100 wide area imaging

Optical, RF payloads and geostationary comms

SSTL 150 high res imaging

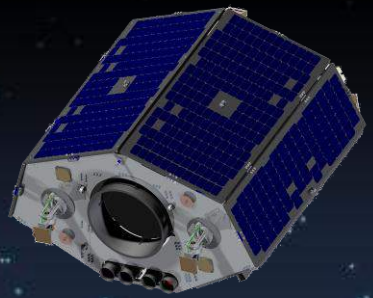
Bus equipment and rapid custom platform design



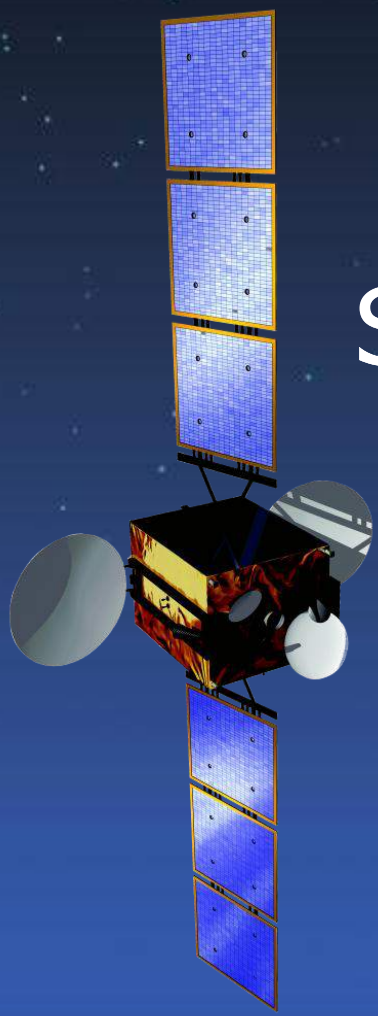
SSTL 300 high performance

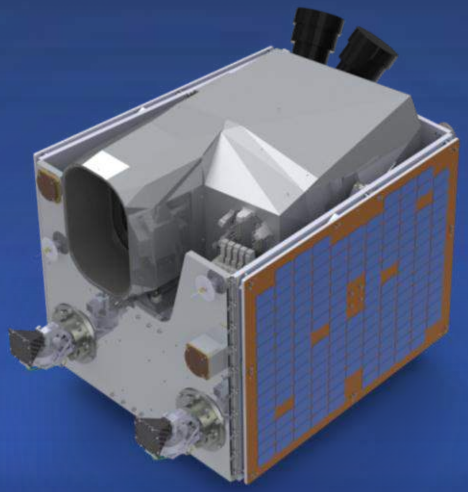
Global network of ground stations

SURREY SATELLITE TECHNOLOGY LTD *Changing the economics of space*

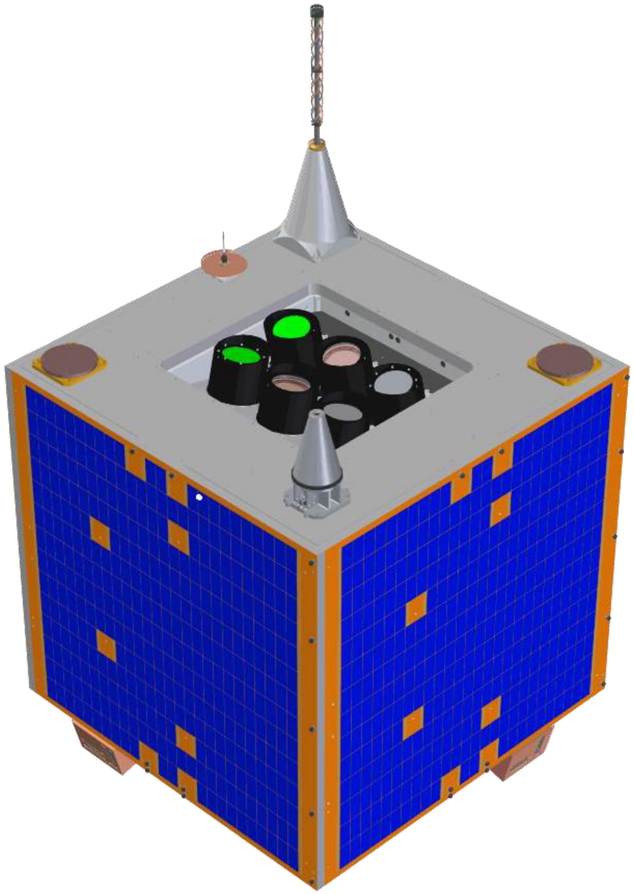


Systems & Applications





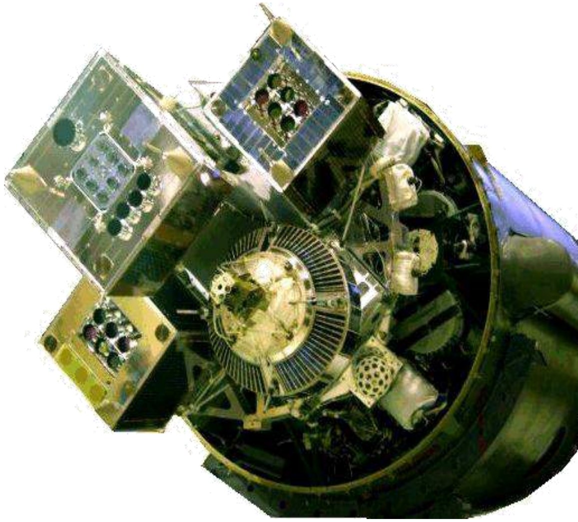
SSTL 100 - Compact Modular Platform



Diverse Payloads

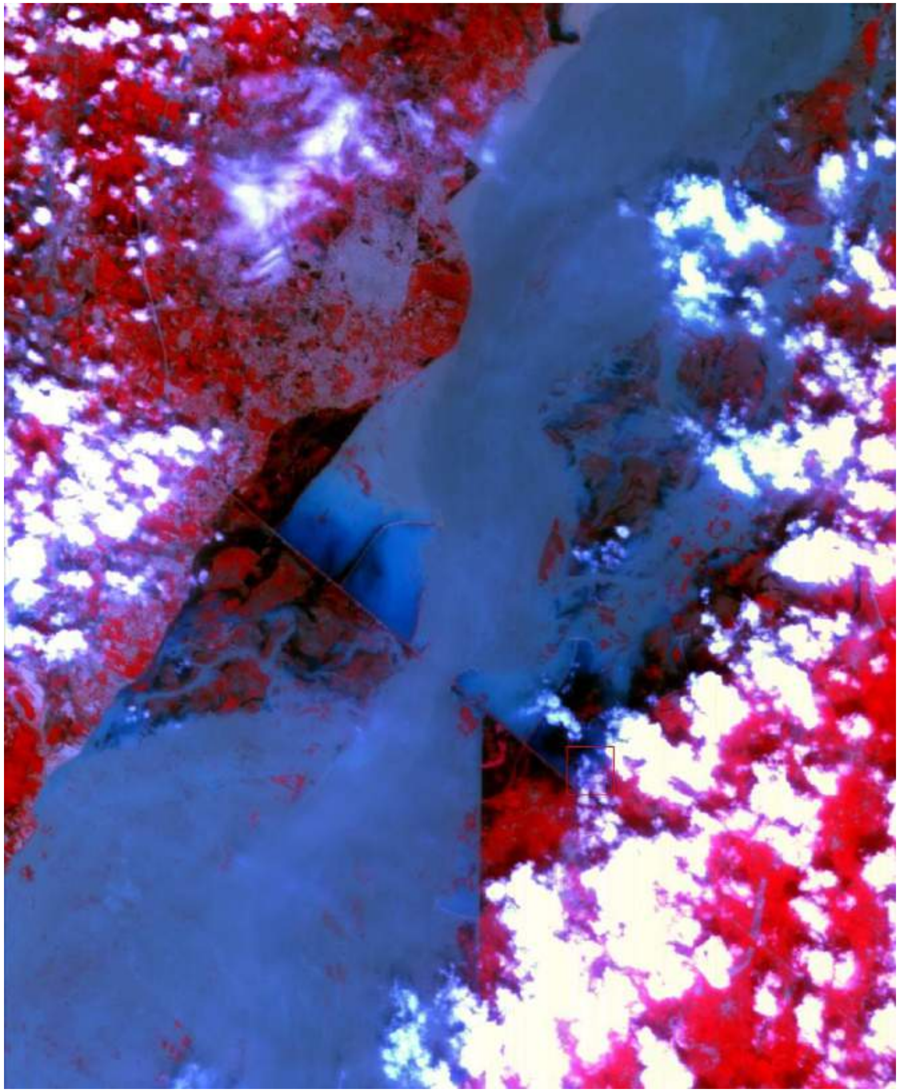
5 year design life

High speed downlink

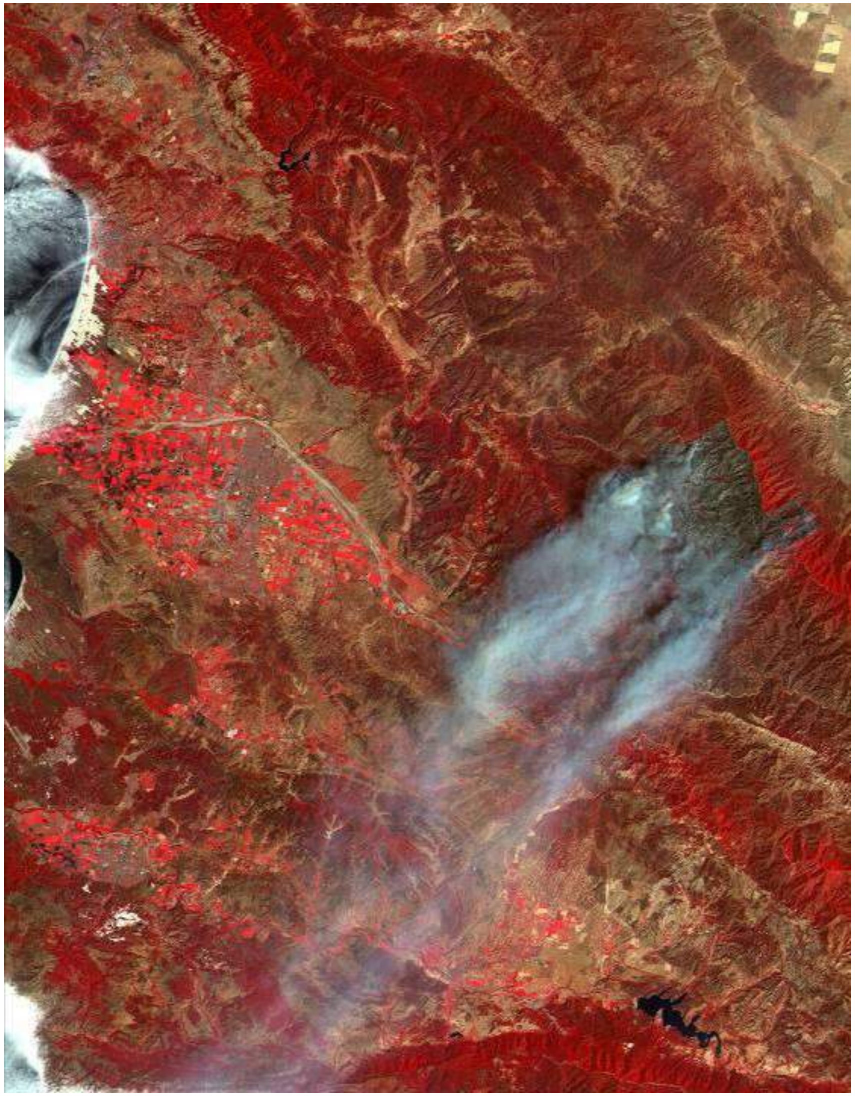


Microsat-70 (14 missions) SSTL-100 (8 missions)
AlSat-1 Bilsat NigeriaSat-1 UK-DMC Deimos-1 UK-DMC2
ADS-1B NigeriaSat-X

Disaster Imaging

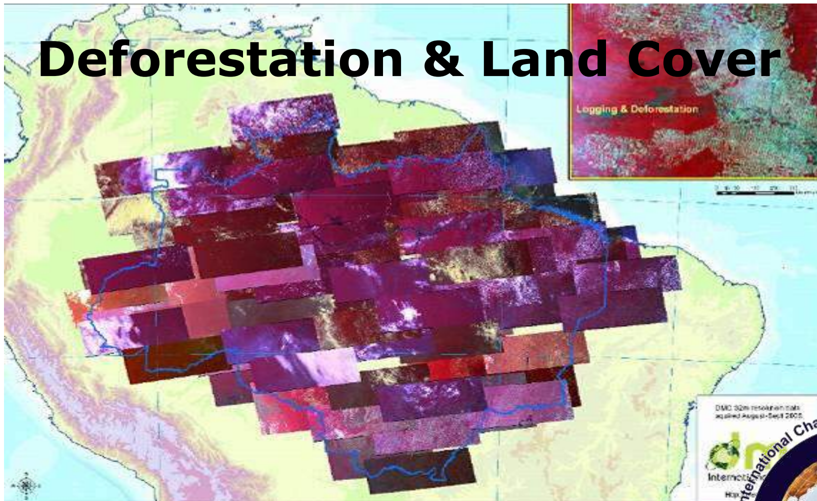


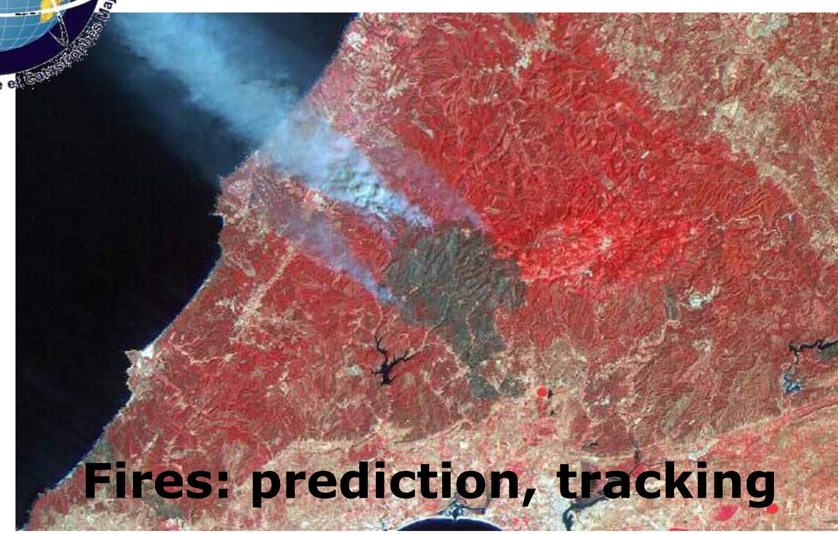
Flooding, Pakistan



Forest Fires, USA

Disaster Monitoring Constellation (DMC)





SSTL 150 - Enhanced Modular Platforms

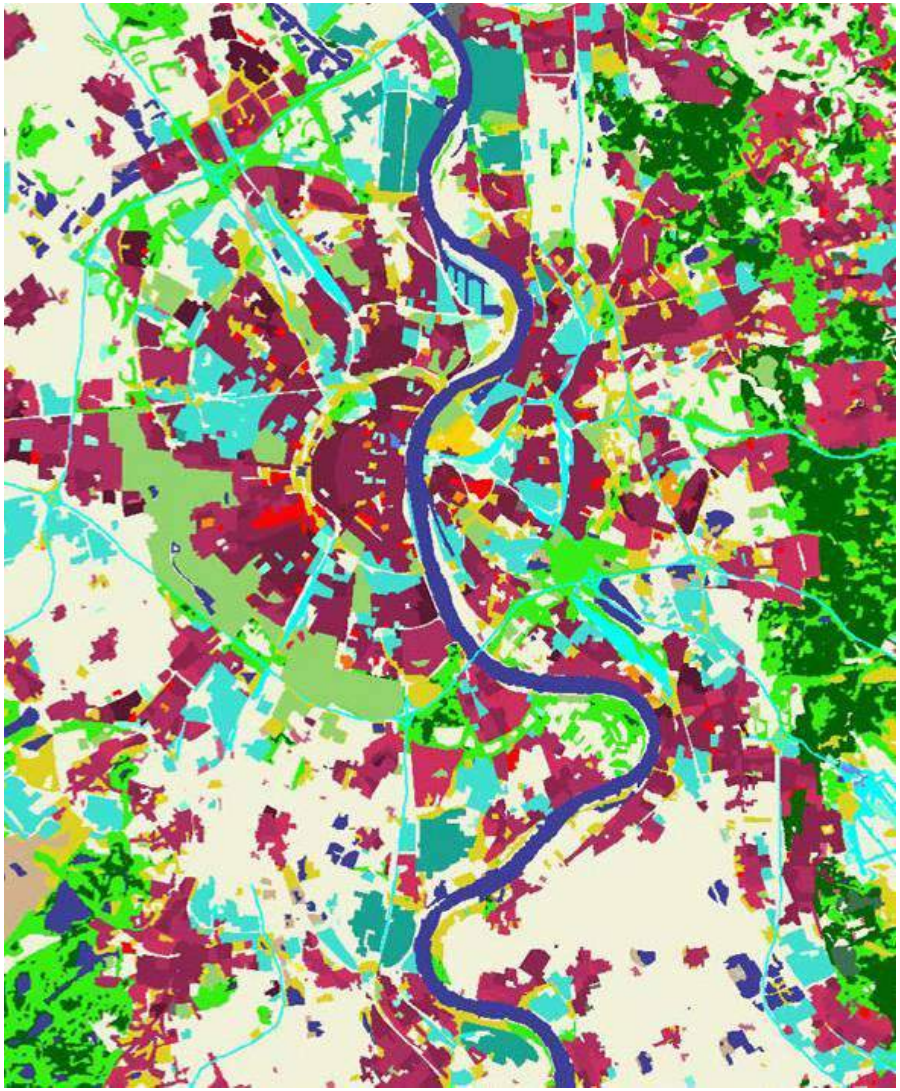
High-performance operational missions

- Higher performance
- 7-10 year design life
- Enhanced power
- Bigger payloads
- Payload data handling
- Propulsion system

TopSat, DMC+4, CFESat, Rapideye x5, Sapphire, TDS-1, Kaz-Mres

Sao Paulo Brazil

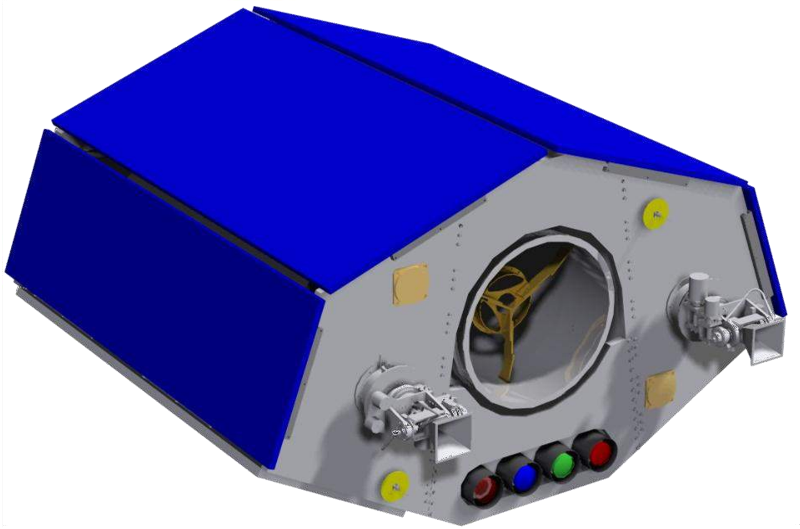
Urban Information

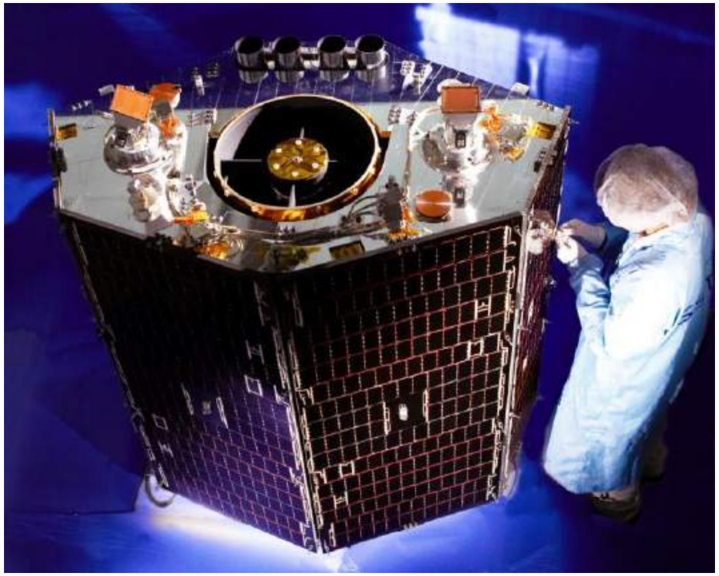


Land Cover Mapping, UK

Consumer Mapping, China

SSTL 300 – High Performance Platforms





Agile

2 Terabit onboard storage

210 Mbps X-band downlink

7 year life

2.5m PAN, 20km swath

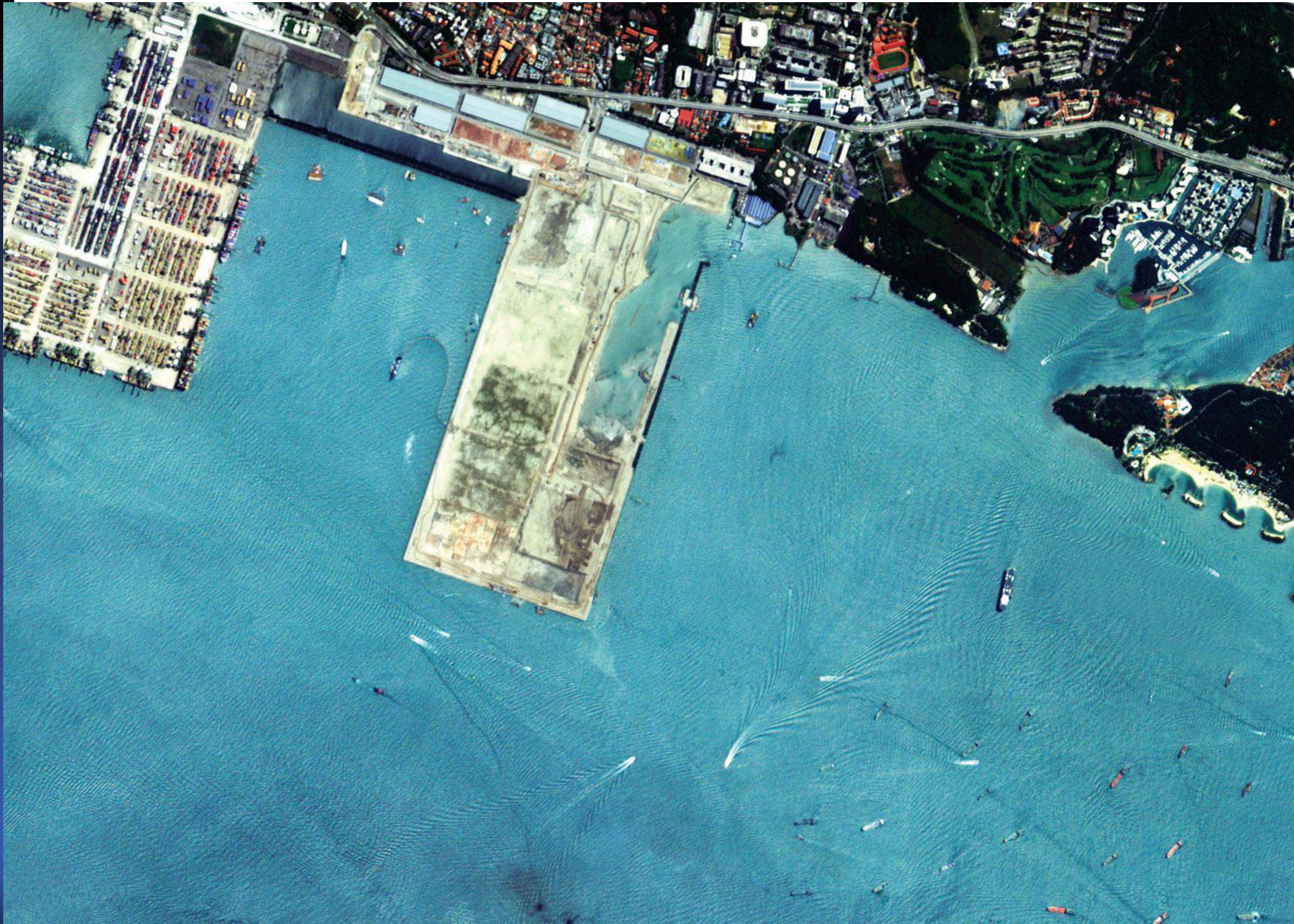
5m 4-band multispectral, 20km swath

32m 4-band multispectral 320km swath

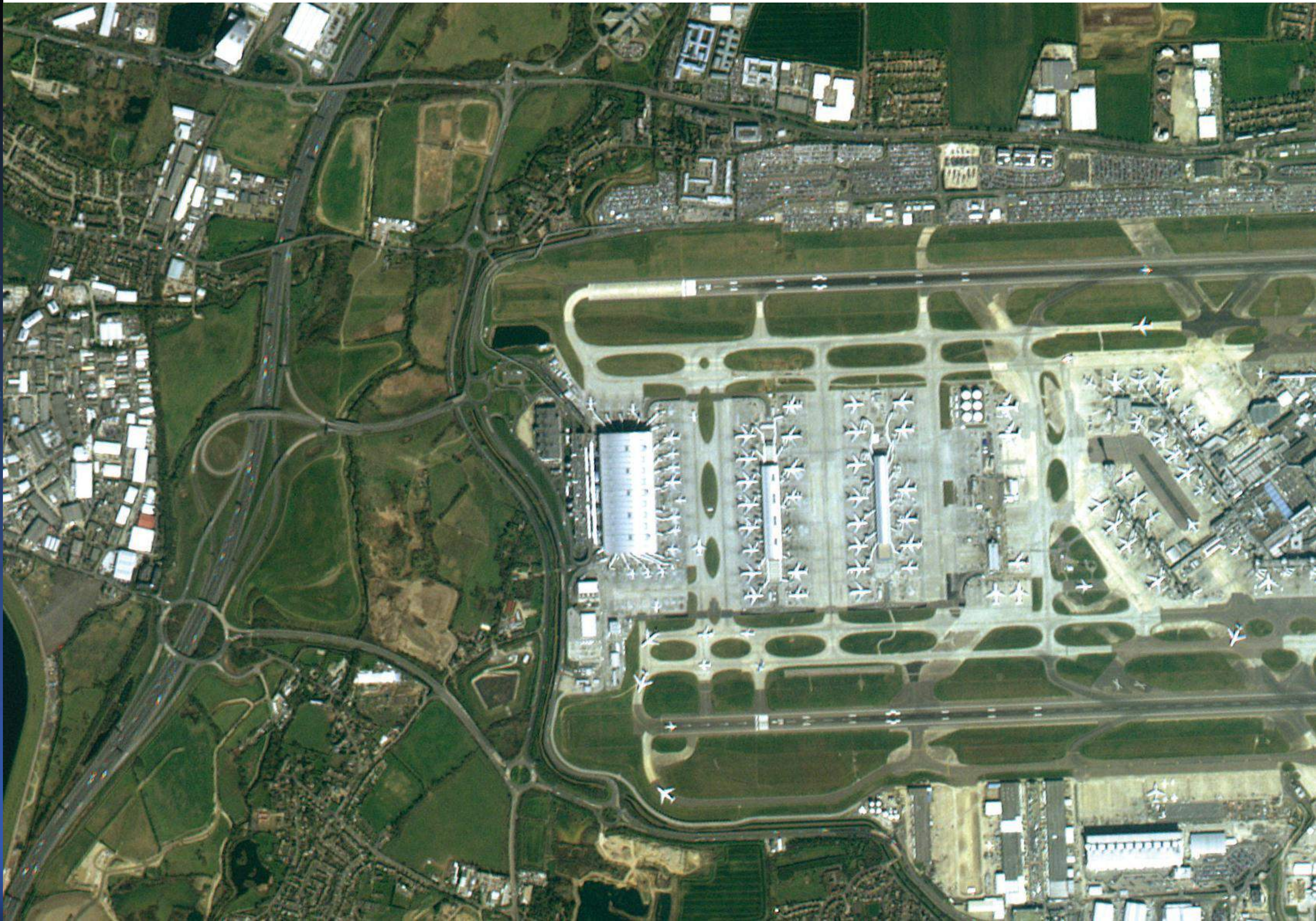
NigeriaSat-2 (2011), DMC3 (3 satellites, 2014)

Sydney, Australia

Singapore Strait

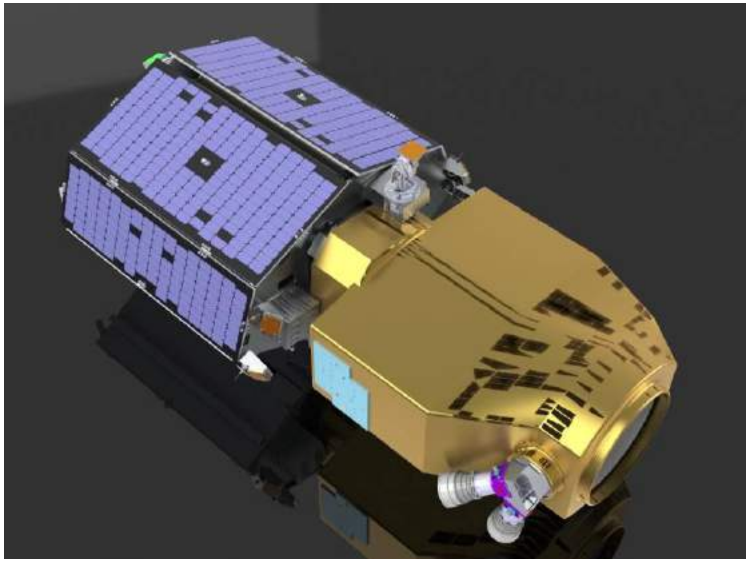


London Heathrow Terminal 5



Next Generation Imaging Missions

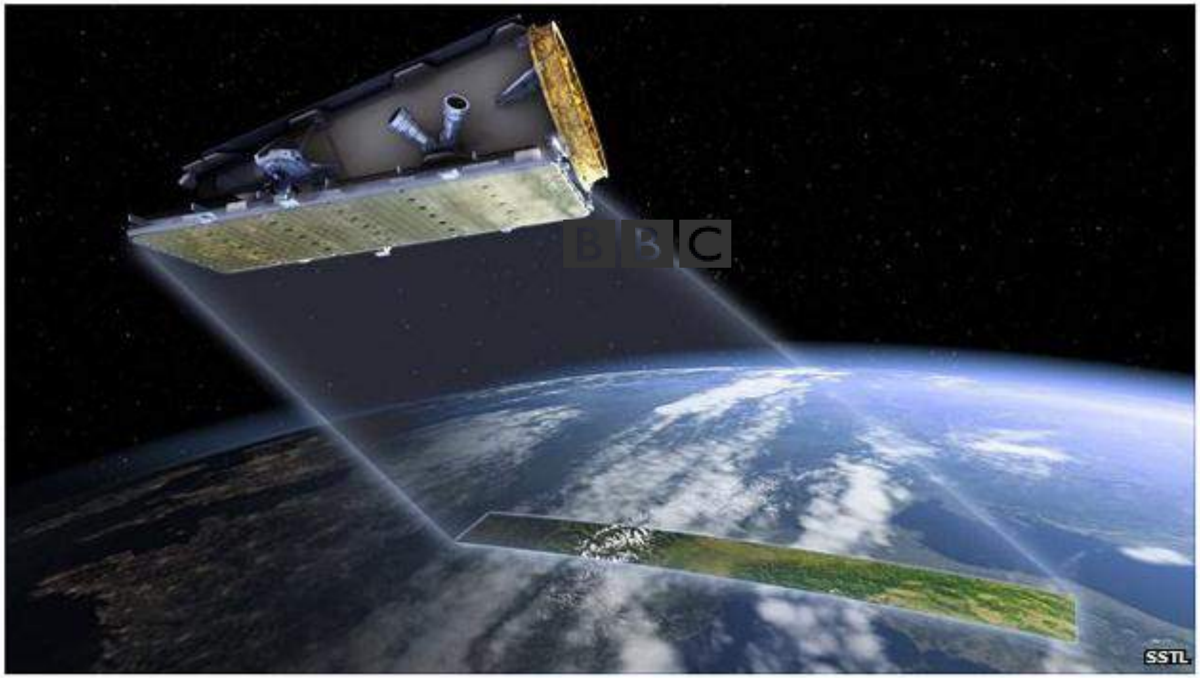
- DMC-3 high res 1m optical constellation
- Ready for launch 2014
- 3 spacecraft built by SSTL for DMCii
- Commercial service provision
- Worldwide daily access
- ~1.5 global access opportunities per day



The UK is Investing

UK space radar project initiated

By Jonathan Amos
Science correspondent, BBC News



The Chancellor's money will help get the first satellite in orbit to demonstrate its capabilities

The UK government is to kick-start an innovative project to fly radar satellites around the Earth, with an initial investment of £21m.

Radar spacecraft can see the planet's surface in all weathers, day and night.

Autumn Statement 2011

As it happened: Autumn Statement

NovaSAR

Low-cost SAR Satellite

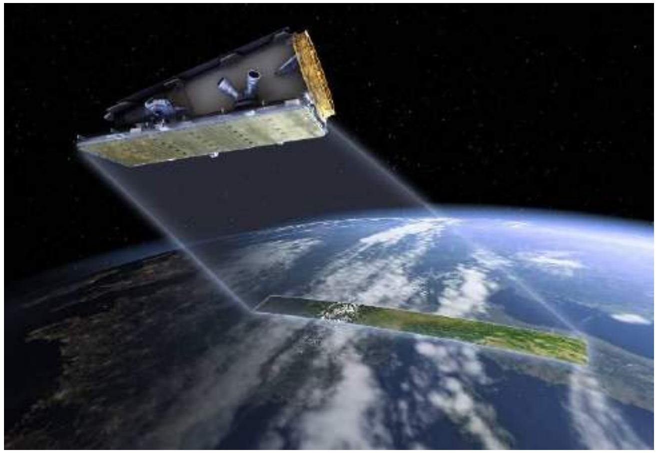
SSTL-Astrium Joint Programme

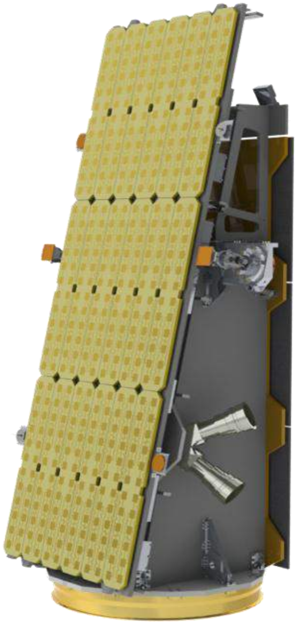
4 Modes: 6-30m Resolution

HMG £21m investment in first satellite

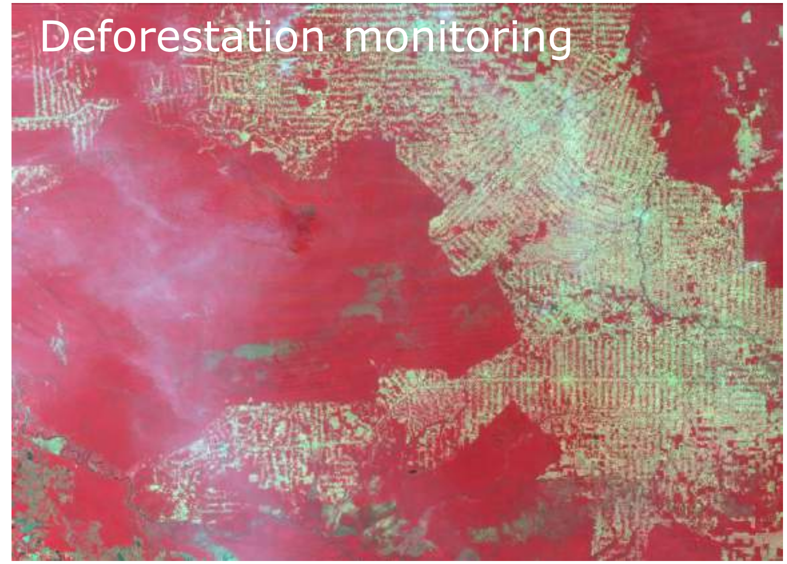
Constellation operations

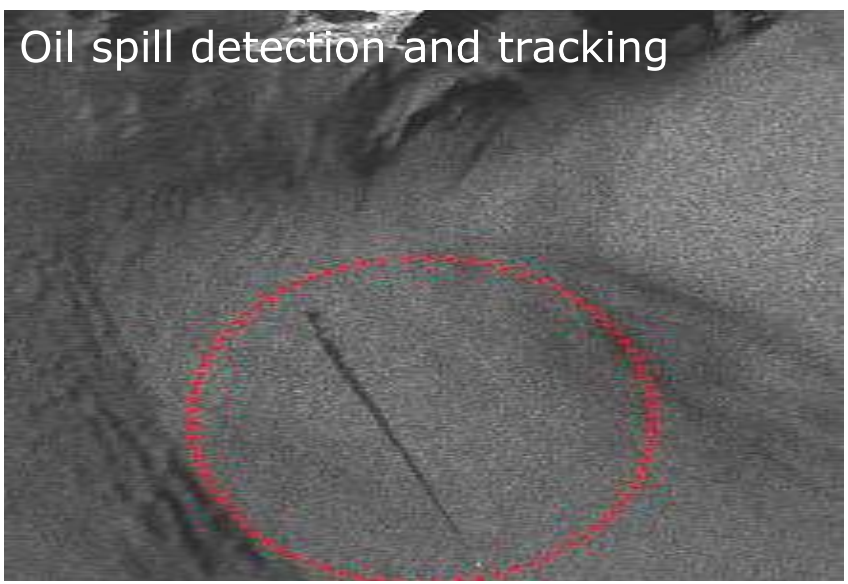
Ready for launch early 2015

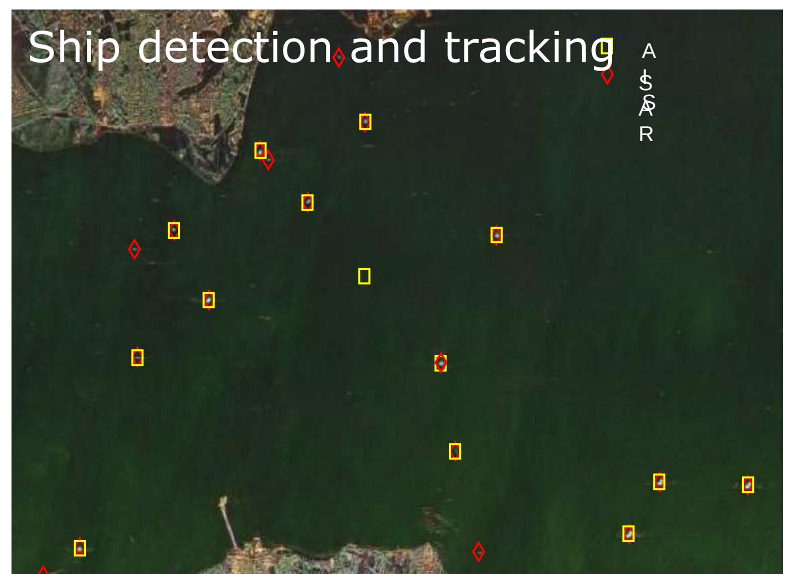




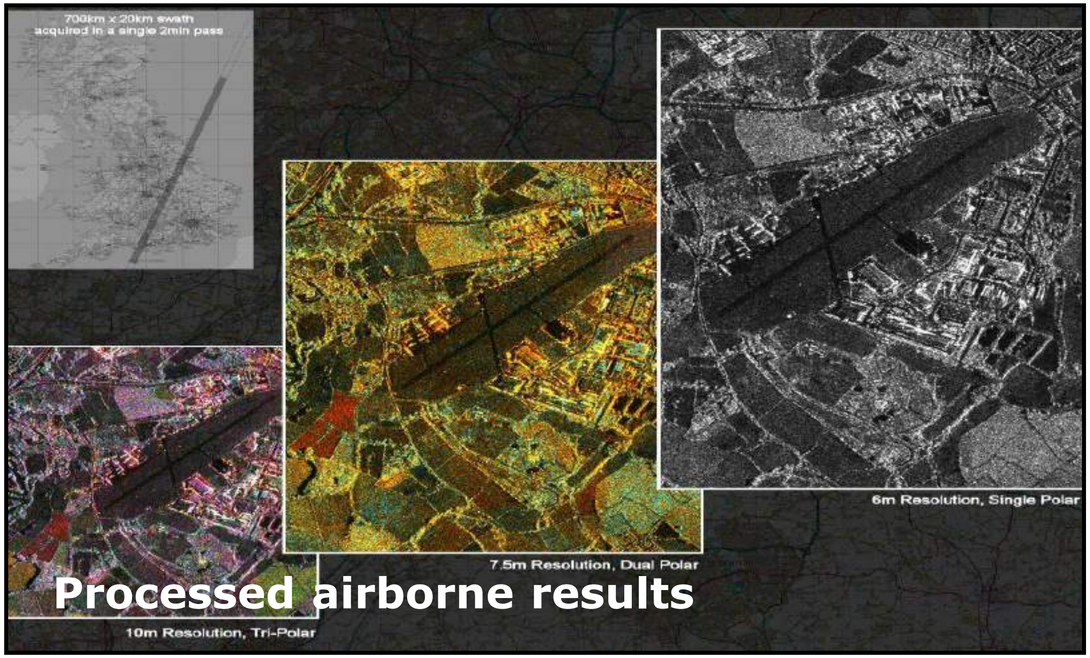
NovaSAR Applications







NovaSAR Results



GMP - Geostationary Modular Platform

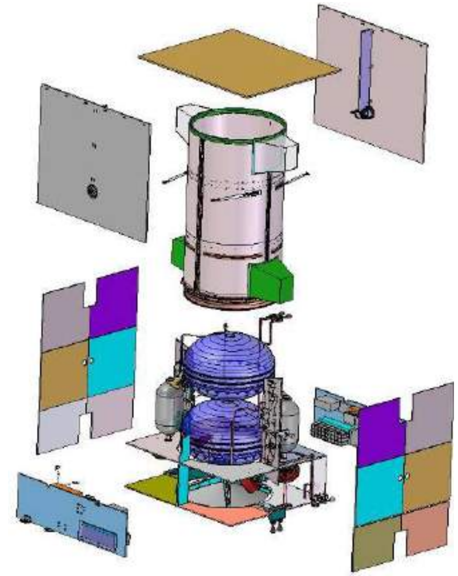
GEO (MEO, HEO, Interplanetary also possible)

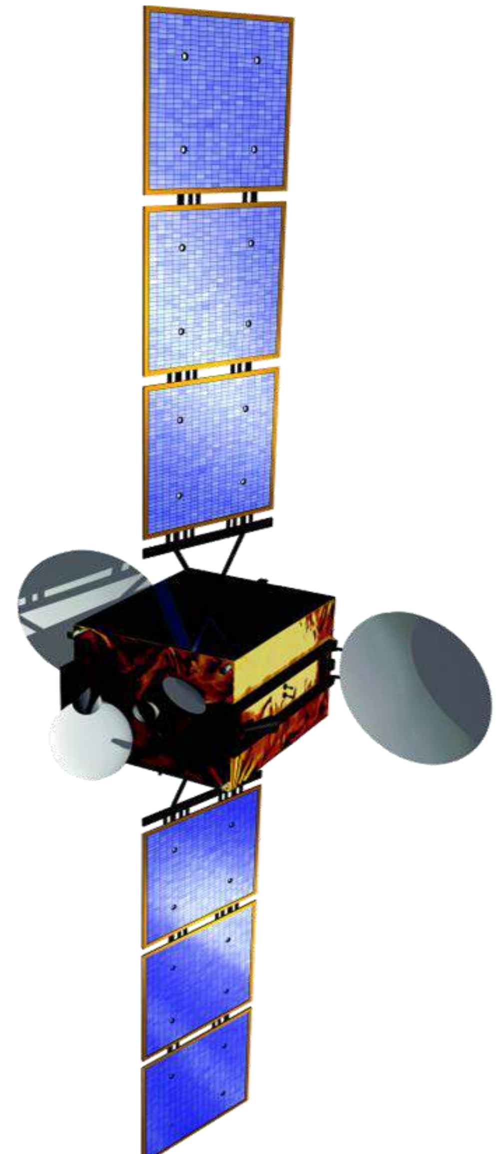
15 year design life

Modular & flexible design

300kg, 4.5kW

~32 active transponders

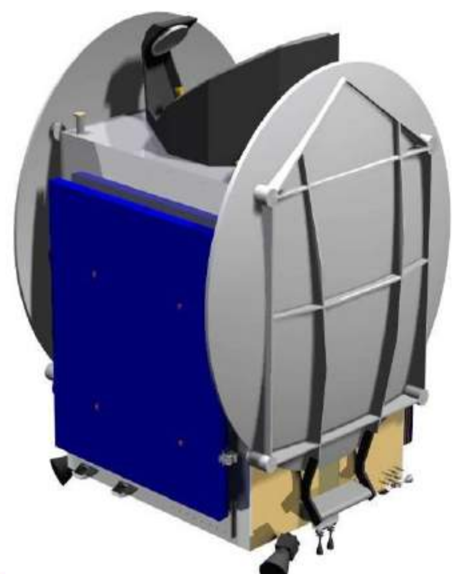




Flight heritage

ESA GIOVE-A (2005)

ESA ARTES Development



esa

GIOVE-A Satellite

1st Galileo Test bed Satellite for:

- claiming ITU Frequencies
- flight proving Galileo equipment

Representative signals, characterising radiation environment

Launched in 2005

Required 2 year life

Now operating for ~7.5 years

Delivered in 28 months for €28M

In 2008 ESA declared "Full Mission Success"

Still being operated by SSTL

Galileo – Full Operational Capability (FOC)

EC programme, ESA procurement

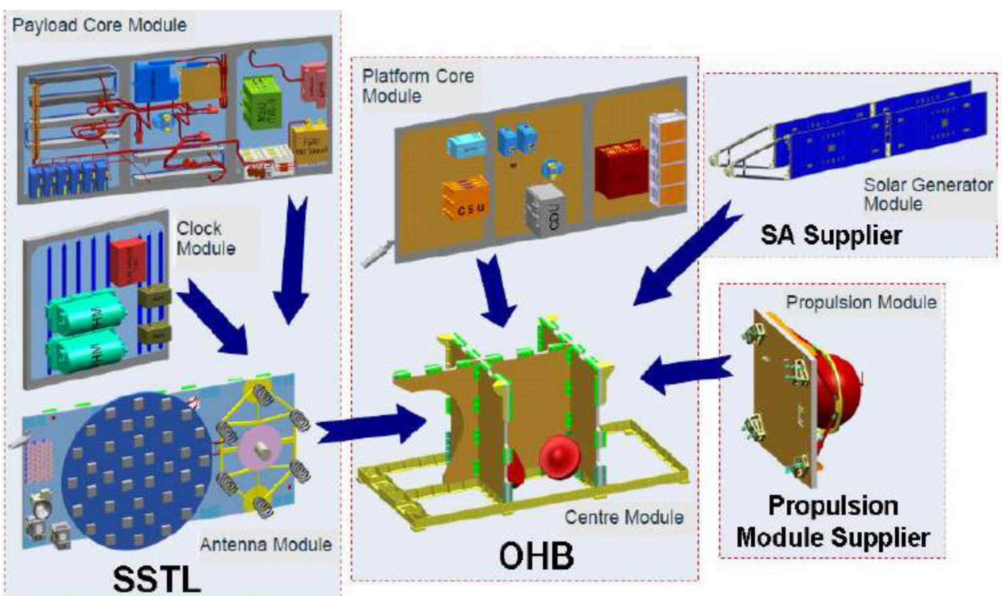
SSTL payload prime for 22 satellites

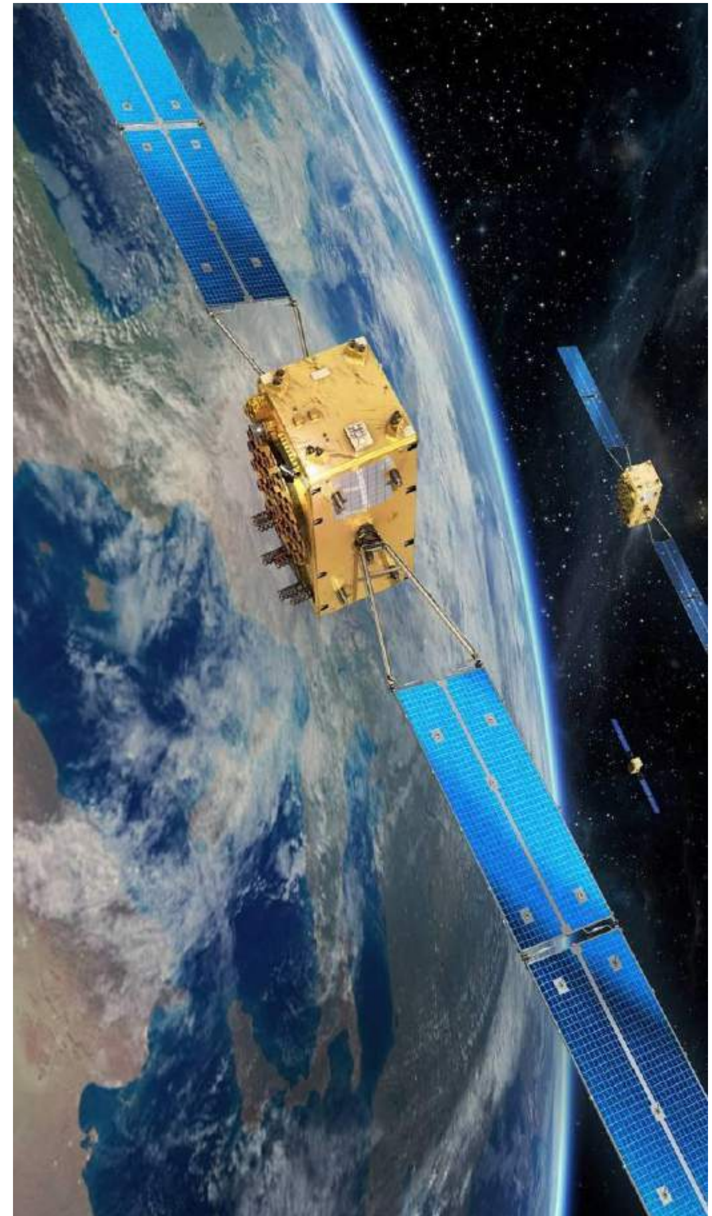
Working with OHB-System

£250m+ contract for SSTL

Satellites ready 2013 - 2016

1 payload delivered every 6 weeks



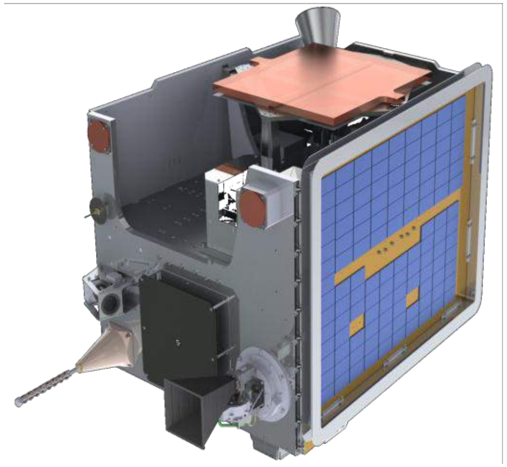


Technology Demonstration Satellites

Demonstration missions

On-orbit flight experience

Funding from TSB/SEEDA



Payload Mass - 50 kg

Data Rate - 40 Mbit/s

Power - 50 W

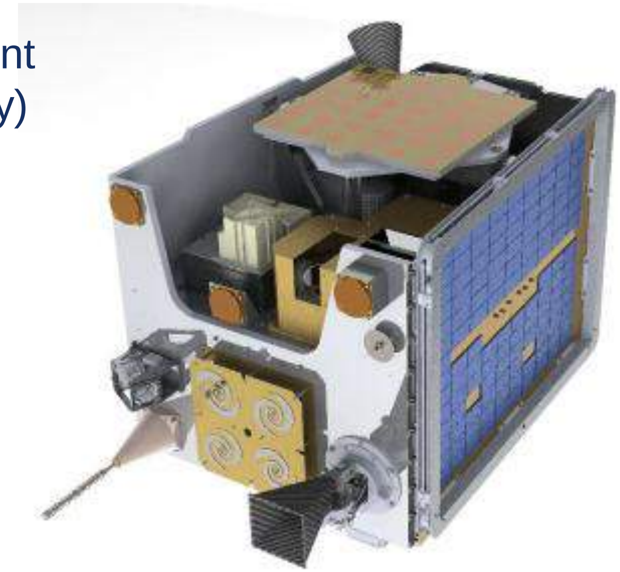
Volume - 700 x 500 x 900 mm

Future TDS missions being planned (UK, ESA, International)

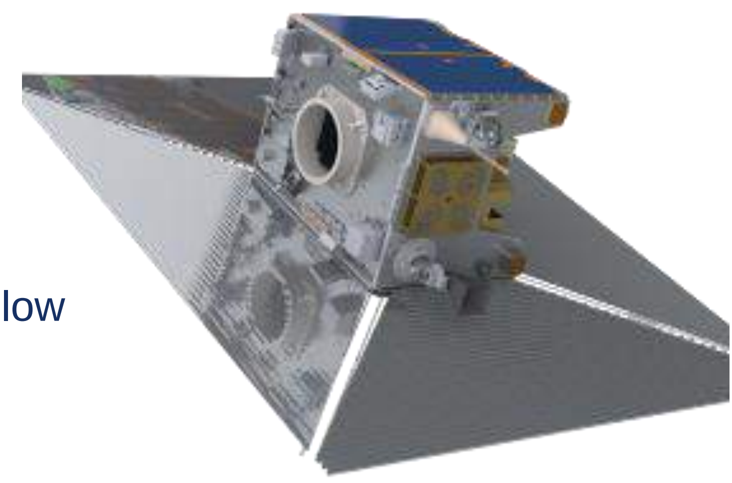
SSTL, Surrey Space Centre, RAL, Langton Star Centre,
Cranfield Uni, MSSL, Oxford Uni, Satellite Services Ltd

UK TDS-1 Technologies

- TDS-1 demonstrations include:
  - ReSI GNSS ocean state reflectometry instrument
  - S-band altimeter – (test of NovaSAR technology)
  - Highly-miniaturised radiation monitors
  - LUCID cosmic ray detector
  - Charged particle spectrometer
  - Compact modular sounder
  - Cubesat attitude control system
  - De-orbit sail
  - 400 Mb/s steerable downlink
  - 128 GB flash MMU
  - Next generation OBC-750
  - Star tracker and low cost data processor
  - MEMS gyros
  - Micro-vibe experiment
  - New mid-range reaction wheel
  - Inspection camera
  - New 150 W BCR – (SAR technology)
  - Pinhole Sun-sensor
  - AOCS interface module
  - Additively manufactured bracket supporting hollow cathode EP system
  - Also: New CAN protocol, new GaAs cells

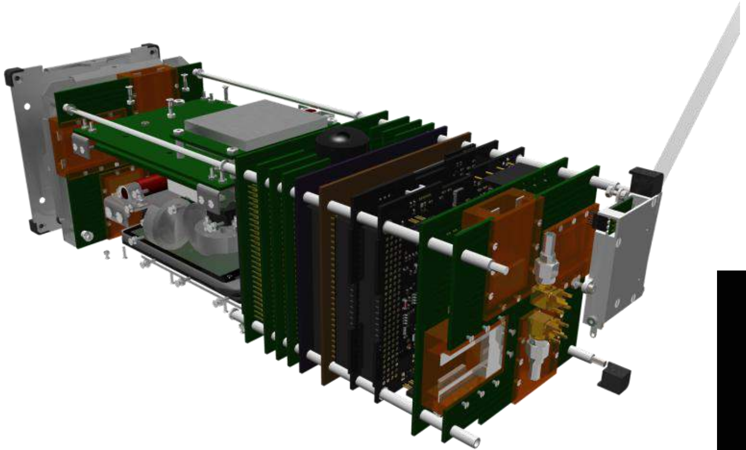


The TDS-1 mission before and after de-orbit sail deployment



Nanosatellites: STRaND Programme

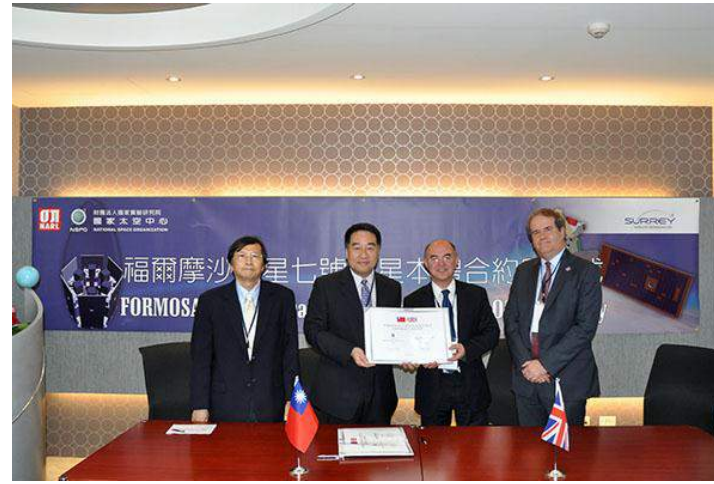
Pushing the Boundaries (and cool!)…



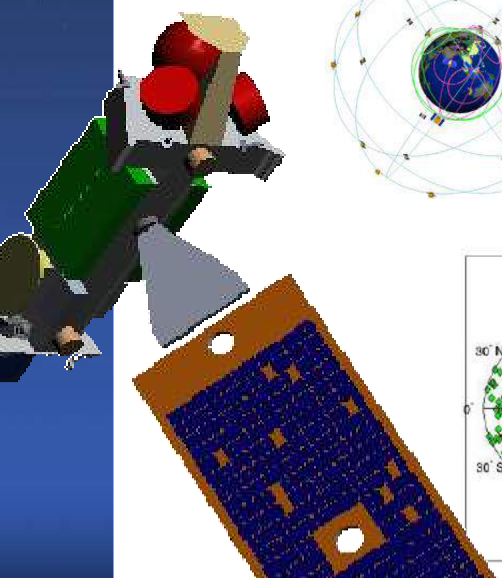
Most Recent Mission: FS7/Cosmic-2

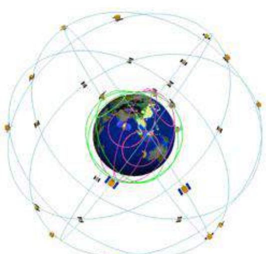
- Taiwan/USA project
- Operational Meteorology
- SSTL provides
  - satellite design
  - 6+6 LEO platforms
  - Launch planned 2016 and 2018

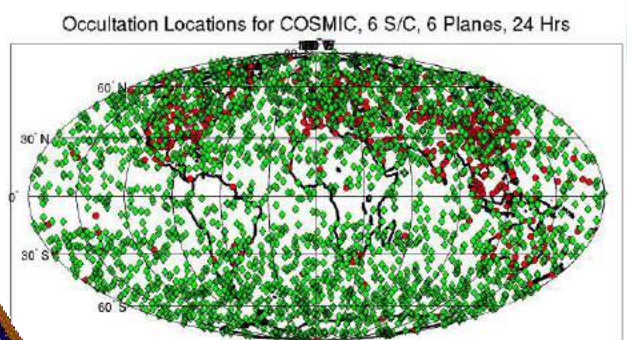
NSPO

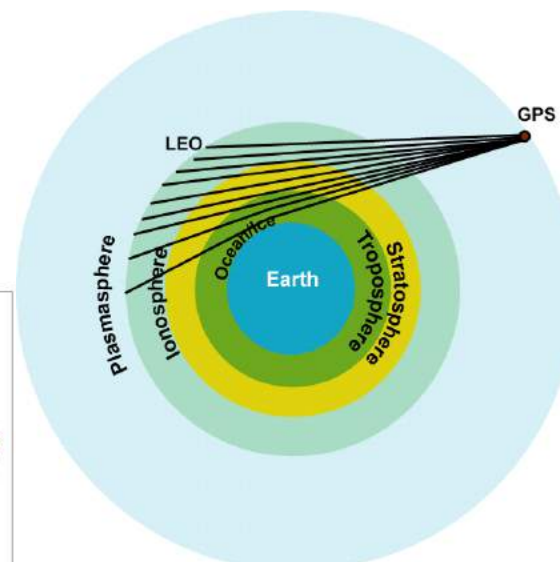


Contract Signature 2012

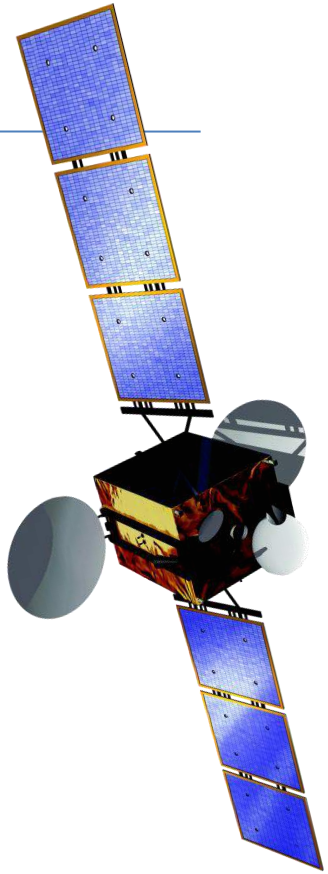




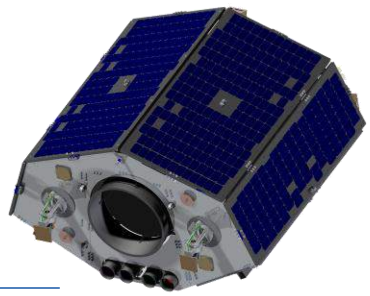




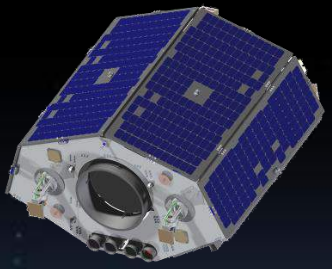
Conclusions



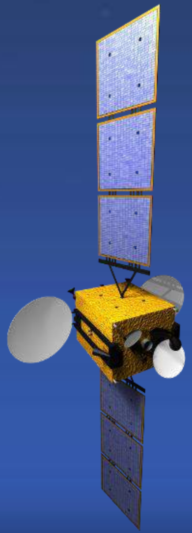
- SSTL continues to innovate
- Systems now are predominantly operational
- For both governments and commercial customers
- SSTL is “changing the economics of space”



SURREY SATELLITE TECHNOLOGY LTD *Changing the economics of space*



Thank You



Tycho House, 20 Stephenson Road, Surrey Research Park, Guildford, Surrey, GU27YE, United Kingdom
Tel: +44(0)1483803803 | **Fax**:+44(0)1483803804 | **Email**: info@sstl.co.uk | **Web**:www.sstl.co.uk

Imperial Space Laboratory Launch

1st July 2013

Together pioneering excellence

ASTRIUM
AN EADS COMPANY

The Company

Astrium: part of EADS – a global leader in aerospace and defence

EADS

Airbus Airbus Military	Eurocopter	Astrium	Cassidian

ASTRIUM
AN EADS COMPANY

ASTRIUM : Facts & Figures 2012

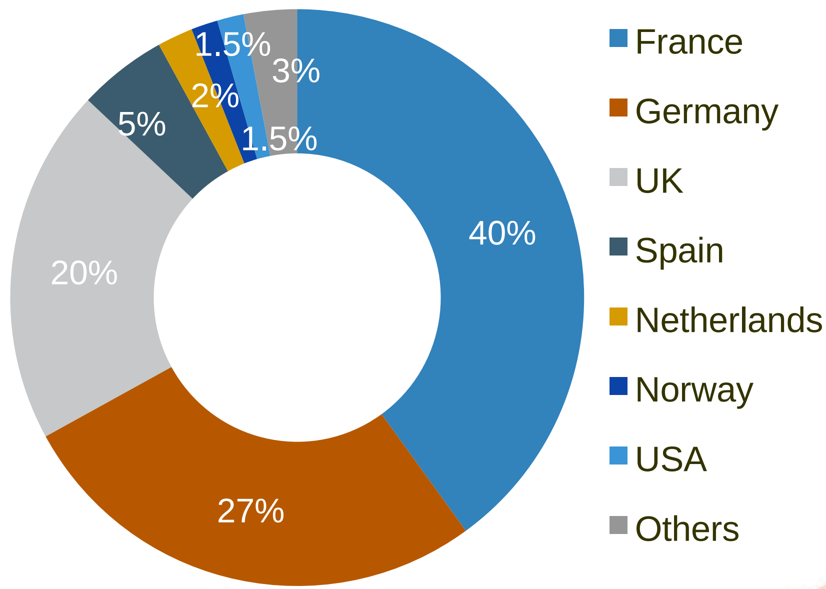
Employees:
18,000

Turnover:
€5.8 billion

Order backlog:
€12.7 billion

CEO:
François Auque

Employees by country:



Astrium: a global company with European roots

ASTRIUM
AN EADS COMPANY

Astrium's activities are based in three key areas to serve governmental and commercial markets

Astrium Space Transportation

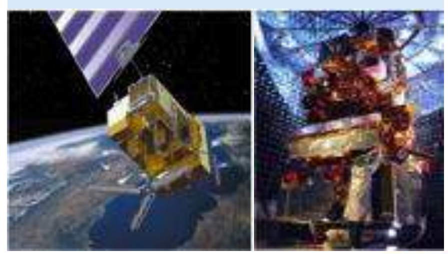
The European prime contractor for space transportation and orbital infrastructure

- -Launchers
- -Defence
- -Orbital Systems & Space Infrastructure
- -Propulsion & Equipment

Astrium Satellites

A world leader in the design and manufacture of satellite systems and ground segments

- -Telecommunications Satellites
- -Earth Observation, Navigation & Science
- -Products



Astrium Services

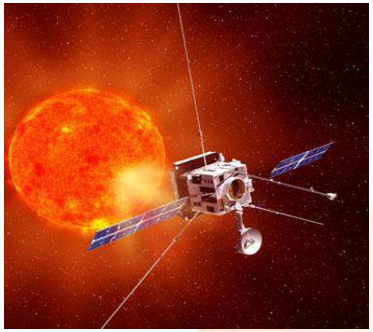
A global provider of end-to-end solutions for satellite communications and geo-information services

- -Government Communications
- -Business Communications
- -Geo-information Services

ASTRIUM
AN EADS COMPANY

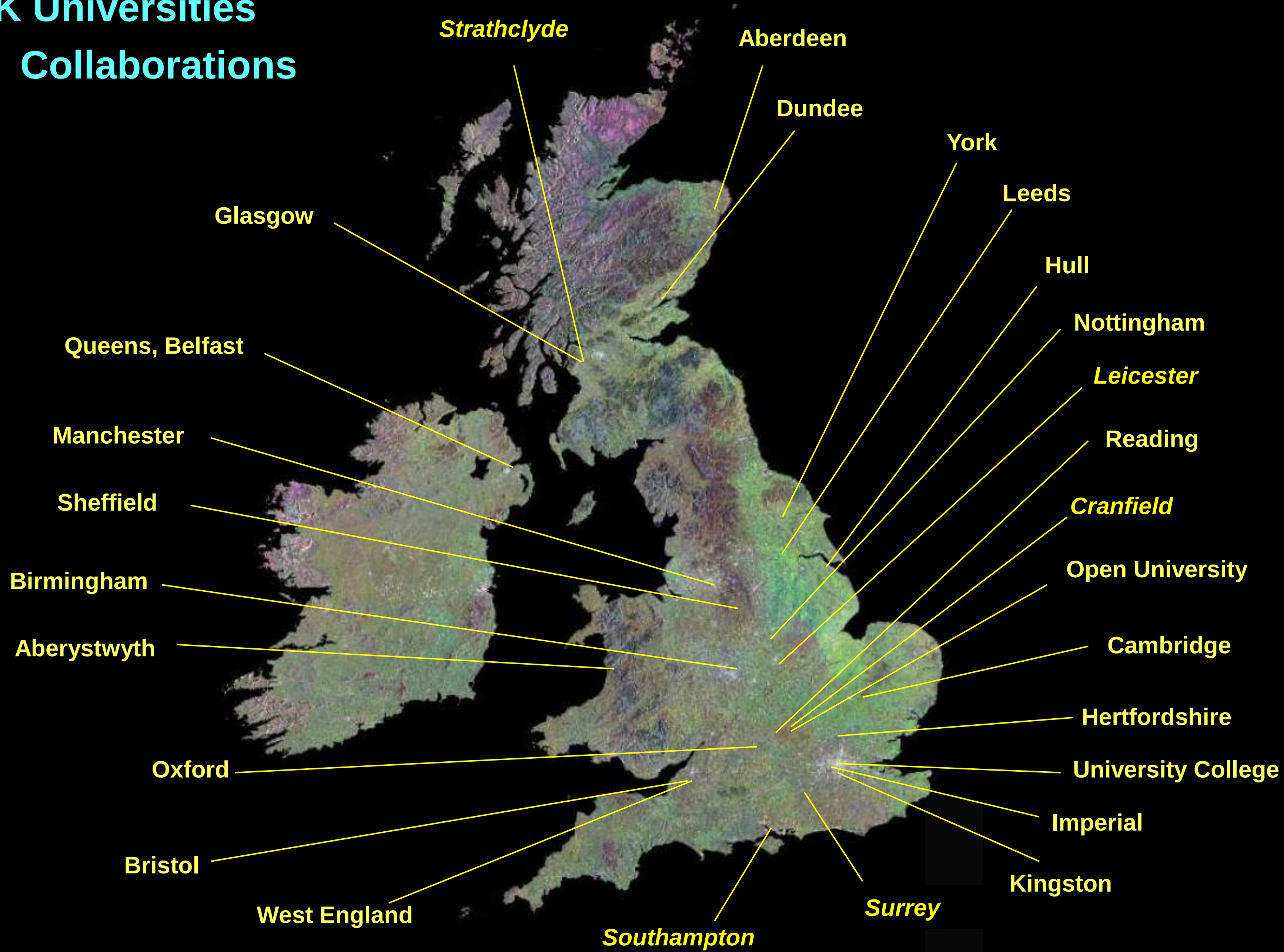
ASTRIUM IN THE UK

- Astrium UK has a balanced portfolio of services and manufacturing, with 45% of turnover deriving from services
- Astrium UK turnover c.£1bn per annum, of which c.50% is exports from the UK
- Astrium employs about 3,500 people in the UK and contributes around 20% of group revenues
- Of £1bn turnover nearly 60% flows down the supply chain:
- **Manufacturing business**:
  - Around 70% or £350M is sub-contracted annually, of which around £100M to UK based suppliers
- **Service business**:
  - Around 35% or £150M is sub-contracted annually, of which around £100M to UK based suppliers
  - 400 UK companies supply to Astrium, with around half being SMEs
- Strategic partnering with SMEs for some key technologies
- A large UK Prime is good for the health of the SME sector; a healthy SME sector vital for Astrium
- Major R&D and other investments into the university sector

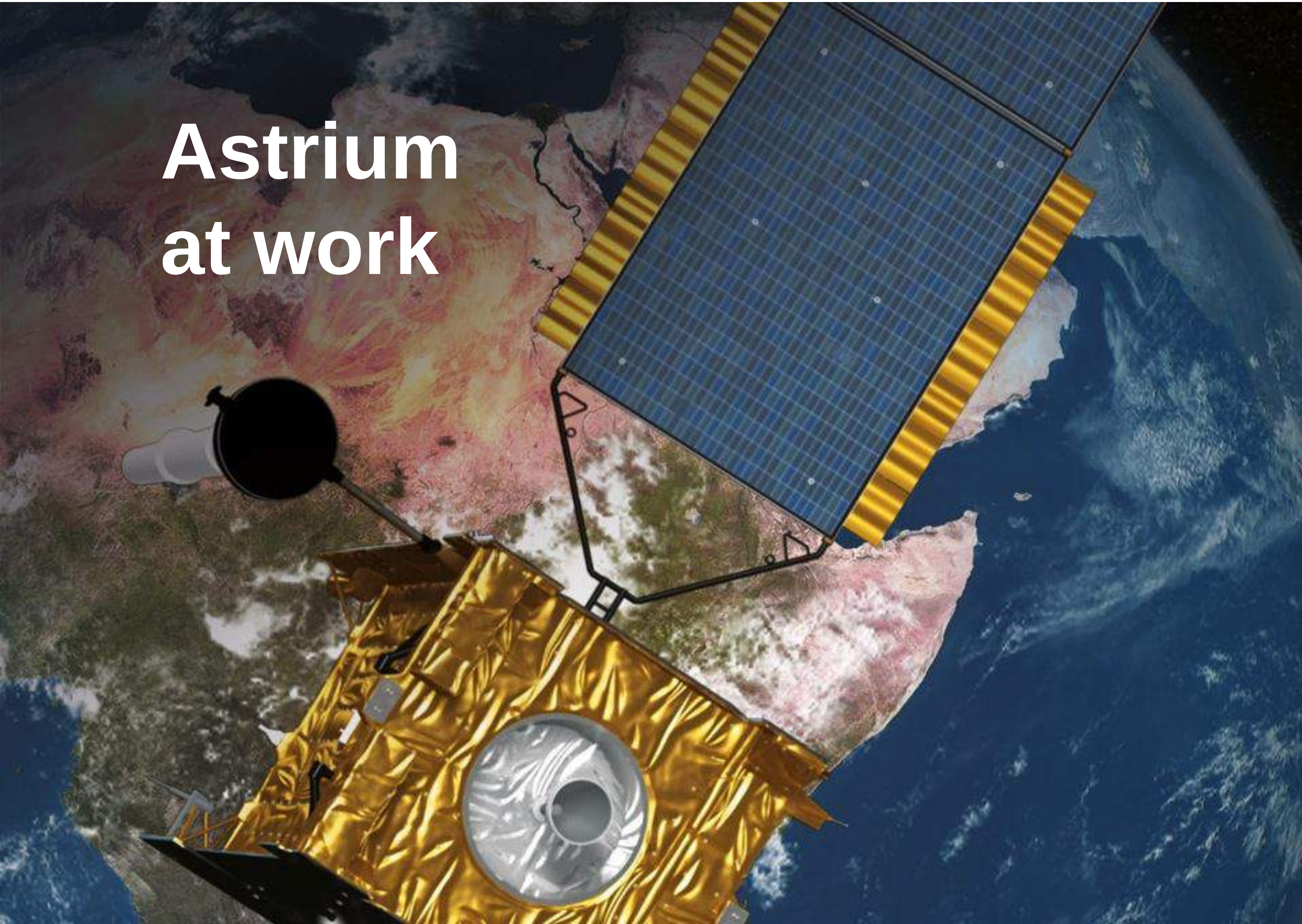


ASTRIUM
AN EADS COMPANY

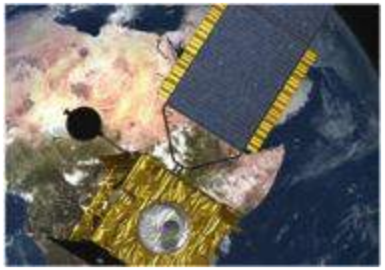
UK Universities
Collaborations

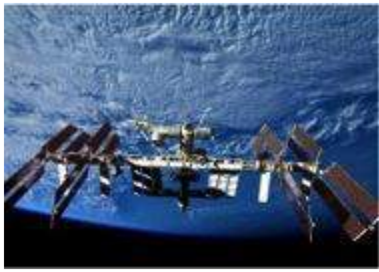


Astrium at work



Astrium at work

"Astrium is a global space industry leader, with world-class expertise and extensive prime contractorship experience across all sectors of the space business."

- No. 1 space company in Europe
- No. 3 space company worldwide
- The only European company that covers the whole range of civil and defence space systems and services

Equipment → Satellite and launcher manufacturing → Launch services → User ground equipment and terminals → Satellite operation → Value-added services

ASTRIUM
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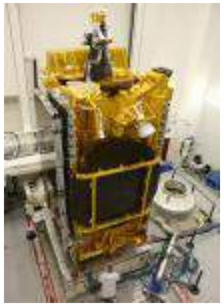
Telecommunications





A market leader

- Established in a challenging commercial market and a major provider of military systems
- Eurostar E3000, best-selling telecom platform
- At the forefront of innovation

Complete capability

- Spacecraft and payload design, manufacture, test, launch and operations
- End-to-end communications system infrastructures
- Civil and military telecom systems

12 communications satellites under construction

- Astra 2E, 2G, 5B
- Alphasat I-XL
- SES-6
- Arabsat 6B
- Measat-3b
- Eutelsat 3B, 9B
- DirecTV 15
- Express AM4R, AM7

In-orbit monitoring for more than 40 satellites

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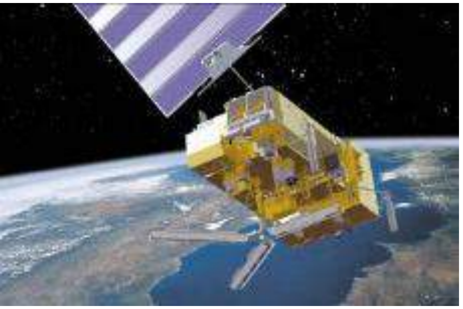
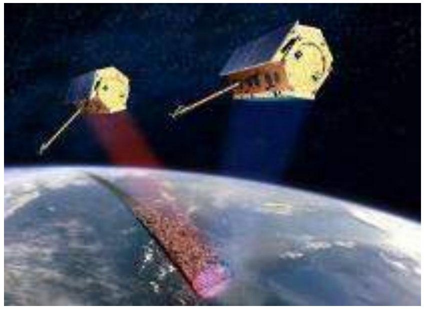
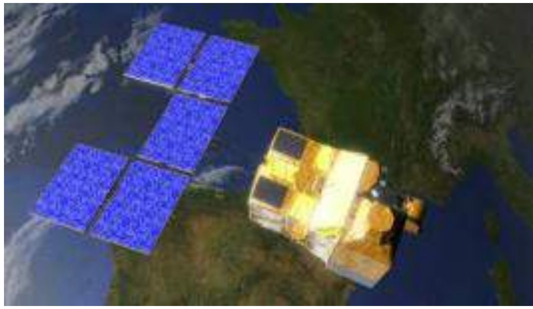
Earth observation



Prime for over 30 Earth observation satellites

- Meteorological forecasting
- Global environment monitoring
- Reconnaissance for national security and peacekeeping

Design and manufacture of highly versatile platforms, optical and radar instruments

Ground segment equipment

Environment: Envisat, CryoSat-2, GOCE, SMOS, Swarm, Sentinel-2, Aeolus, EarthCARE

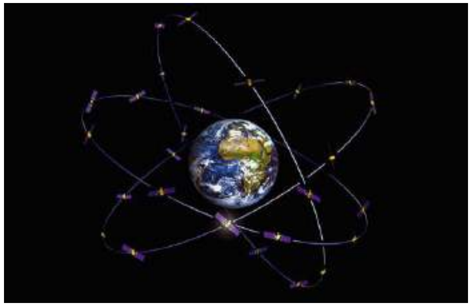
Imaging: Spot 5, TerraSAR-X, TanDEM-X, ALSAT-2, Theos, Pléiades, SSOT, Ingenio, Paz, ERSSS, Spot 6 & 7, VNREDSat-1

Meteorology: MSG, MetOp, COMS

Security: Helios II, ESSAIM, Spirale, ELISA, CSO

Navigation






- A major EC–ESA partner in the design and development of Galileo
- Prime for a concept phase study for ESA on the next generation of the European Geostationary Navigation Overlay Service (EGNOS)
- A leading role in the development of practical and cost-effective solutions for secure and safety-critical Global Navigation Satellite System application infrastructures

Space Segment

- Prime for the GIOVE-B test satellite
- Prime for the four In-Orbit Validation satellites
- Supply of the payloads and platform equipment for the first batch of FOC satellites

System Support Segment

- Major role in systems engineering with leading expertise in signal design, performance and verification

Ground Control Segment

- Prime for the Galileo Ground Control Segment

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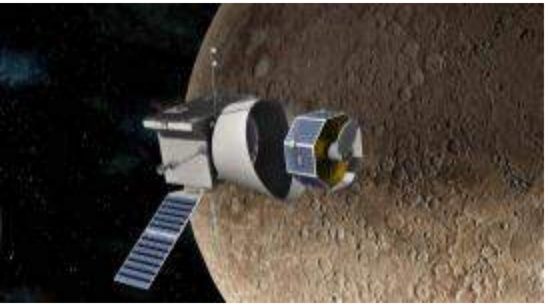
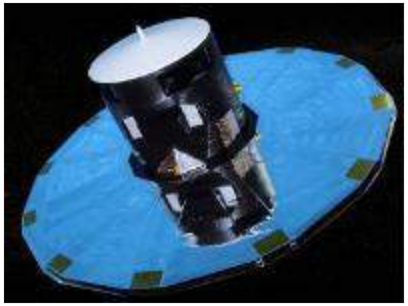
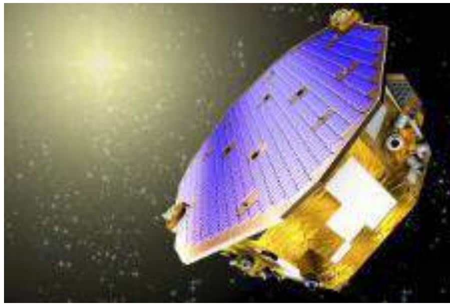
Space science



World-renowned expertise for building satellites, probes and instruments for exploration missions

- Planetary exploration
- Deep space missions
- Astronomy
- Fundamental physics missions
- Monitoring solar activities and Sun-Earth interaction

- **Planetary exploration:** Mars Express, Venus Express, BepiColombo, ExoMars Rover Vehicle
- **Deep space:** Rosetta
- **Astronomy:** XMM-Newton, Herschel telescope, Gaia, JWST instruments
- **Fundamental physics:** LISA Pathfinder
- **Solar science and Sun-Earth interaction:** SOHO, Cluster II, Solar Orbiter

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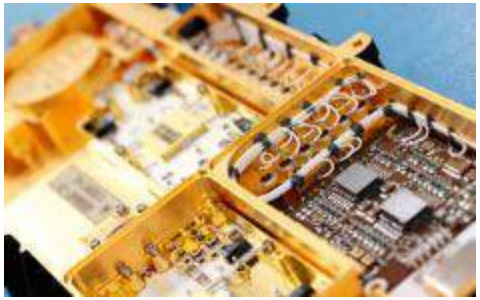
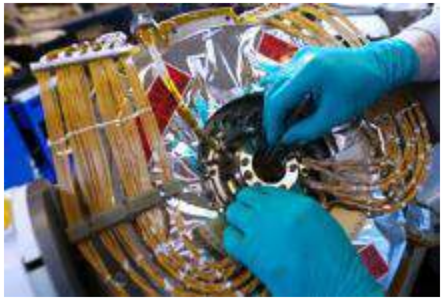
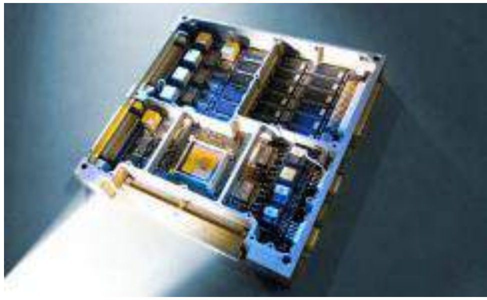
Products







World-class developer and supplier of space products for internal and external customers

In-house development of key equipment, subsystems and leading-edge technologies

- To optimise spacecraft performance
- To enhance cost-effectiveness
- To provide generic products across many fields

Sustained R&D effort to foster innovation breakthrough

- Key space products include
  - Solar generators
  - Power equipment and subsystems
  - Electrical, RF and microwave equipment
  - On-board digital processors
  - Sensors and actuators
  - Mechanisms
  - Optical, radar and navigation payload equipment

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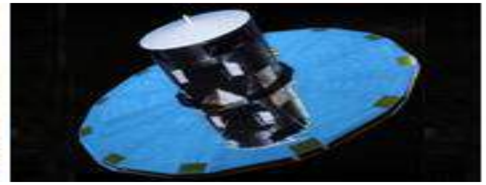
Astrium Collaboration with Imperial College

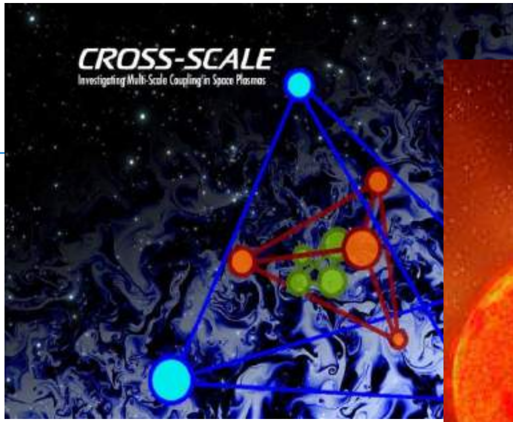
Astrium Collaboration with Imperial College



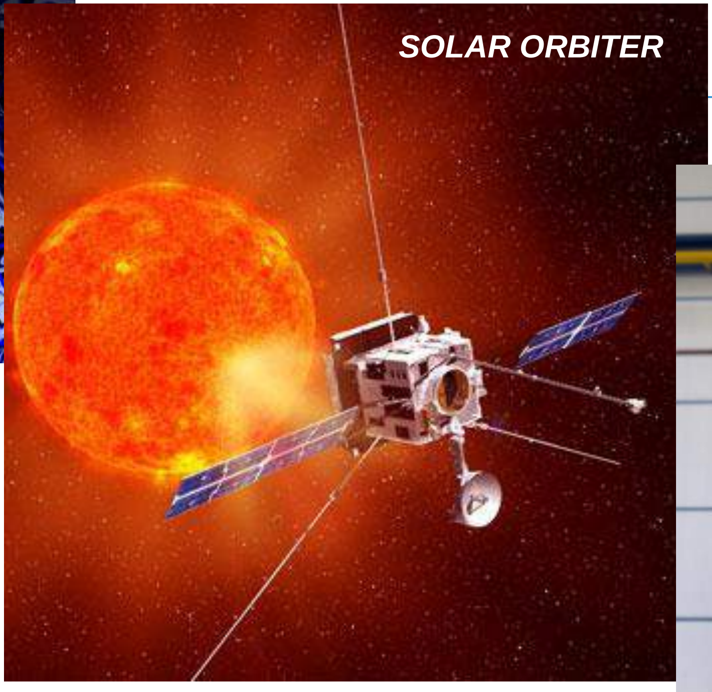



University POC	Area of collaboration	Project Description	Type of Collaboration	Start	End	Astrium BU
Chris Carr	EMC/Magnetic research	EMC	PhD CASE studentship	Nov-11	Nov-14	ENS Erik De Witte
Daniel Jabry, Prof John Harries	Earth Observation (F-IR)	Mission systems	Student Internship	Oct-09	Sep-12	ENS Brian O'Sullivan
Dr Richard Ghail Dr Chris Cochrane	Preparation of Explorer bid to ESA, maritime surveillance	Mission systems	Support to bid	Sep-10	Dec-10	ENS David Hall
Dr. Helen O'Brien	Rad-hard ASIC for Magnetometer	Electrical engineering	Collaboration	Nov-09	2011	ENS Rajan Bedi
Dr. Joao Magueijo	LISA gravity science	Mission systems	Collaboration	2008	2010	ENS Christian Trenkel,
Chris Carr	Space CITI	Magnetometer	Collaboration for proposal	2012	2013	ENS Alex Wishart
Neil Hoose	Smart transport infrastructure	Telecoms	Study concept	2008	2010	Telecoms Products Group
Prof Goran Strbac, Dr Javier Barria	Smart Grid Communications	Telecoms	Study concept	2008	2010	Telecoms Products Group
Chris Carr	PRISM (Integrated payloads)	Magnetometer	Study	2009	2009	ENS Alex Wishart

Mission implementation



Early Phase Studies



Inventing new science
from planned missions

LISA PATHFINDER => Testing Modified Gravity

How do Astrium & Imperial interact on science missions when funding lines are partitioned between spacecraft & instruments?

Still exists mutual dependence for ensuring feasibility

=> Astrium seeks to support mission proposals

And for achieving launch schedule & data quality

=> PhD sponsorships (e.g. magnetic cleanliness)

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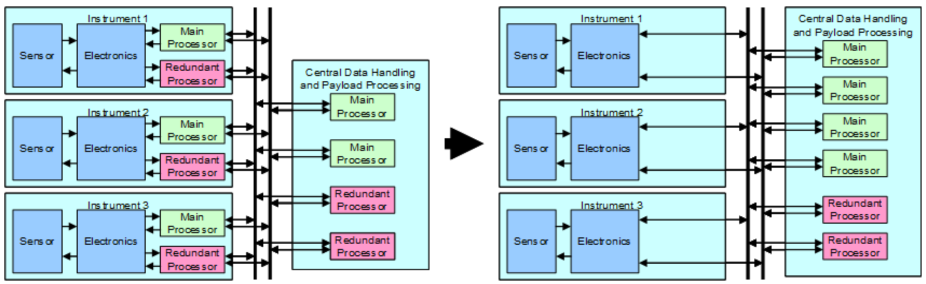
Instrument & spacecraft data processing architecture

PRISM project

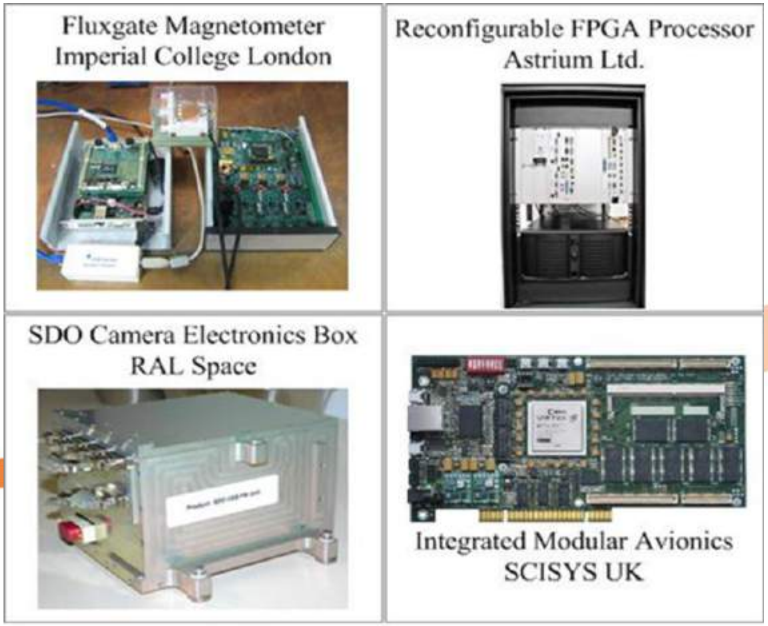
Traditional | PRISM



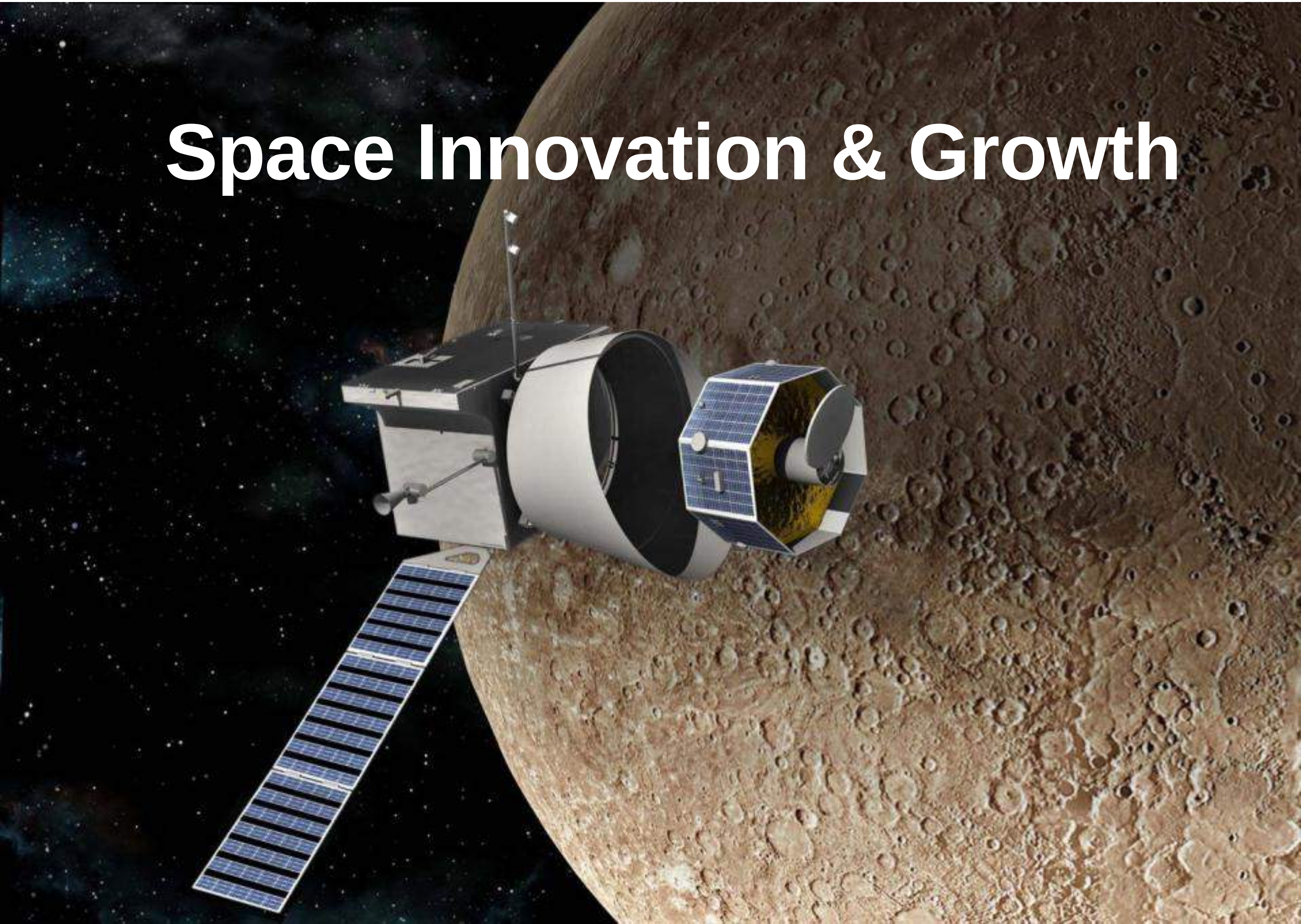
10 Processors | 5 Processors

Now a demonstration project under UKSA's SpaceCITI programme

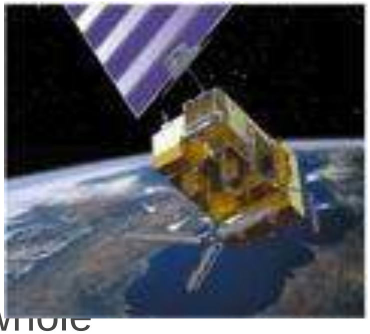
Based at Harwell
Using Imperial Fluxgate Magnetometer & RAL Space SDO camera



Space Innovation & Growth



Space Innovation and Growth



- The UK space sector:-
  - Currently has ~ £9.5bn annual turnover
  - Has grown at 10% pa over last decade
  - Employs 25,000 people directly and supports a further 70,000 jobs
  - Contributed 4x the GDP per worker than the UK average
  - Invests in R&D at 5% or 3x as R&D intensive as the economy as a whole
  - Has ~ 60% of workers at bachelor degree level or above
- The Space Innovation & Growth Strategy (IGS) sets out a vision
  - Ambition to grow the sector to £40bn or 10% of the global market by 2030
  - The majority of that growth is in the “downstream” applications and services derived from space data and infrastructure
  - Investment in space infrastructure is the enabler for downstream growth
  - All the major UK downstream success stories can trace their origins back to the upstream sector
- The UK Government has
  - Increased its investments in ESA substantially
  - Investing nationally in technology and applications

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Space Innovation and Growth

- Astrium is part of the growth story
  - Planning to grow its footprint in the UK to at least a £2bn company by 2030 (i.e. doubling in size)
  - Although the bulk of the space sector growth will be in the downstream and driven by new entrants
  - Astrium provides the essential "critical mass" of enabling technologies and infrastructure
  - Astrium provides skills and man-power to fuel the space economy
  - Astrium implements graduate and apprentice development programmes
- Astrium is a space champion for the UK
  - Competes on a global stage in all our markets against the best in the world
  - Actively seeking to increase exports globally in an intensely competitive market
  - Pursuing numerous export campaigns and engaging with UKTI
  - Is an enabler for SMEs and other "downstream" applications and services industries

Science & Technology
Facilities Council

Imperial Space Lab Event

1 July 2013 London

STFC External Innovations Programme Funding Schemes

Dr Vlad Skarda DBA CPhys

External Innovations

Science and Technology Facilities Council

vlad.skarda@stfc.ac.uk

Funding Mechanism

HM Government (and HM Treasury)

↓

BIS | Department for Business Innovation & Skills

↓

RESEARCH COUNCILS UK

RCUK Executive Group

↓

Arts & Humanities Research Council

BBSRC bioscience for the future

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

EPSRC Pioneering research and skills

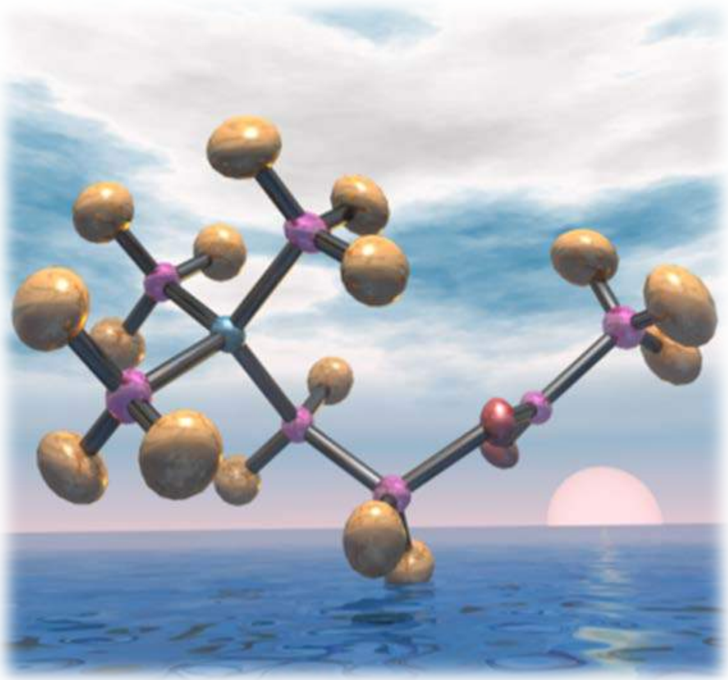
MRC Medical Research Council

NATURAL ENVIRONMENT RESEARCH COUNCIL

Science & Technology Facilities Council

Science and Technology Facilities Council

STFC funds world class and world-leading research in **astronomy, particle physics, space science and nuclear physics**



- This research takes place in
  - **university groups**
  - **STFC sites/laboratories**
  - **international organisations**
- Providing access to world class **UK facilities and overseas facilities**
- **Funding university researchers** 1,700 academic staff in UK universities

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UK Astronomy Technology Centre
Edinburgh, Scotland

Polaris House
Swindon, Wiltshire

Chilbolton Observatory
Stockbridge, Hampshire

Daresbury Laboratory
Daresbury Science and Innovation Campus
Warrington, Cheshire

Rutherford Appleton Laboratory
Harwell Science and Innovation Campus
Didcot, Oxfordshire

Joint Astronomy Centre
Hawaii

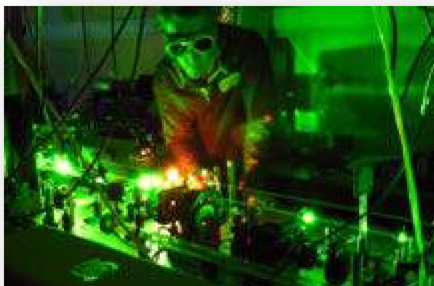
Isaac Newton Group of Telescopes
La Palma

Science & Technology Facilities Council

STFC Facilities – driving scientific research

Neutron Sources

Providing powerful insights into key areas of energy, biomedical research, climate, environment and security



High Power Lasers

Providing applications on bioscience and nanotechnology and demonstrating laser driven fusion as a future source of sustainable, clean energy

Light Sources

Providing new breakthroughs in medicine, environmental and materials science, engineering, electronics and cultural heritage

Science & Technology Facilities Council

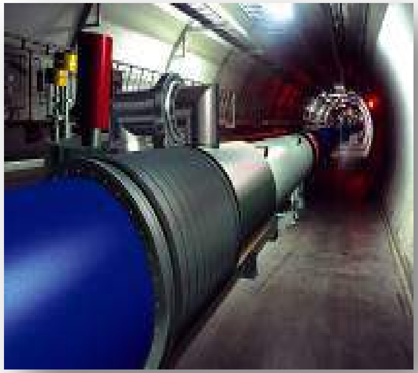
International Partnerships

- CERN
- European Southern Observatory (ESO)
- European Space Agency (ESA)

- European Synchrotron Radiation Facility (ESRF)
- Institute Laue-Langevin (ILL)

Science & Technology Facilities Council

STFC's Science Programme
Understanding our Universe



Particle Physics/Particle Astrophysics

- Revealing the structure and forces of nature - Large Hadron Collider, CERN
- Advanced LIGO will observe and study Gravitational Waves, opening a new window on the universe

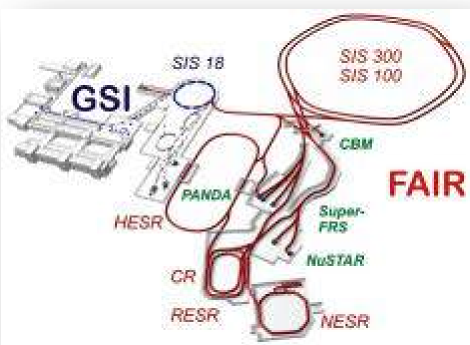
Ground based Astronomy

- European Southern Observatory, Chile
- Very Large Telescope
- Atacama Large Millimetre Array
- European Extremely Large Telescope

Science & Technology Facilities Council

STFC's Science Programme
Understanding our Universe

Space based Astronomy
- European Space Agency
- Herschel/Planck/GAIA/James Webb Space Telescope
- Bilaterals – NASA, JAXA, etc.
- STFC Space Science Technology Department



Nuclear Physics
- Facility for Anti-proton and Ion Research, Germany
- Nuclear Skills for - medicine, energy and environmental applications

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Technology to underpin science

Developing and delivering innovative technologies in STFC laboratories and in collaboration with University groups

Key Technology Strengths

- Accelerator technologies
- Instrumentation
- Detectors and Sensors
- Data Acquisition and Processing Systems
- Microelectronics design
- High power lasers
- High Performance Computing

- Engineering technology centres based at Harwell and Daresbury Science and Innovation Campuses
- Collaborative efforts

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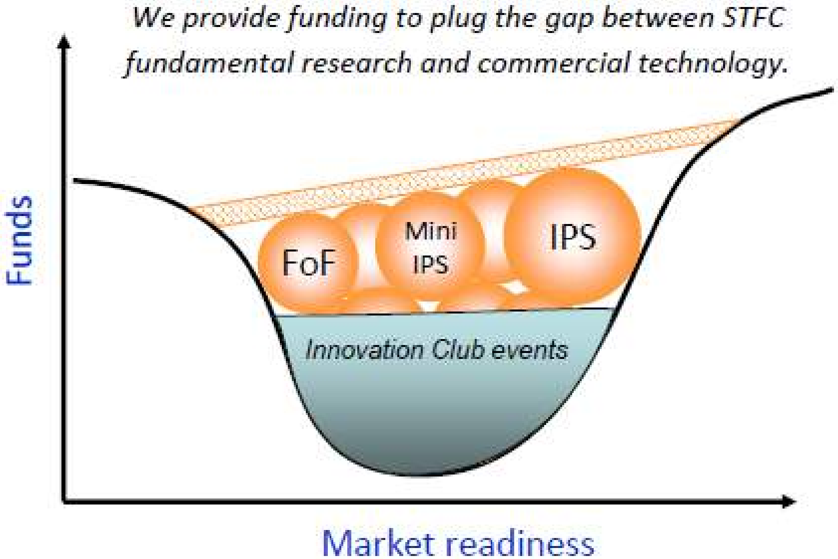
External Innovations Funding Programme

- **Generate impact** by providing funding support to help bridge the ‘commercialisation gap’
- **Key aims**
  - Transfer
  - Exploitation
  - Partnership & Collaboration
  - Economic Impact



Impact through innovation

STFC External Innovations Objectives

- To transfer knowledge to diverse technological sectors
- Promote interdisciplinary collaborative research with industry leading to commercialisation

Eligibility for STFC External Innovations Funding

- **Eligibility arises from STFC funded research as the source of knowledge (academic lead)**
- Funding schemes open to STFC Labs, HEIs and international subscriptions (CERN, ESO)

- **Other Universities or industry can participate** provided that they collaborate with STFC funded partner

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External Innovations Funding Schemes

- **IPS** - Innovations Partnerships Schemes – **next deadline** 11 September 2013
  - **Follow on Funding**
  - **IPS and Mini-IPS**
  - **IPS Fellowships** - dedicated technology transfer staff
- **CLASP** – Challenge Led Applied Systems Programme
  - Aligned to STFC Futures Programme
    Energy, Environment, Healthcare, Security
  - **Energy call**
- **Knowledge Transfer Partnerships**
- **RSE Enterprise Fellowships**

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Follow on Funding

Aim - To establish commercial feasibility on scientific and technical merit

- Proof of concept funding
- Undertaking further scientific and technical development of an idea
- Improving an intellectual property (IP) position
- Gaining further information about the market for the new products or process
- Identifying potential licensees or opportunities for joint ventures

Not in partnership with industry

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IPS / Mini - IPS

Collaboration

- With industry
- With another academic discipline

Range of activity

- Feasibility studies to prototyping
- Route to market must be considered

IPS is a State Aid Notified Scheme

- Funding can be given to industry partners in line with State Aid rules

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IPS Fellowships

- This is a dedicated technology transfer role - not a research fellowship
- Duration – up to 48 months
- Host institution must be in receipt of substantial STFC funding
- Promoting commercial exploitation
- Transferring the technologies developed through STFC

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Scheme features – 3 calls/year

PROJECTS	IPS ACADEMIC / INDUSTRY	IPS ACADEMIC / ACADEMIC	MINI-IPS	FOLLOW ON FUNDING	IPS FELLOWSHIPS
Eligibility of non STFC organisations	Industry as supporter or co-recipient	Academic groups not funded by the STFC as supporter or co-recipient	Industry and/or academic groups not funded by the STFC as supporter or co-recipient	None	None
Maximum duration	36 months	36 months	12 months	12 months	48 months
Maximum project values	£450K	£450K	£150K	£110K	No maximum
Maximum %	80 % Full economic cost STFC or academic partner % contribution to industry dependent on size of business see Table 3			80% Full economic cost	80% (fEC limit) of 50% of costs
Maximum STFC contribution	£360K	£360K	£120K	£88K	No maximum

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CLASP

Annual calls in one of the STFC Futures Programme areas:
Energy, Environment, Healthcare and Security

- **Two stage application process**
  - **two page technical outline** should include impact, timescales, markets and work plan – **deadline 10/09/2013**
- Shortlisted applicants
  - **will be invited to develop full proposals** with assistance and advice from STFC Innovations staff and panel members.
  - **will be required to present** their final proposals to the Evaluation Panel
- Typically £1.5M STFC funding available per call
  - any size of project
- Industry can be included in a project offering in-kind support or as a subcontractor for key tasks

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Knowledge Transfer Partnership (KTP)

- **Collaborative project between business and knowledge base (KB)**
  – developing new products or processes
  – improving existing products or processes

- **KTP Associate employed by the KB to enable**
  – business to increases profitability and embed knowledge
  – knowledge base to transfer research to users
  – opportunity for post-graduates to bridge the gap to industry

- **Projects last 1 – 3 years**
- **Programme run by TSB, sponsored by STFC + others**
  - support available from TSB during application

www.ktponline.org.uk to find local KTP adviser

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RSE Enterprise Fellowships

- **Support to commercialise any STFC funded research**
- A year's salary to develop your commercial proposition
- Business training to help you to prepare a viable business plan
- Access to networks of mentors, business experts and professional advisors

STFC Innovations Club

- **Set up to promote the opportunities for Knowledge Exchange**
- Membership is free, provides organisations with information about the calls and the opportunity to search for potential collaborative partners
- **Runs an active programme of workshops and events and monthly Newsletter** for the benefit of academics, industrialists and other interested research and technology organisations.
- **Our events are free to attend and are primarily for companies and academics** to learn about recent developments and encourage collaboration while promoting funding opportunities
- **Established business network** includes many sectors including defence, medical, security, aerospace,
space sector…

Science & Technology Facilities Council

Science & Technology Facilities Council

www.stfc.ac.uk/1788.aspx

Thank you

A New Space Applications Service Opportunity

Integrated Situational Awareness Services

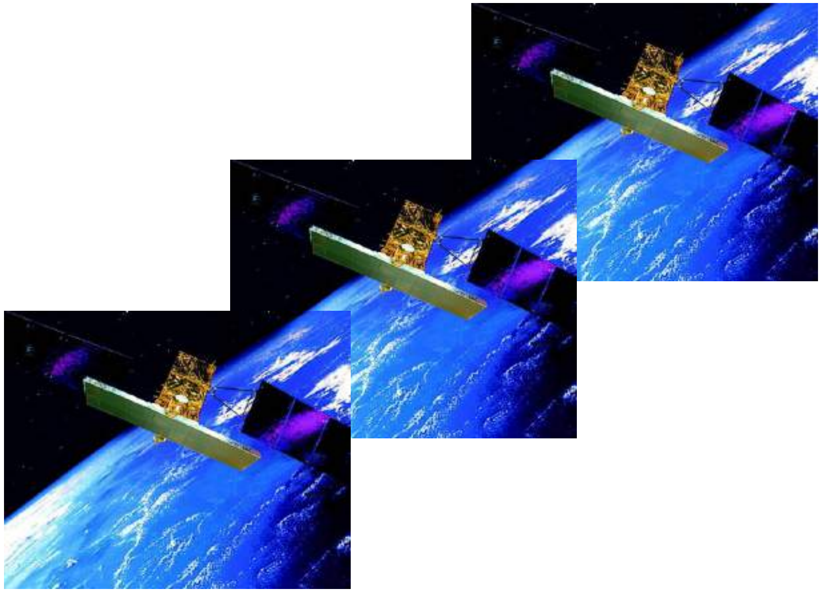
With

Telespazio VEGA UK

Ian Encke –
At the Imperial Space Lab Launch
1st July 2013

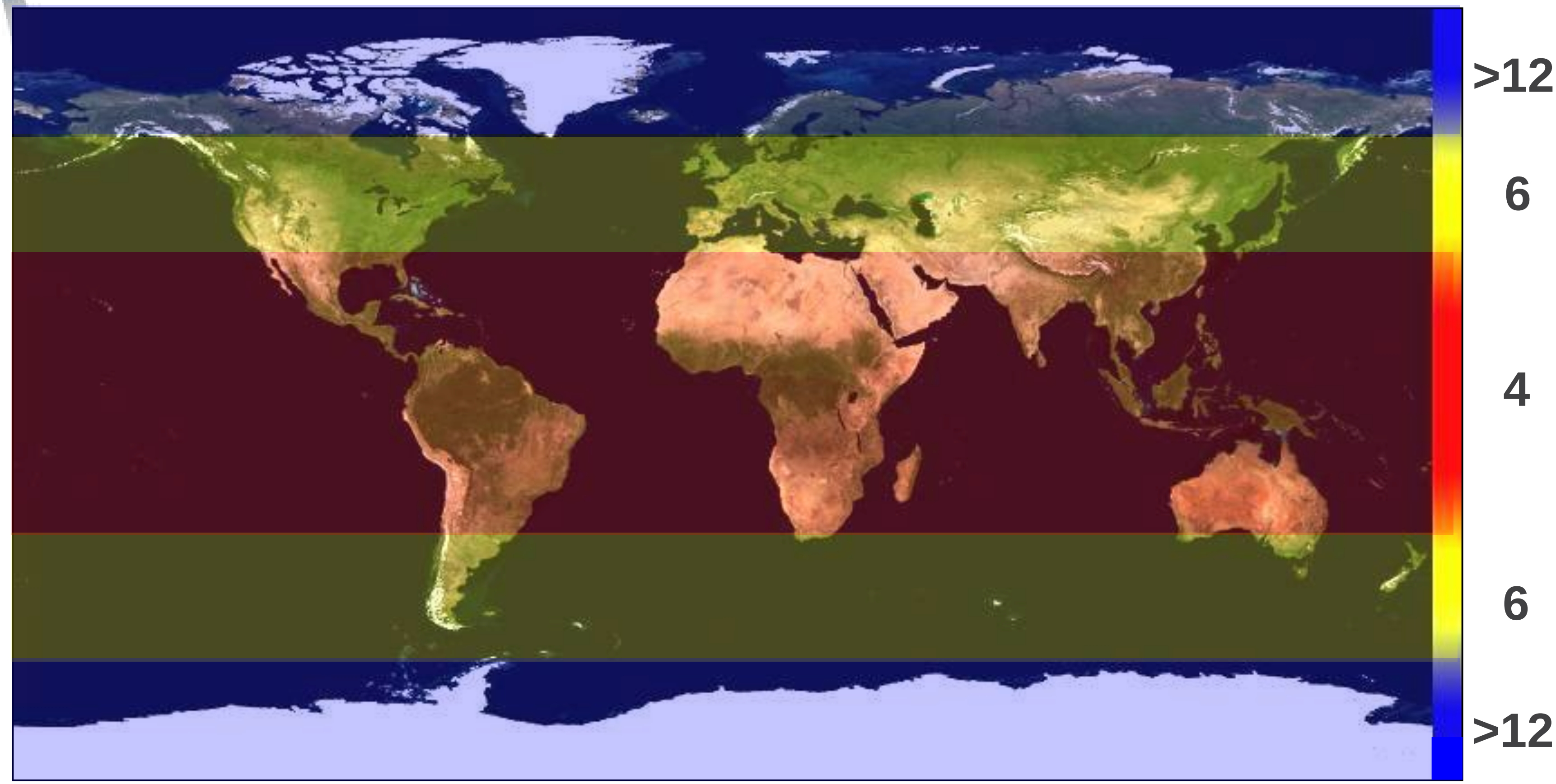
Why a NEW service opportunity?

- Today the space applications industry has an emerging capability to provide truly 24/7 surveillance services
- Why?



- For the first time we have access to enough timely, high resolution, all weather, night and day space imaging

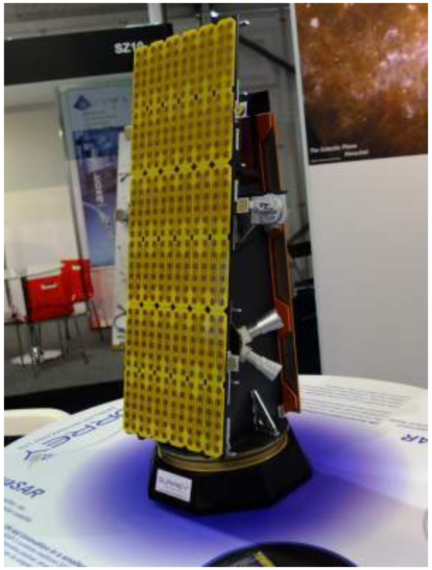
Cosmo Skymed alone revolutionises revisit capability



Acquisitions per day with the 4 satellites constellation

(the acquisitions are not spread uniformly throughout the day)

Opportunity for UK?



- Soon more Radar satellites will join the global constellation including, within a couple of years, our own UK Nova SAR
- Meanwhile, through Telespazio VEGA UK and Astrium UK we have preferential access to:
  - 4 Cosmo Skymed & 2 future Argentinian SAR sats
  - 1 TerraSAR / Tandem pair & 1 future Spanish TerraSAR variant
  - Through ESA we will have access to the future 2 Sentinal 1 satellites
- With the recent increased UK government investment in space, and the set up of UKSA and the Space Applications Catapult, UK is well placed to exploit this opportunity

Why Integrated Situational Awareness Services? It allows addition of UK innovation!

- High revisit radar is well suited to a range of situational awareness applications
  - Maritime and O&G
  - Security and Crisis Management
  - Agriculture and Forestry
- German and Italian companies have already cornered the market in ‘first level’ value add
- Telespazio VEGA UK believe the opportunity is to take those products further downstream through “integration” of UK innovations
- **We are looking for ‘layer partners’ partners to join our ISAS team to supply / develop innovative value add**

Who we are

- Telespazio VEGA UK (*VEGA Space Ltd rebranded in March 2012)*
  - Part of Telespazio (a Finmeccanica / Thales Company)
- UK SME made good! Small company ethos within a large company.
  - 1978 start up - 33 years' space domain knowledge
  - One of top 3 system consultancies supporting ESA and ranked first amongst top 4 selected by ESOC
  - Europe's leading data quality and spacecraft operations & simulations provider
  - Very strong reputation as a flexible and customer focused service provider
- Now also the Telespazio group supplier of Geo-Information services to
  - The UK and UK based international customers
  - The Netherlands and additional tbd markets

Finmeccanica's UK presence

AnsaldoSTS

Railway technologies
(London)

TELESPAZIO VEGA
UNITED KINGDOM
A Finmeccanica / Thales Company

Space and Satellite Solutions
140 employees *(Luton)*

DRS TECHNOLOGIES

Defence electronics
50 employees
(Farnham, Long Bennington)

AgustaWestland
A Finmeccanica Company

Helicopter development and production
3,500 employees
(Yeovil, Newquay, Farnborough)

MBDA
MISSILE SYSTEMS

Missile systems
3,000 employees
(Bristol, Stevenage, Lostock)
(25% owned JV)

FINMECCANICA

Selex ES

4,600 employees

Sensor solutions
(Basildon, Edinburgh, Luton, Portsmouth, Southampton, Lincoln)

Secure networked solutions
(Basildon, Christchurch, Filton, Portsmouth, York, key UK ports)

Prime contracting and systems integration
(London, Southampton)

Vega

Consultancy
150 employees
(Bristol)

UK HQ: Great George Street, London SW1
Total UK employees: 8,000+

Group Geo-Information capability

Telespazio SpA

Telespazio Geo-Information capable companies

Tpz VEGA UK Ltd | **e-geos SpA** | **GAF AG** | **Tpz France SAS**

- **UK Portal to Group Capability**
- **<u>Adding More Value in UK</u>**
  - **Customer focus**
  - **Tailored & Integrated Solutions**
  - **Innovative delivery techniques**
  - **Leading a range of SME's and expert partners**
- **Drawing UK Govt. Downstream investment**

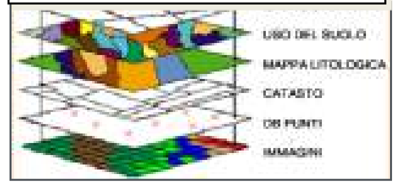
Broad expertise and international partner / subsidiary base

Tpz VEGA Geo-Information Services:
A complete range - optical & radar, space & airborne

Defense & Security
- Multi-mission Satellite Data
- Border Control
- Rapid mapping
- Activities Monitoring

Maritime Surveillance
- Oil spills
- Ship detection
- Marine water quality
- Off-shore activities

Geo Info System
- Geographic Information Systems
- GIS Applications for territory and activity management



Integrated GIS
- On-line access
- Processing of geo-info products
- Web systems & Services

Agriculture
- IACS-GIS Solutions
- Parcel Reference Systems
- Subsidy Controls
- Assistance to Administrators and Farms
- Agro-Risk Management

Forestry
- Forest Mapping
- Forest Inventories
- Biomass and Carbon Stocks
- Biodiversity Inventories
- Forest Management Systems

Geology
- Geological Mapping
- Mining Management
- Hydrocarbon Exploration
- Groundwater Exploration
- Administration Support

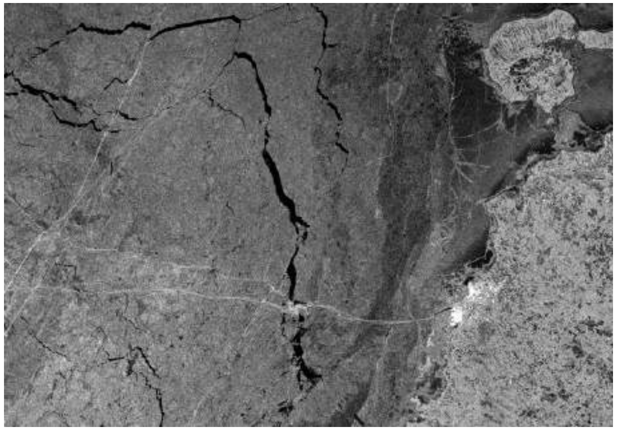
Cadastre / Land Mgt
- Land Administration
- Cadastres
- Water Management
- Land Information Systems
- Institutional Land Management

Orthom & Cartography
- Satellite data
- Aerial/satellite orthoimages
- Technical Cartography
- Digital Terrain Models
- Land Use and Land Cover
- 3D models and visualization

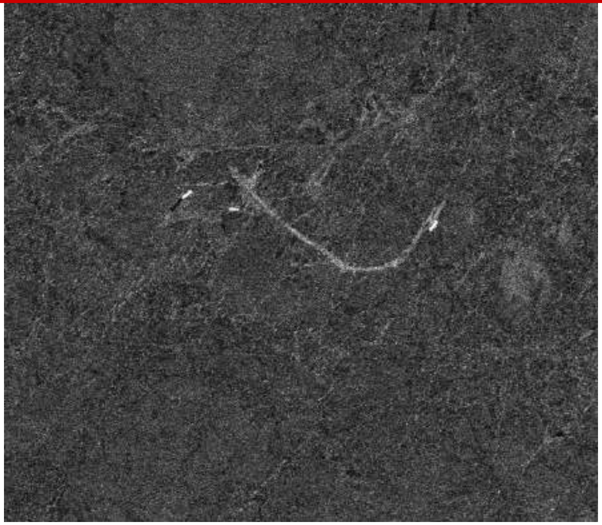
Infrastructure
- Transportation Systems
- Utility Management
- Facility Management
- Communication Solutions
- Location Based Services

Risk Mgmt, Civil Protection
- Landslide;
- Forest fires;
- Floods;
- Geohazard;

Environment
- Environmental quality analysis
- Subsidence;
- Coastal zone management
- Land Use Planning
- Watershed Management
- Disaster Management
- Environ. Capacity Building



An Integrated Situational Awareness Service Example Exploiting Ice Monitoring & Maritime Services



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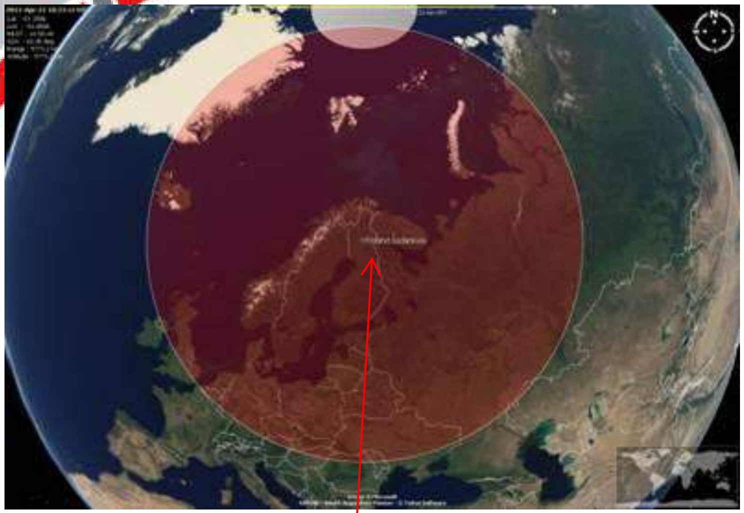
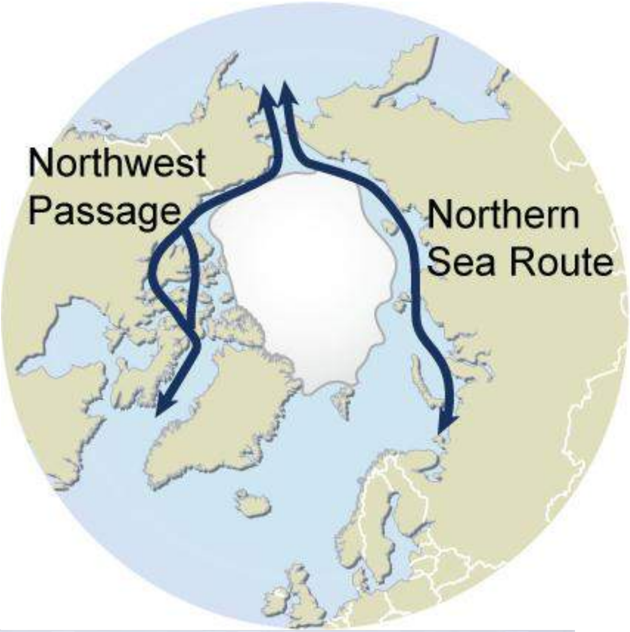
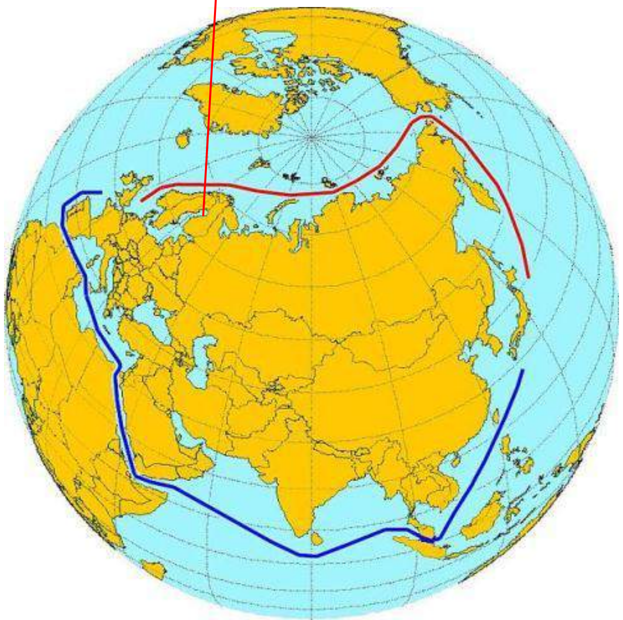
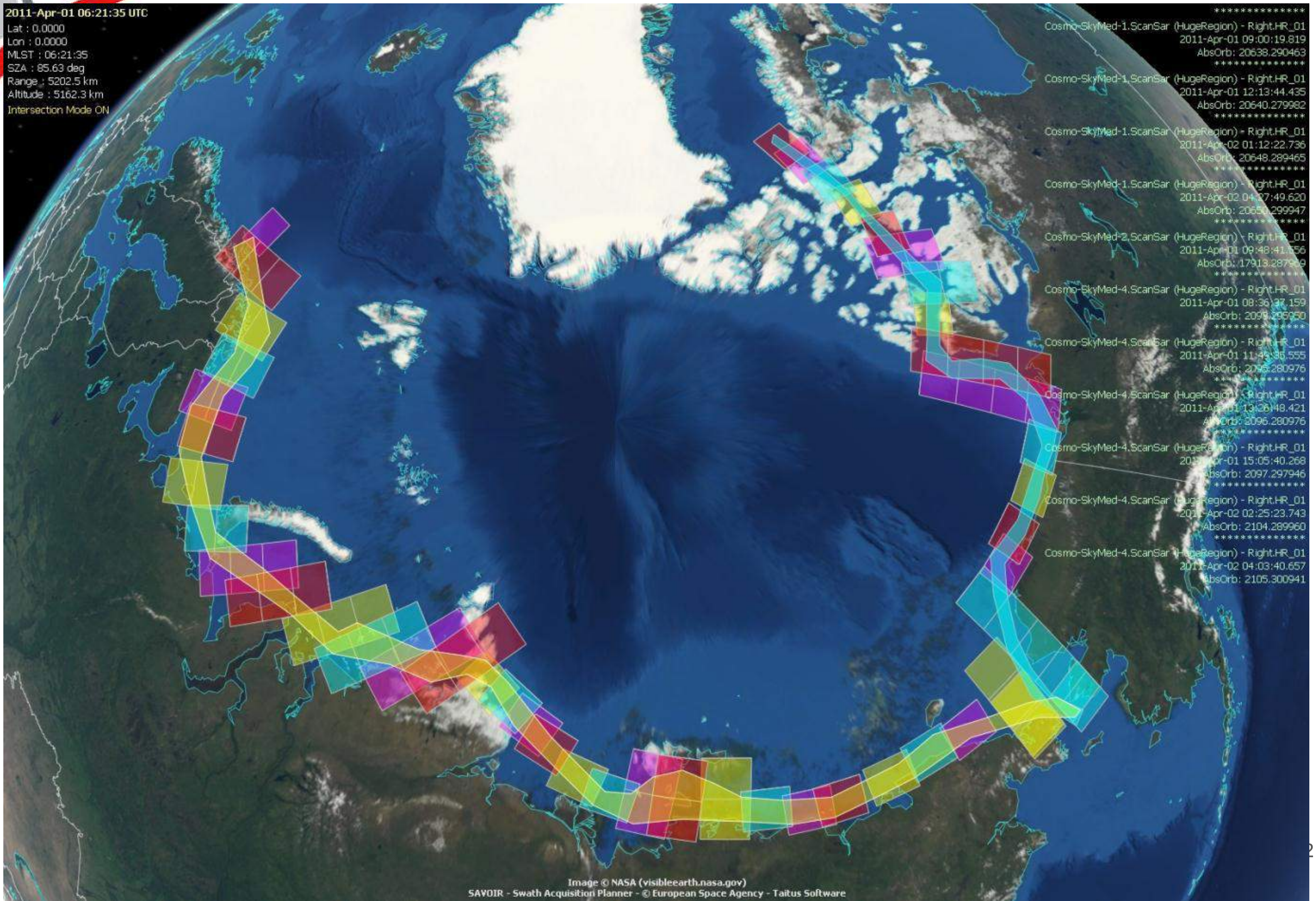
Ice Mapping & Monitoring - The Polar Sea Routes





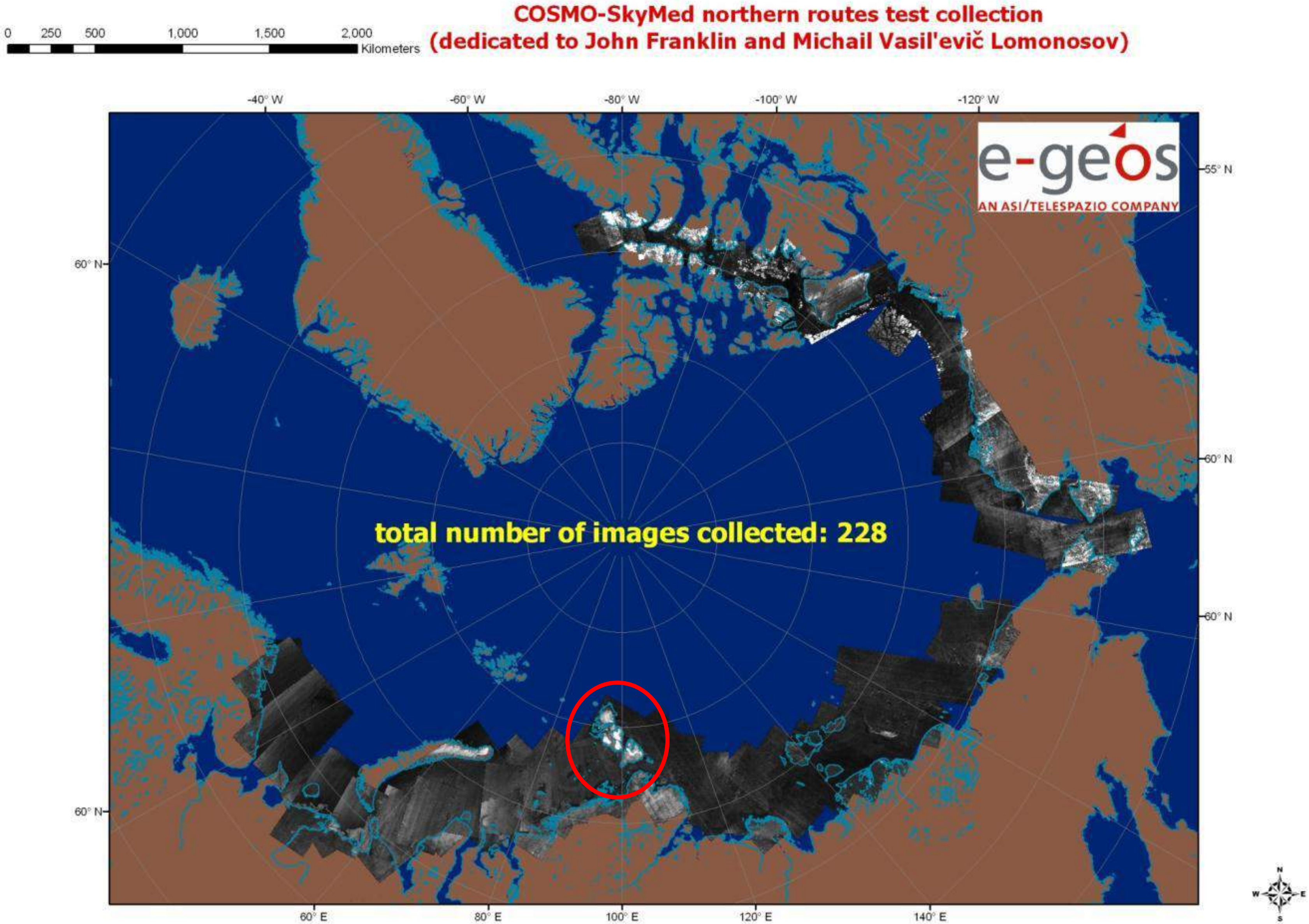


Cosmo constellation allows daily monitoring
- Scenario shows 24 hr descending cover



Demonstration:

– 228 images in 24 hours



New Tpz VEGA-UK Services

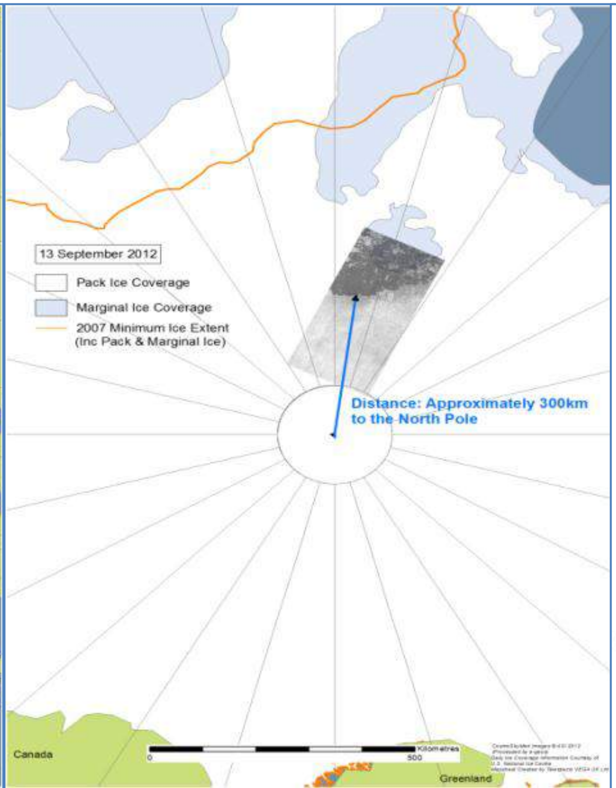
2012 - we partnered with BAS and PMOC Cryosat team to develop:

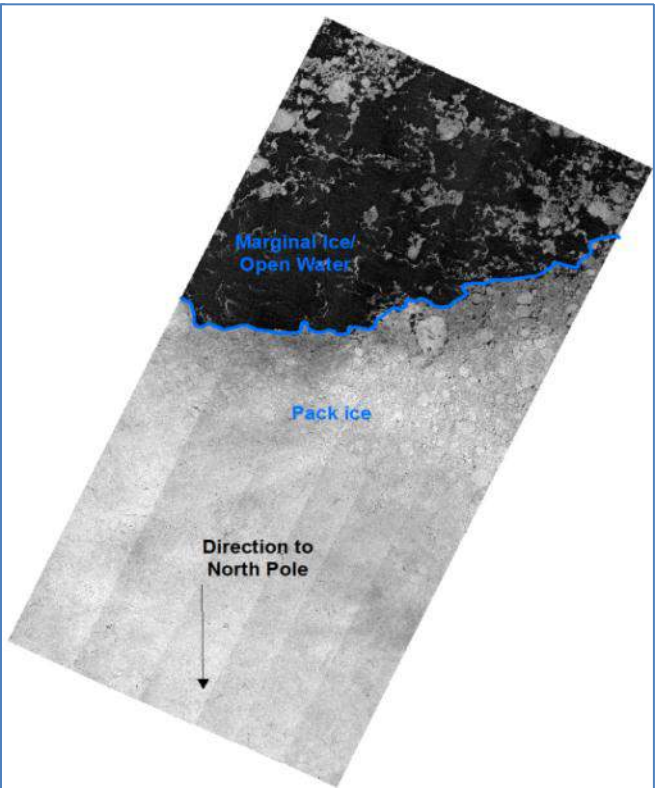
- New ice related products (SME partner)
- Delivery to high latitudes through low B/W links (SME partner)
- Tablet & Mobile platform product delivery

2013 - we expanded partner base to develop an

Integrated Situational Awareness Service (ISAS) for the Arctic

- **We would welcome additional partners for both maritime & land ISAS applications**





Integrated Situational Awareness Services

ISAS – Maritime

(Includes Arctic)

- Scope & Background (1)

  – **Provide, via tailored innovative & user friendly interfaces, a situational awareness service supporting the maritime environment**

  – **Integrating:**
    - Near Real Time (NRT) Geo-I imaging (space & air) and analysis
    - Weather data and modelling
    - Situational modelling
      – e.g. inshore and deep water oil drift analysis, forward & back tracking, co-operative and non cooperative target identification, ice movement and thickness, crowd sourced wave height and bathymetry, etc.
    - Geo-location (AIS, VMS, etc)
    - Narrow Bandwidth Satellite Communications
    - Real Time in situ Verification data
      – Volunteered and solicited crowd and other sourced verification data (video, photos, human intelligence, ships instruments, buoys, etc.)
    - Total maritime picture

Integrated Situational Awareness Services

ISAS – Maritime

- Scope & Background (2)
  - **Application Primarily maritime / littoral but also lakes & rivers**

Maritime Application Fields:

- Crisis Response (Environmental or Security)
- Maritime Traffic Management & Monitoring
- Environmental & Pollution Control and Policing
- Off shore Oil & Gas, Mining and Energy Operations
- Border Control
- Port security and environmental monitoring
- Search & Rescue
- Piracy Prevention / Response
- Fisheries Protection
- Anti Trafficking
- Minimum Emissions Routing
- Maritime Tourism
- Maritime Leisure Market
- **Operations in Ice and in Ice-burg waters**
  (Niche Market within Maritime ISAS

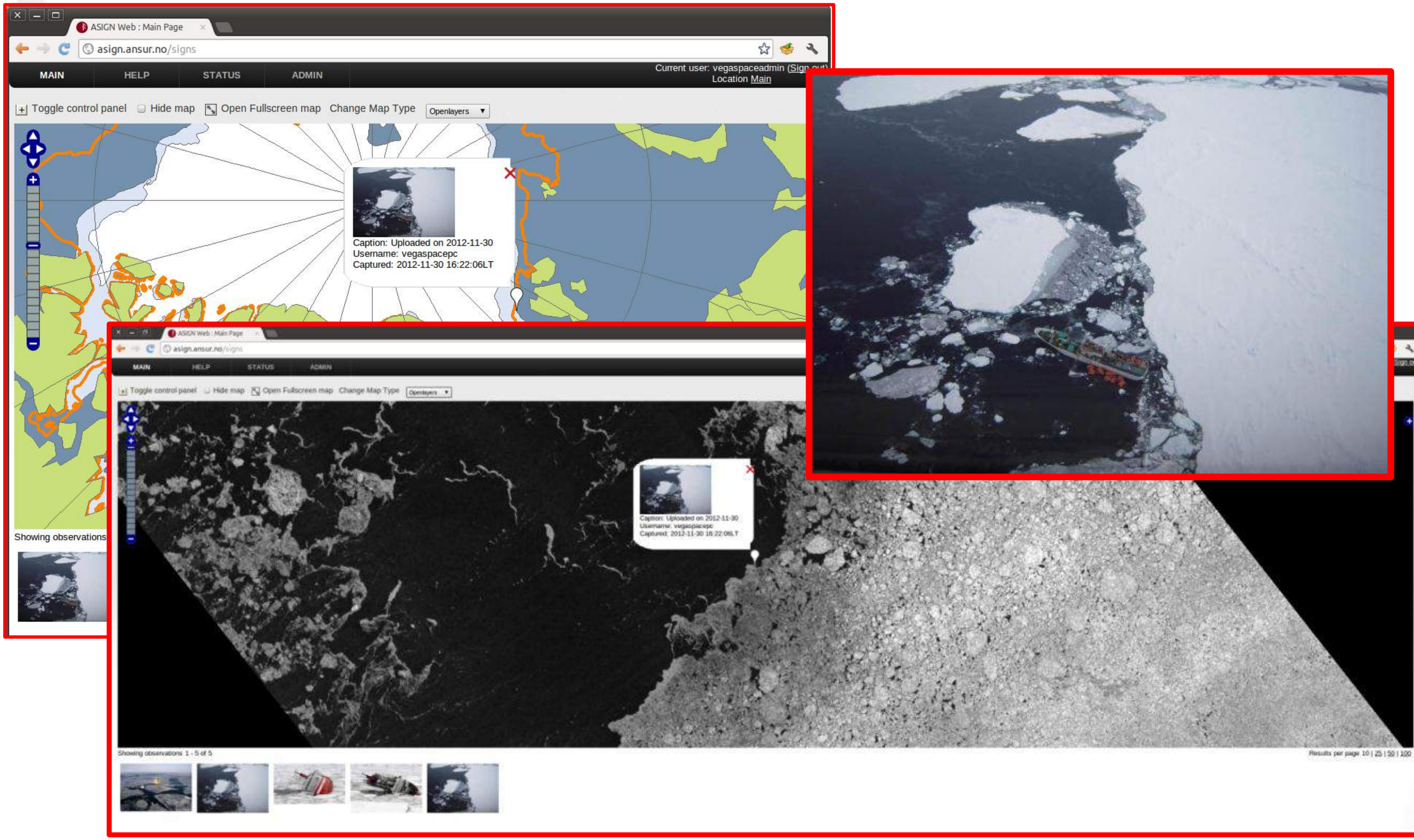
Situational Awareness in remote locations – In Situ Images & Video

- Increasing Arctic activity means increased risks

- More need for detailed (high bandwidth) 2 way data exchange
- At high latitudes communications band width is limited so utility of ice charting and emergency services is limited
- Vega and partners aim to solve this problem

17

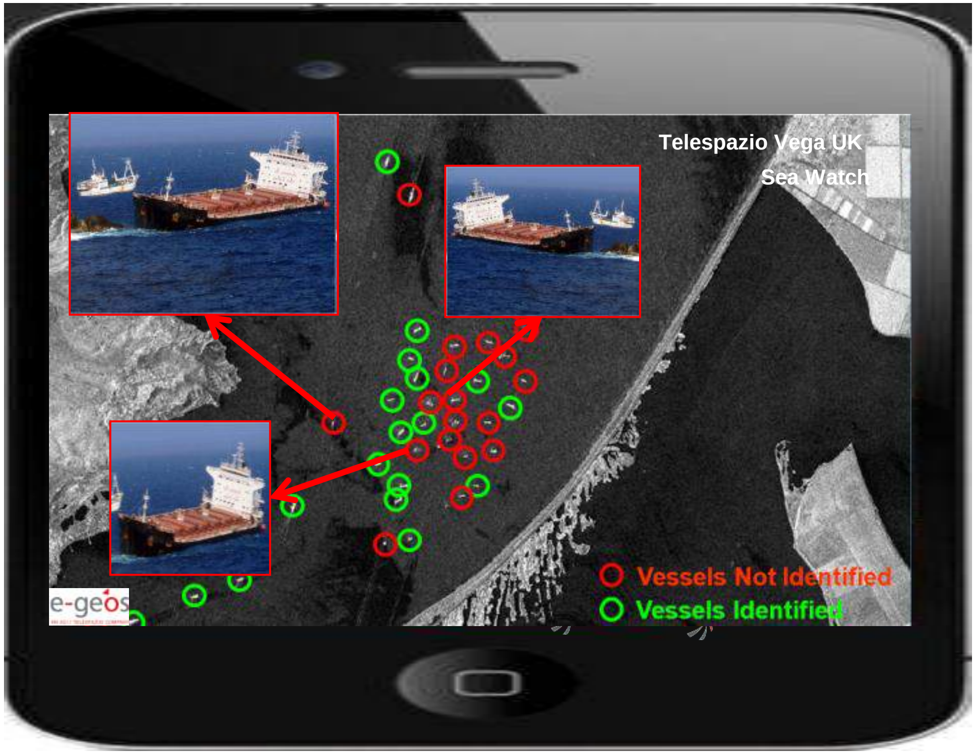
Situational Awareness in remote locations – In Situ Images & Video



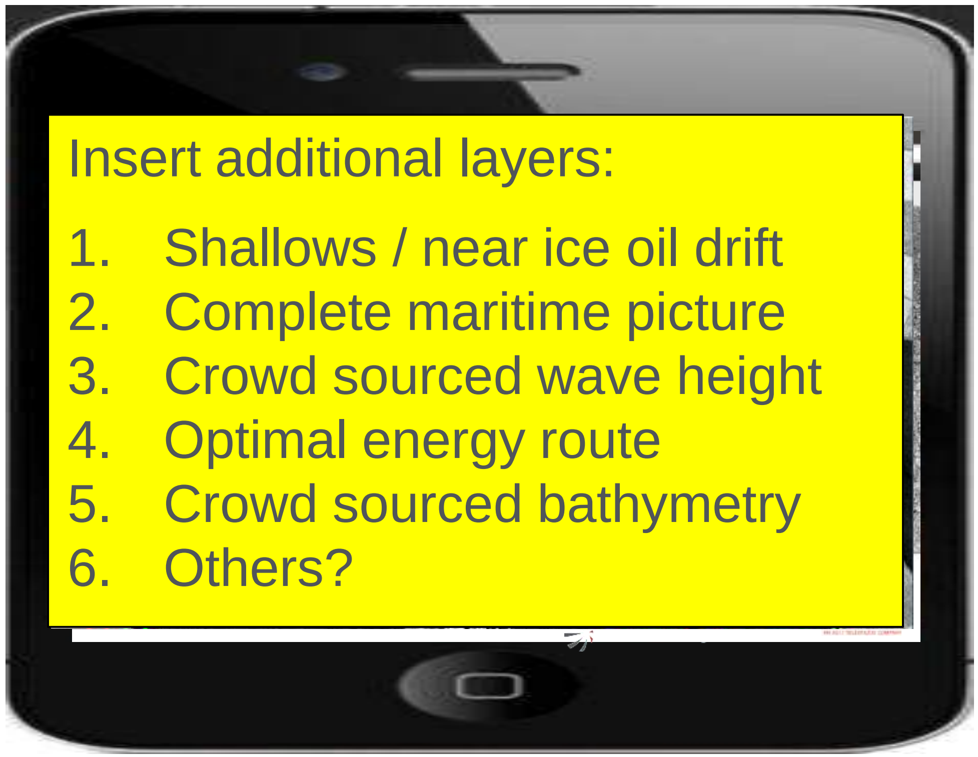
Integrated Situational Awareness Services (ISAS) – The Vision

Arctic Services – 'Ice Watch' Preview:

Maritime Services – 'Sea Watch' Preview:



Maritime Services – 'Sea Watch' Preview:



Insert additional layers:

1. Shallows / near ice oil drift
2. Complete maritime picture
3. Crowd sourced wave height
4. Optimal energy route
5. Crowd sourced bathymetry
6. Others?

Integrated Situational Awareness Services

Current Partners – Service Development

– **Current Service Development Partners:**

- **Telespazio Vega UK -** ISAS integrator and supplier
- **E-geos** – Existing O&G / Maritime & Ice Products and Services
- **GAF** – Consultancy services

- **HR Wallingford / Sea Zone -** Maritime research centre, Web delivered services - weather, winds, currents, etc. fo
- **FedNav –** Ice breaker fleet and in house operational Ice Service provider
- **AnsuR –** Low Bandwidth delivery of integrated of high resolution situational awareness imagery and data
- **AstroSat –** In shore, in port and near ice oil drift modelling
- **Smart Com** – crowd sourced bathymetry
- **Critical Software** – operational Search & Rescue total maritime picture integrator

- **Marine South East –** maritime cluster – consultants on maritime user requirements
- **Exact Earth** – Satellite AIS supplier
- **Iridium** – High Latitude Bandwidth supplier
- **Inmarsat** – Bandwidth supplier

Integrated Situational Awareness Services

Current Partners - Users

- **Current User Partners:**

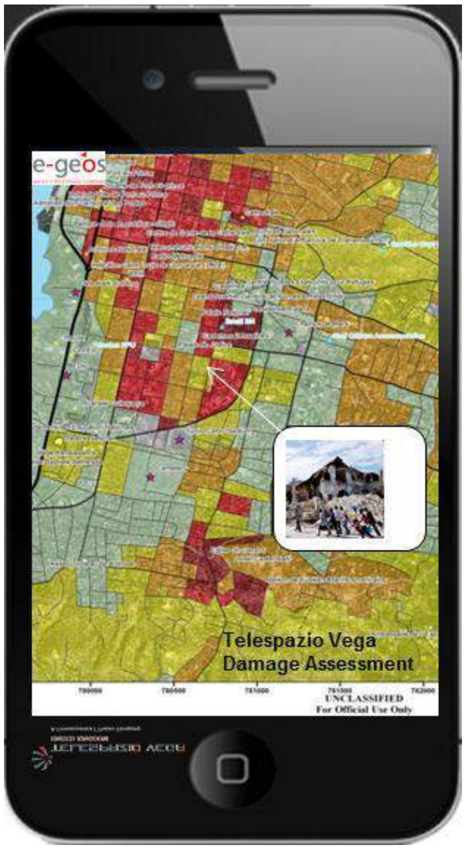
  - **All domains below plus Fishing & on Shore Mineral Extraction**
    - Government of Greenland
  - **Shipping**
    - JSC Murmansk Shipping Company,
    - FedNav
  - **Tourism**
    - Association of Arctic Expedition Cruise Operators (AECO),
    - Lindblad Expeditions,
  - **Oil & Gas**
    - ENI
    - Conoco Philips
    - Spatial Energy
    - One other major oil company support letter in approval loop at time of bid
    - One other major oil company requested involvement post bid

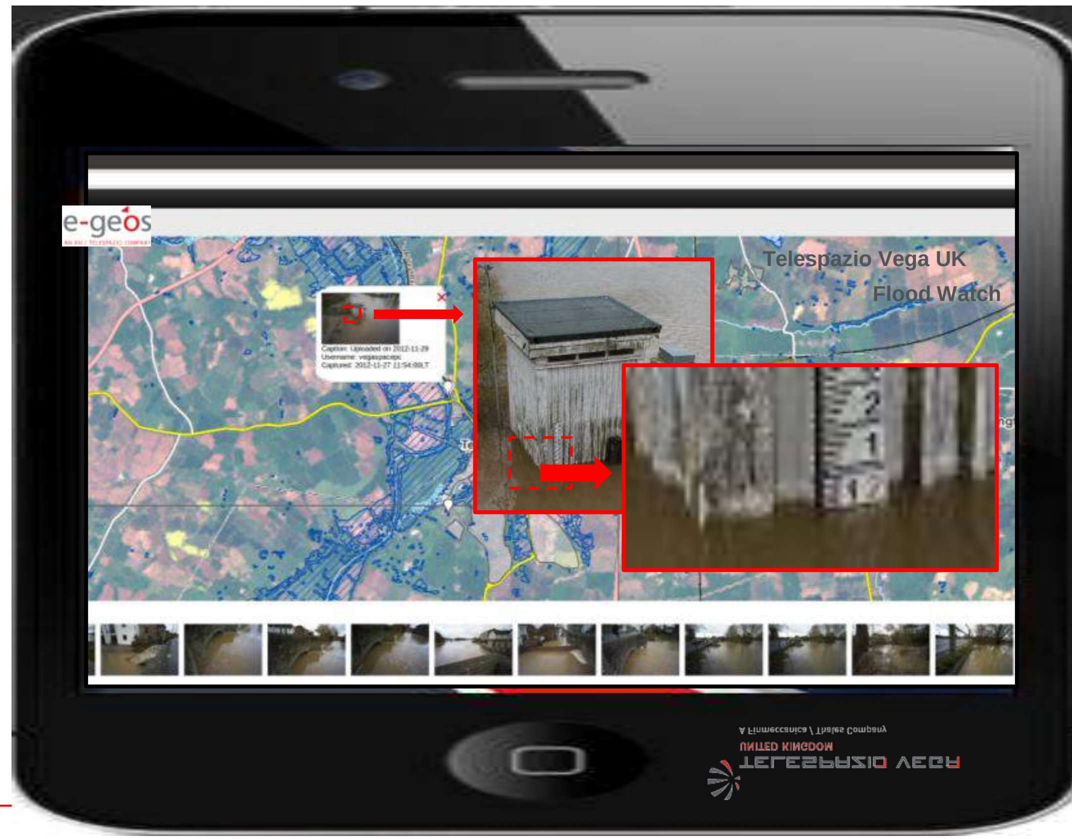
Integrated Situational Awareness Services

ISAS – Crisis Management **(Primarily Land)**

- Scope & Background
  - **Provide, via tailored innovative user friendly interfaces, a dual use commercial SA service supporting Crisis management**
  - **Integrating:**
    - Near Real Time (NRT) Geo-I imaging (space & air) and analysis
    - Pre/During/Post event situational modelling
      - (e.g. Nuclear crisis management tools, fire detection modelling, flood management tools, traffic management tools, damage assessment modelling, etc.)
    - Narrow Bandwidth Satellite Communications,
    - Real Time volunteered and solicited in situ crowd and other sourced verification data (geo-located video, photos, human intelligence)
  - **Application Fields (Primarily Land)**
    - Disaster
      - (e.g. Flood, Earthquake, Severe Weather, Fire, Nuclear, Post and pre event insurance)
    - Security
      - (e.g. Terrorism, Border Control, **Critical Infrastructure Monitoring (commercial or otherwise**), Trafficking, Population Displacement, Policing (Major Events / Civil Unrest), Military Conflict)

ISAS – Crisis Management Solution – The Vision





Improved remote situational awareness for NRT land emergency services

Thank you for listening!

Happy to answer any questions now and later.

If you would like to join the team or have an ISAS delivery tailored to your or your customers needs please get in touch!

Telespazio VEGA UK

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Never Beyond Reach
–
Inmarsat’s Global Satellite Services

Rupert Pearce, CEO
Marcus Vilaça, Chief Scientist & VP Technology Strategy

Satellite services - a transforming industry

- The 70’s saw a rapid proliferation of C Band Geo systems.
  - Global (Intersputnik), regional (Eutelsat) and national (Telesat).
  - Mostly used to provide trunk capacity, like transatlantic links.
  - Inmarsat created in 1989.
- During the 80’s the growth continued, taking satellites from the science pages to day-to-day experience.
  - Very Small Aperture Terminals (VSAT).
  - TV broadcast.
- The 90’s and 00’s saw the explosion of Ku band TV broadcast and low data rate mobile satellite systems.
  - Sky, DirecTV, Echostar,…
  - ICO, Iridium, Globalstar, …
- 2010’s – the rise of Ka band and broadband systems
  - Wildblue, Viasat, Jupiter, Avanti…

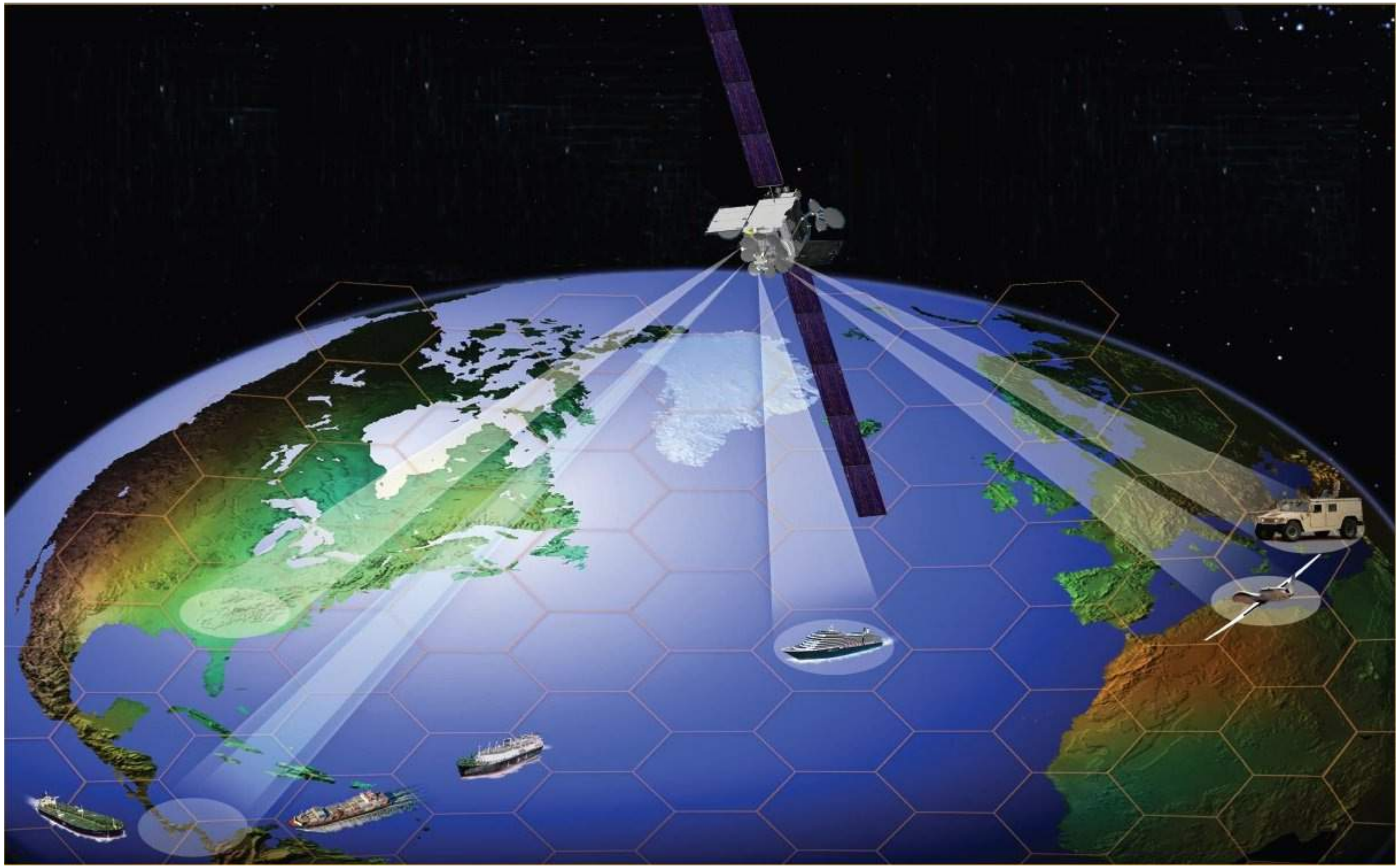
inmarsat

Inmarsat - a parallel path

- Created in 1979 as an IGO.
- First generation services using leased satellite capacity
  - Inmarsat A maritime terminal
    - Analog, voice, telex and fax
- Inmarsat 2 – launched in the early 90's.
  - Inmarsat B (maritime), M (land) and Aero (aeronautical)
    - Digital, voice, fax and data at 9.6 kbps
- Inmarsat 3 – launched in the late 90's
  - Fleet (maritime), Mini-M & GAN (land) and Swift (aeronautical)
    - Voice, fax and data at 64 kbps
- Inmarsat 4 – launched in the mid 00's
  - Inmarsat FB (maritime), BGAN (land), SB (aero) and ISatPhone
    - Voice, fax and data at ~0.5 Mbps
- Inmarsat 5 – to be launched in 2013-14
  - Inmarsat GlobalXpress broadband satellite mobility
    - Data at up to 50 Mbps

inmarsat

GlobalXpress – global mobile broadband



inmarsat

Different users, different needs

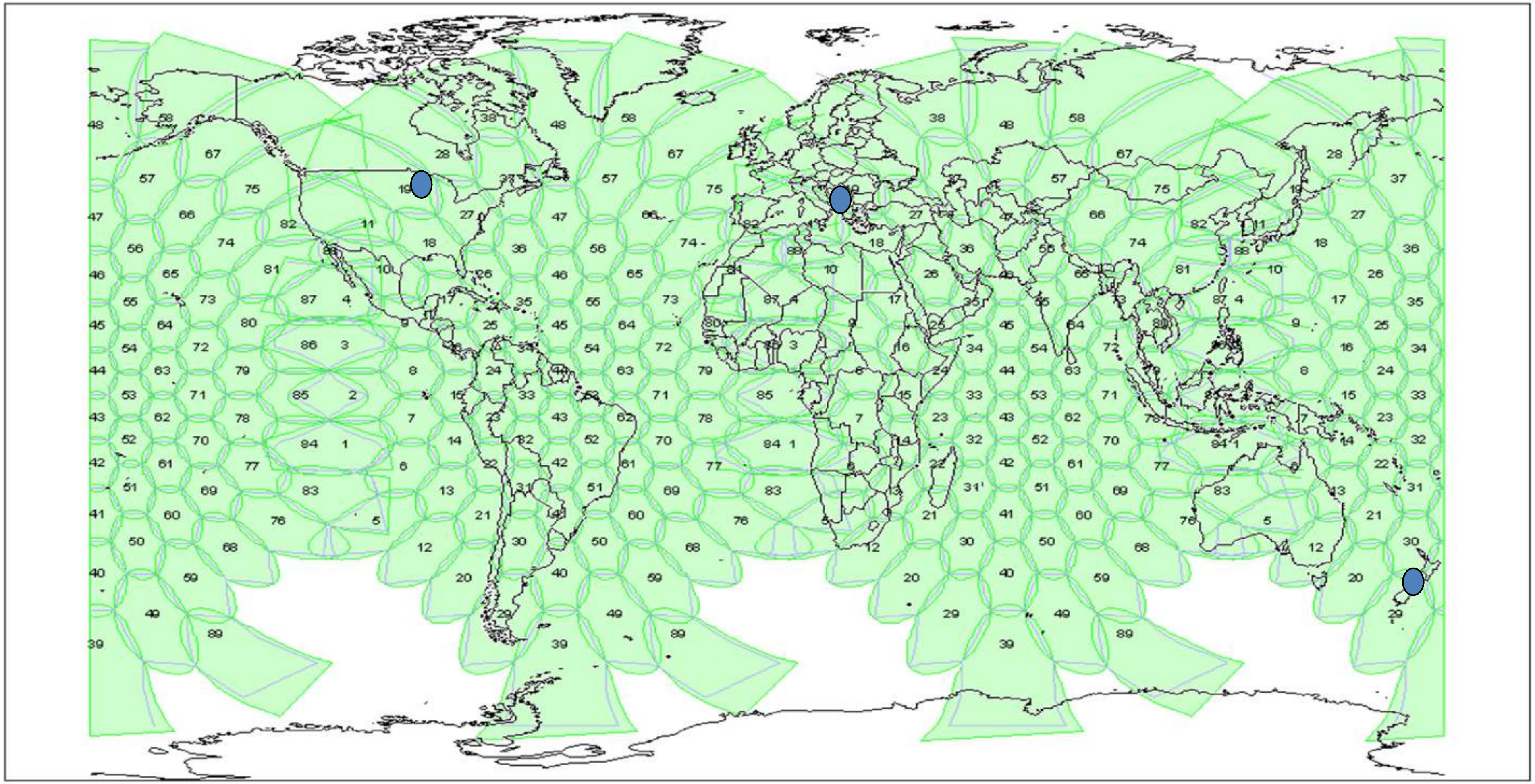
- Coverage versus throughput
  - Global coverage, lower throughput = Inmarsat-5
  - Regional coverage, higher throughput = Viasat-1, Jupiter
- Fixed versus mobile
  - Fixed = Viasat-1, Jupiter
  - Mobile = Inmarsat-5, Spaceway 3
- Scattered communities versus consumer
  - Scattered communities = Inmarsat-5, Spaceway 3
  - Consumer = Viasat-1, Jupiter
- Payload flexibility versus capacity
  - Bent pipe = Inmarsat-5, Viasat-1, Jupiter
  - Onboard processing = Spaceway 3
  - Steerable beams = Inmarsat-5, Spaceway 3

Inmarsat 5 Outline

- A new generation of global Ka band broadband MSS
  - Major leaps forward in capacity and throughput
    - >30 x Inmarsat-4 capacity & >50Mbps Fwrd/5Mbps Rtrn to a 60cm dish
  - Independent from L-band, but integrated as a service offering
- Global payload
  - 89 fixed beams per satellite
    - Highly flexible bent-pipe design variable power and bandwidth per beam
  - 2 x 72 x 40 MHz Channels
    - >6 Gbps aggregate throughput per satellite
- High capacity payload
  - 6 fully steerable beams per satellite
    - Traffic landed in gateway beams
  - 2 x 8 x 125 MHz transponders for commercial Ka services
    - Additional capacity on government Ka band frequencies

inmarsat

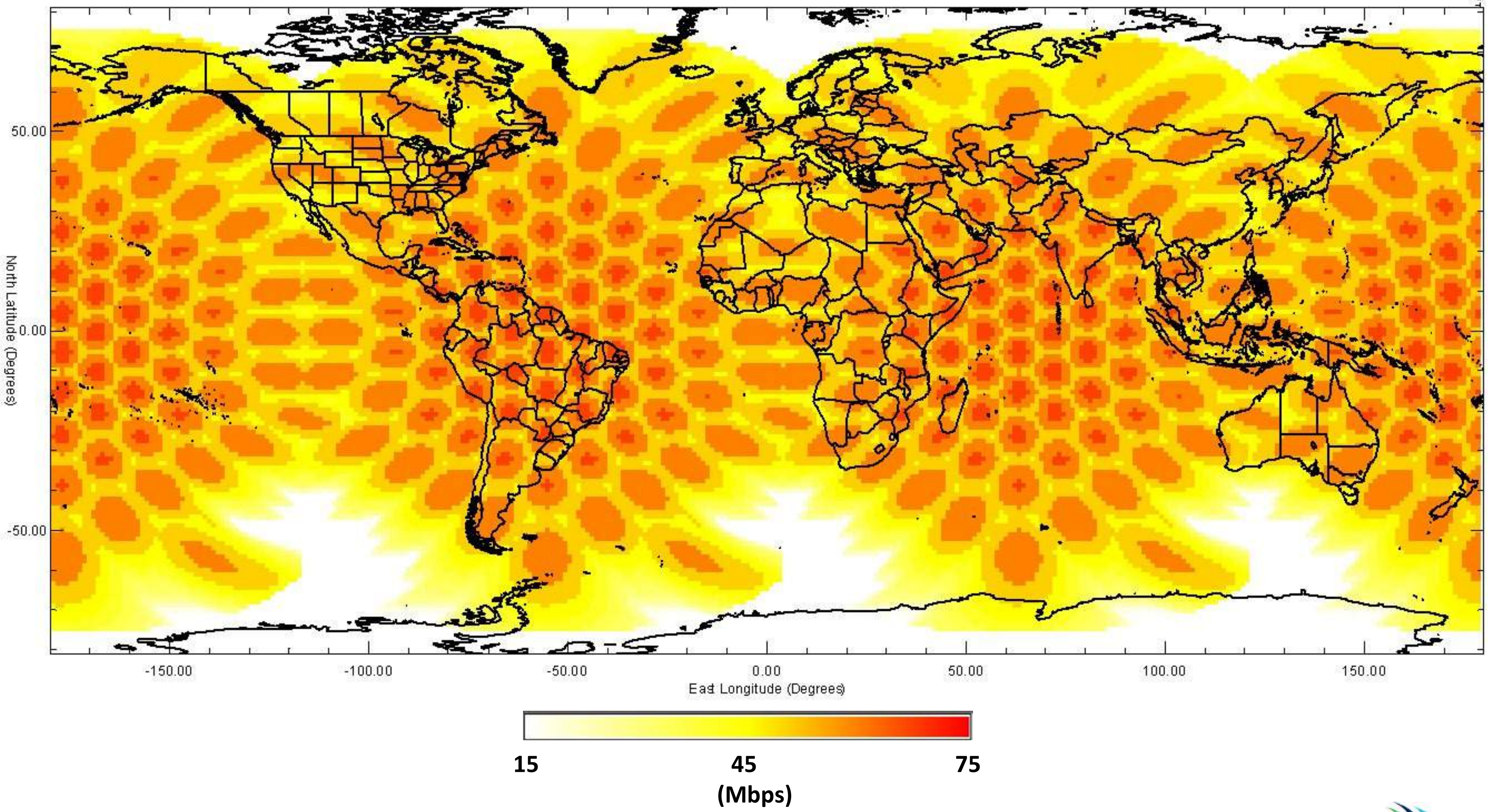
Global coverage



Indicative gateway locations

inmarsat

60 cm dish – forward link, clear sky



inmarsat

The challenges at Ka band

- Rain and other propagation impairments are factors impacting the performance of wireless communications systems.
- Those factors are frequency dependent, and are also affected by specific local parameters, including:
  - Rain rate and rain height
  - Altitude
  - Atmospheric gases
- In the specific case of satellite communications systems, another significant issue is the elevation angle to the satellite.
- Propagation issues have been extensively studied over the last 20 years by the International Telecommunications Union (ITU), European Space Agency, NASA and other agencies.
- Detailed methods have been developed by the ITU to evaluate propagation effects, and have been proved in real systems.

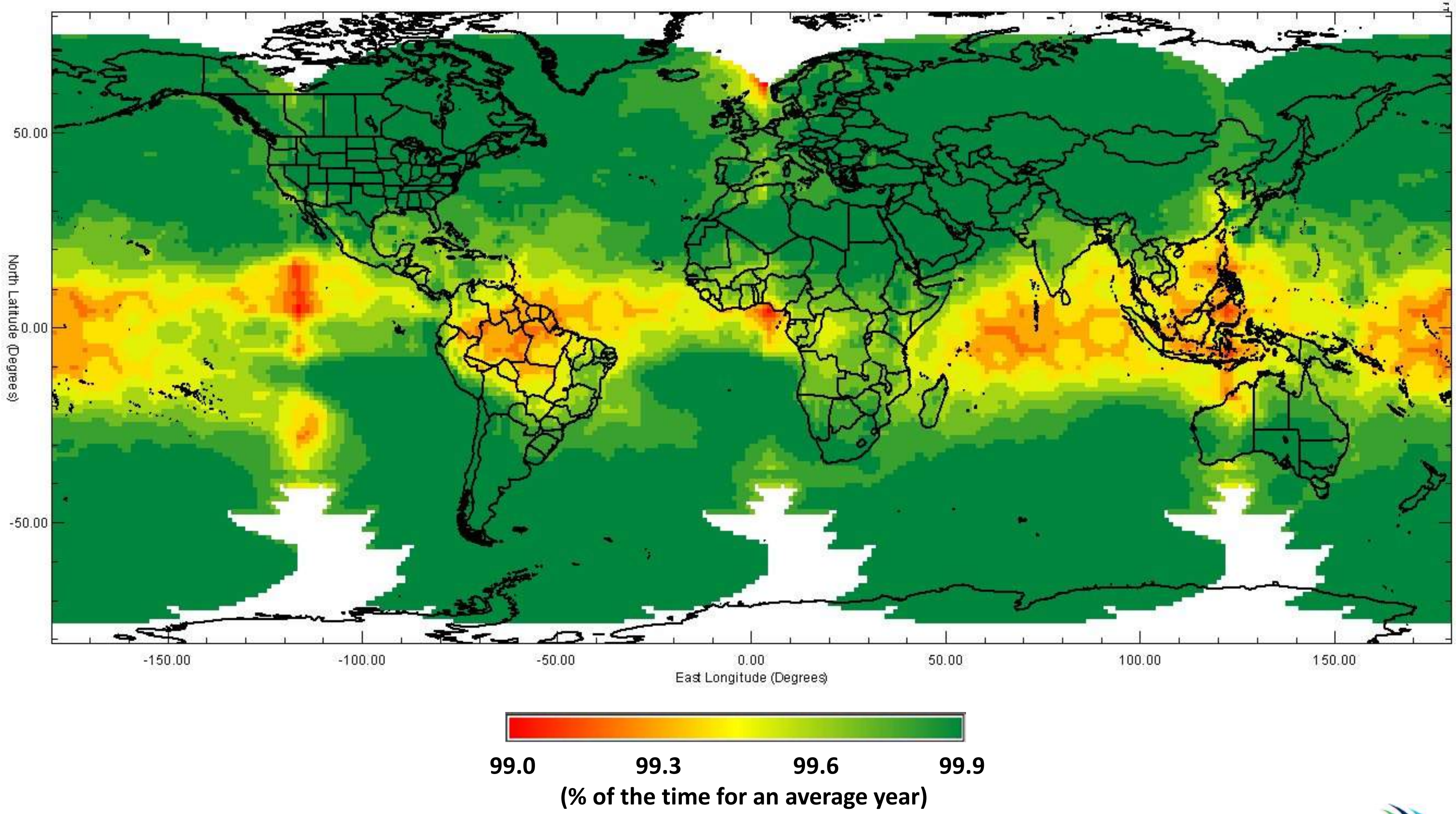
inmarsat

Solving the problem

- Rain attenuation is the main factor affecting system availability for Ka band satellite systems.
  - *Not an issue for aeronautical applications*
- The main tools to cope with rain attenuation are:
  - adaptive code modulation (ACM)
  - link margin yielded by the user antenna size and satellite power
  - forward link automatic level control (ALC) at the satellite.
- For GX, the combination of those parameters deliver an average user link clear sky margin of 15 dB, for a 60 cm antenna.
- For a 1 m antenna, the average user link margin increases to close to 20 dB.
- The feeder link downlink clear sky margin is around 20 dB on the downlink, increasing to close to 25 dB on the uplink, due to the use of ALC on the satellite.

inmarsat

Return link availability for a 60 cm dish



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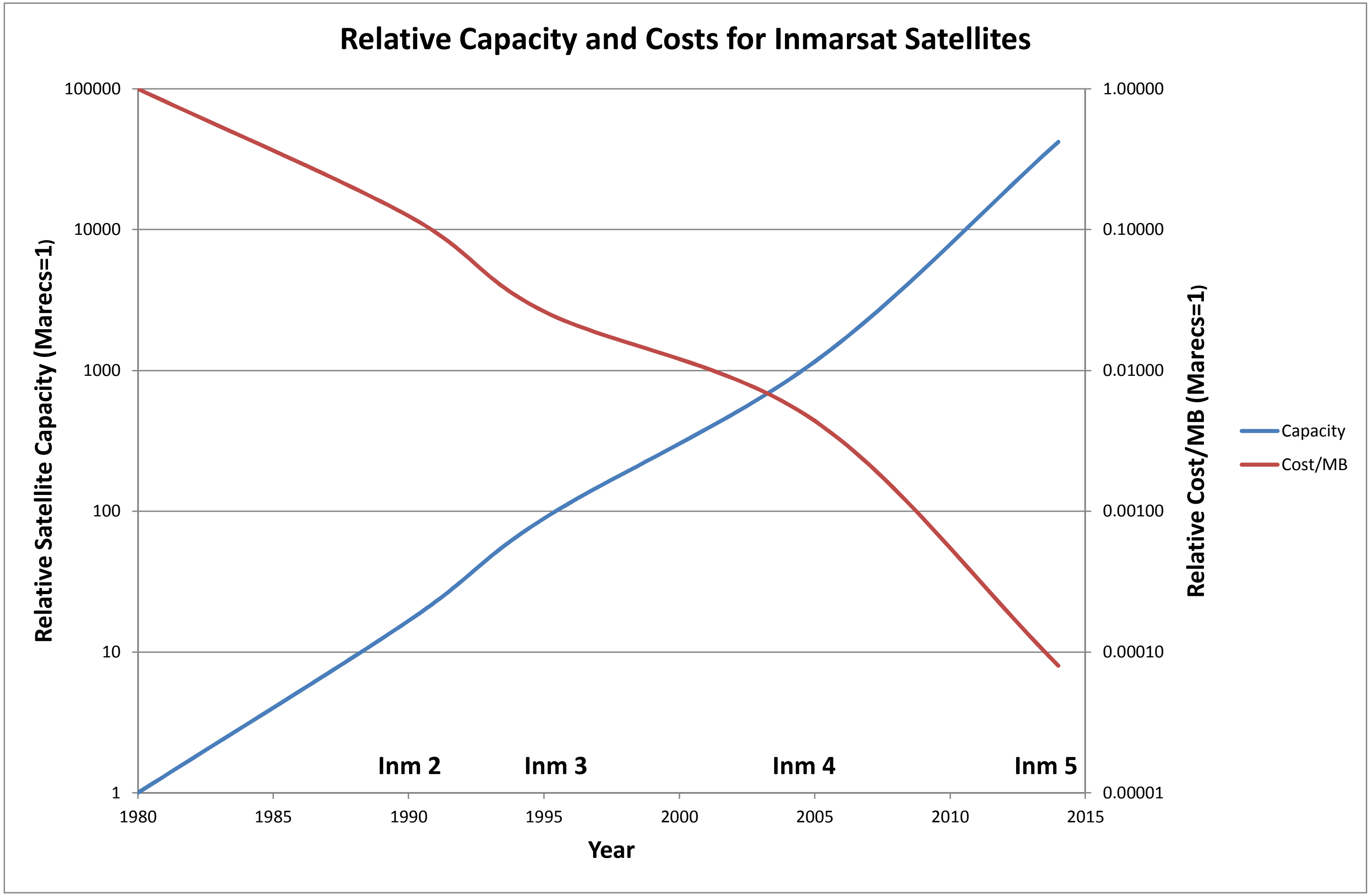
Inmarsat system capacity and cost/MB



inmarsat

Looking forward

- How to ensure the technologies required to maintain the trends in capacity increase and in cost reduction observed during the last >30 years, are available to us for future systems?
- Satellite
  - Antennas
  - Digital channelisers and beamformers
  - High power SSPA at higher frequency bands
- System
  - Network architecture
  - Higher frequency bands
  - Compression, processing, modulation and coding techniques
- User terminal
  - Battery technology
  - Electronically steered antennas

Conclusion

- Communications satellites have been an key part of global communications systems for the last 40 years, transforming and adapting to new technologies and user demands.
- The last few years have seen unprecedented growth in demand for data and broadband applications.
- Recent technology developments have made possible a revolution in the provision of broadband services by satellite.
- We have to continue developing new technologies and exploring ways to ensure that future systems continue to offer higher capabilities and meet user demands.
  - Flat electronically steerable antennas
  - Efficient battery technology
  - Advanced modulation, coding and compression techniques
  - High power/high efficiency solid state power amplifiers
  - More ideas?

Thank you!