Centre for
EO Instrumentation

New Technologies for Future EO Instrumentation

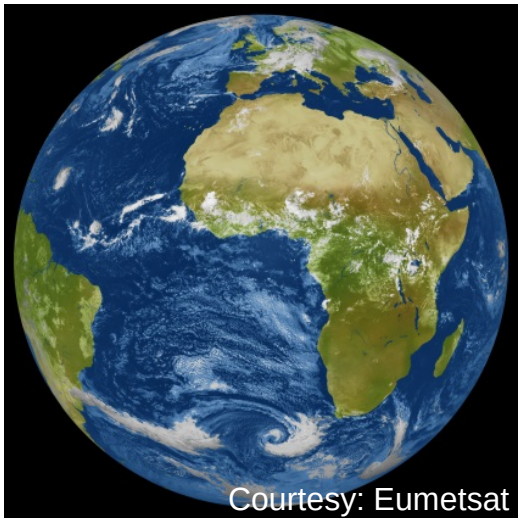
Mick Johnson

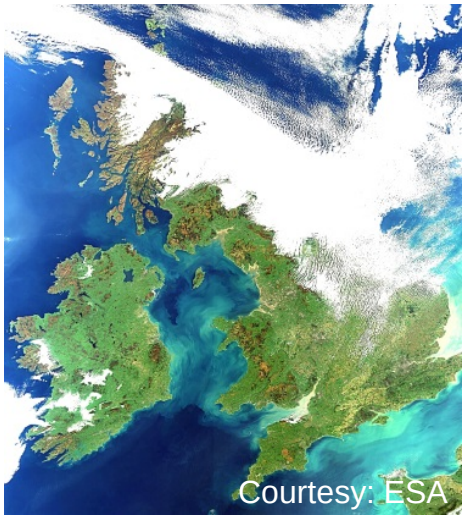
Director of CEOI

Monitoring the Earth from Space

What data do EO satellites provide?

- Earth Observation science
- Operational services
  - Weather, climate
- Commercial EO services
  - Precision agriculture
  - Forestry
  - Maritime information

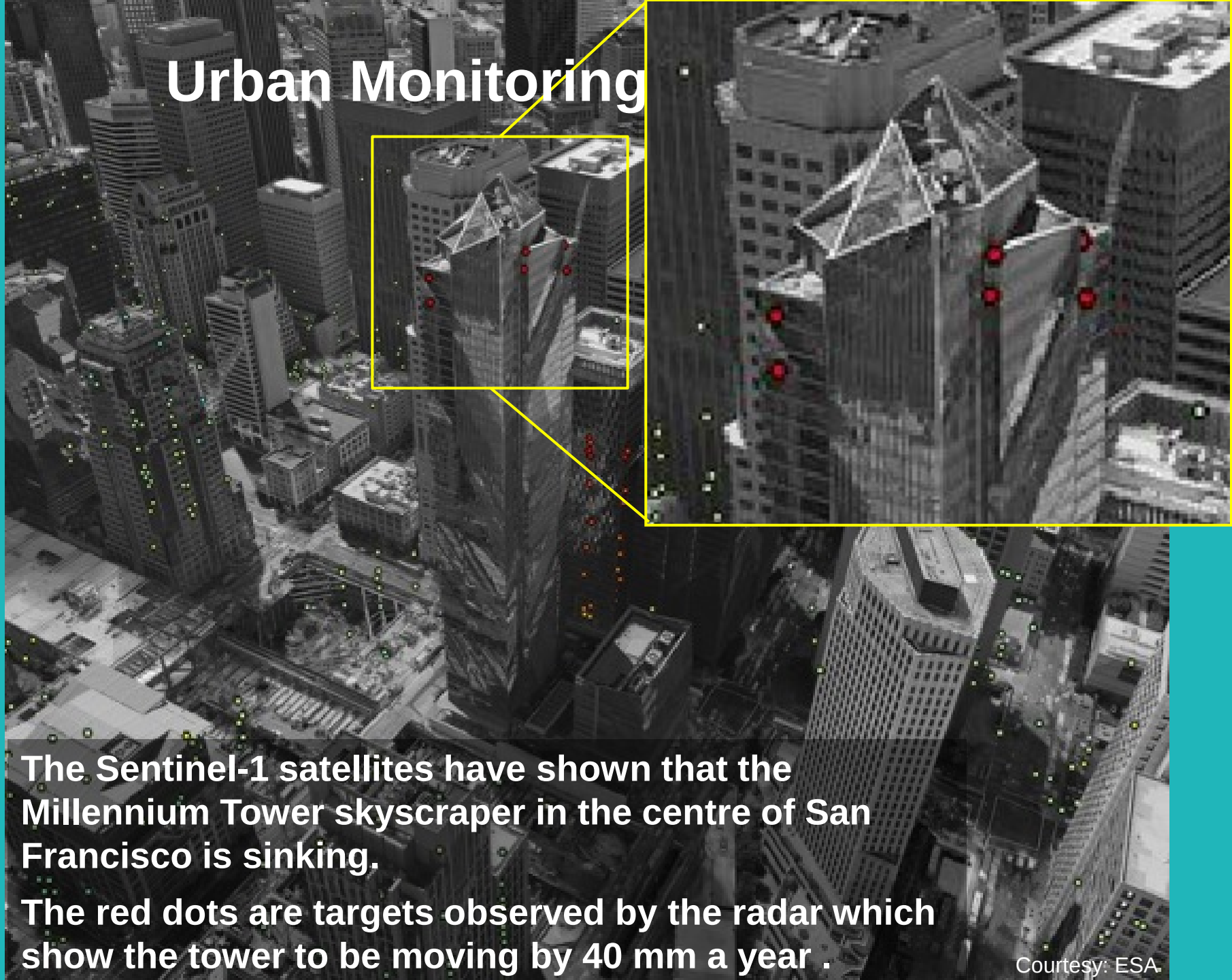




Current assets in Earth Observation

- ESA: Earth Explorer satellites
- Eumetsat: MeteoSat, MetOp
- EU Copernicus: Sentinel satellites
- Commercial EO satellites: TerraSAR-X, RapidEye, DMC, NovaSAR

Urban Monitoring



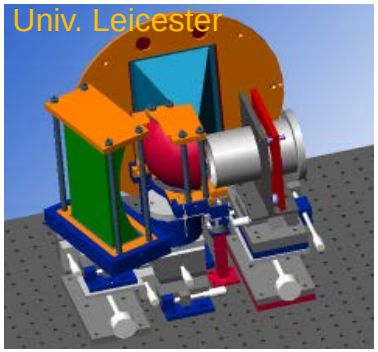
The Sentinel-1 satellites have shown that the Millennium Tower skyscraper in the centre of San Francisco is sinking.

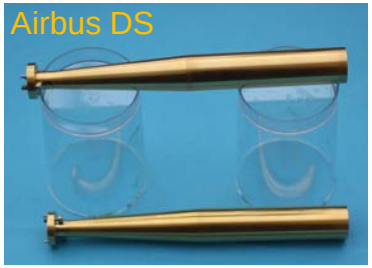
The red dots are targets observed by the radar which show the tower to be moving by 40 mm a year .

Courtesy: ESA

Objectives of the Centre

- UK Space Agency initiative to boost UK capability and remain at the forefront of EO technology for space
- Programme focus on:
  - Innovative EO instrumentation and technologies
  - Maturing technologies for future EO missions
  - Improved access to ESA missions
  - Focus on technologies for economic growth
- CEOI has managed and delivered more than £17M of technology projects over last 3 years
- Added Value programme of workshops and Technology Transfer
- Developing a new EO Technology Strategy
- Future funding opportunities





Delivered by the established CEOI partnership

Science & Technology Facilities Council
Rutherford Appleton Laboratory

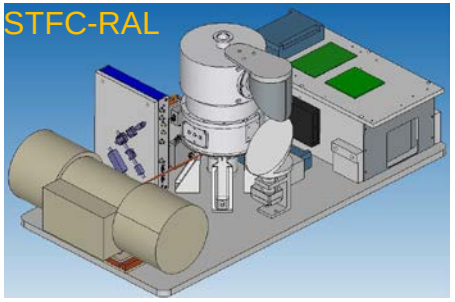
University of Leicester

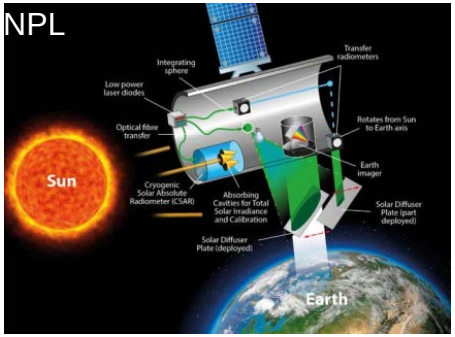
QinetiQ

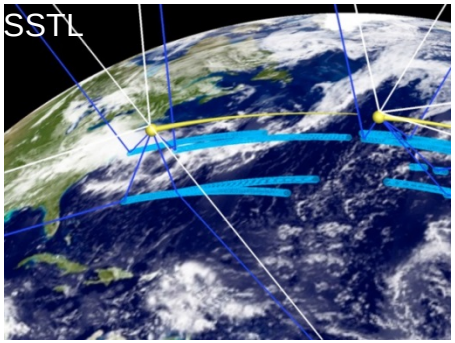
AIRBUS DEFENCE & SPACE

Developing technologies for future EO missions

- UV/visible high resolution spectrometer
  - CompAQS instrument for air quality
- Advanced millimetre wave and TeraHz technologies
  - Microwave Sounder (MWS) for MetOp-2G
  - Development of LOCUS mission and technologies
- Climate and GHG Monitoring
  - In-orbit SI-traceable calibration (TRUTHS)
  - Technologies for CNES bilateral (MicroCarb)
- Advanced Radar Systems and Missions
  - Ocean currents and global winds
- GNSS reflectometry for sea surface winds



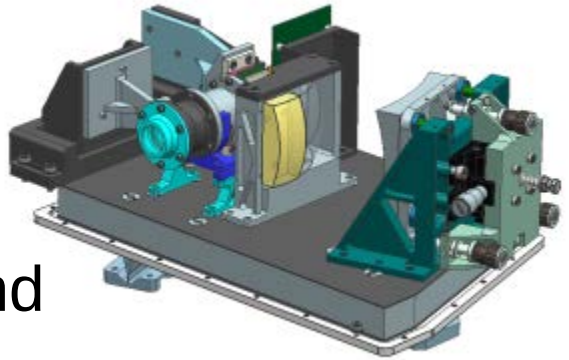




CompAQS - Air Quality Spectrometer

Univ. Leicester, SSTL

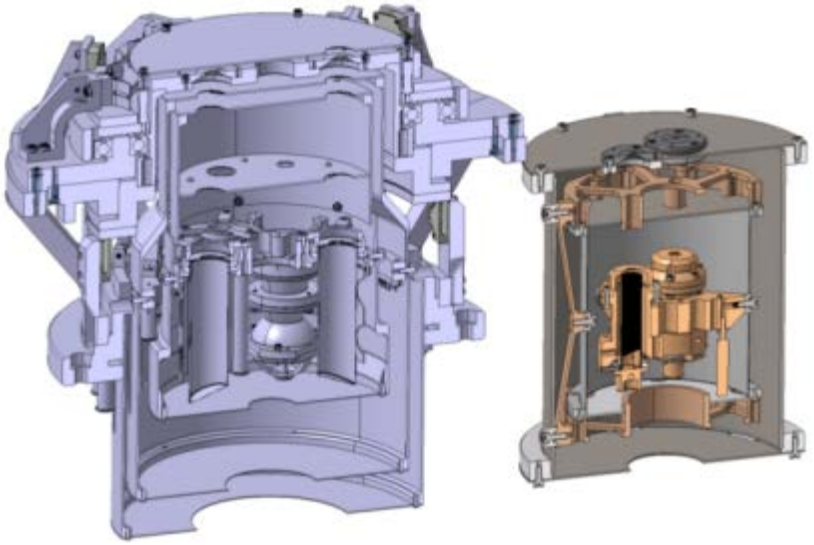
- Quantification of air pollution (NO_2 & aerosols):
  - Map sub-urban concentrations
  - Constrain emission inventories to 50-100%
- Achieved through:
  - High spatial and temporal resolution UV/optical spectrometer
  - Accurate retrievals to determine emission sources
- Development of compact optical spectrometer
  - System, optical and mechanical designs complete
  - Procurement almost complete, some optics to come
- Instrument build in progress, TVAC test and airborne demonstration in 2017



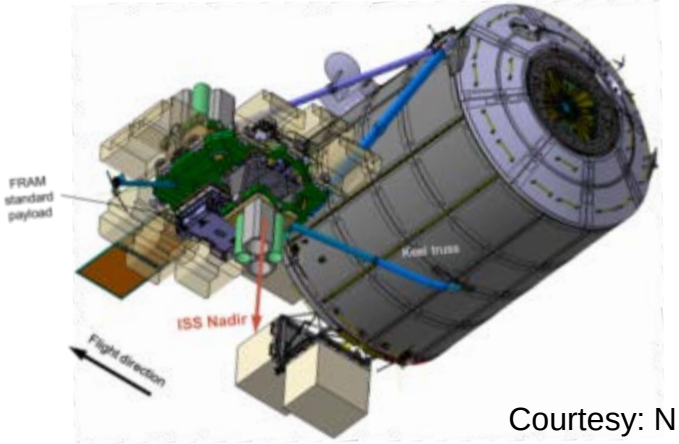
Univ. Leicester

TRUTHS
NPL and Airbus

- Mission to provide benchmark measurements of incoming (solar) and outgoing (reflected solar) radiation
- Sufficient spectral resolution and accuracy to detect the subtle changes in climate within ~12 yr period
  - limited by natural variability of the climate system.
- Developing a lab demonstration of the Cryogenic Solar Absolute Radiometer and the in-flight calibration system
- Approaching end of manufacturing phase and entering integration and test phase.



New low mass & volume CSAR design

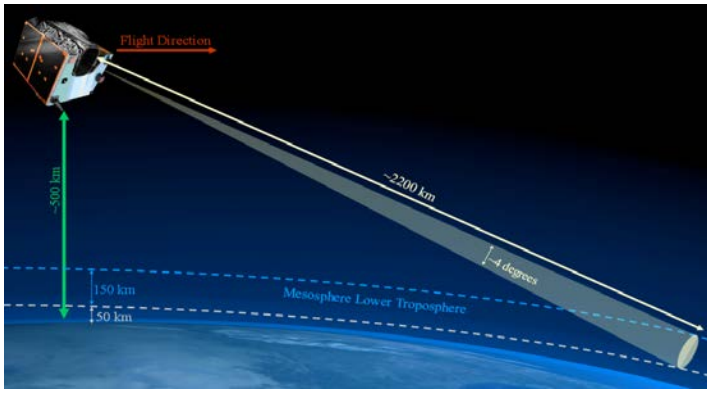


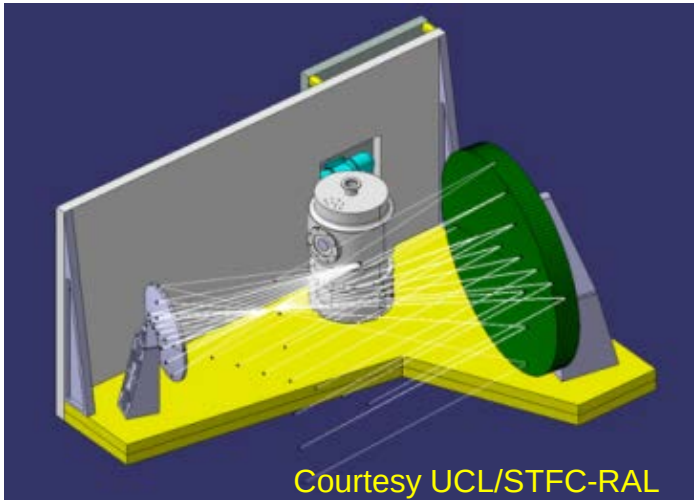
Courtesy: NPL

LOCUS

UCL, STFC RAL, STAR Dundee, Univ. Leeds, Univ. Glyndwr/Huddersfield, JCR Systems

- **LOCUS mission objective**
  - to observe the Earth's Mesosphere and Lower Thermosphere (~50-180 km) using passive teraHz radiometry
- **Project objectives**
  - verify payload system performance
  - reduce the payload power consumption,
  - demonstrate its compatibility with the space environment
- **Work Content**
  - Design, construct and test in representative thermal environment of the LOCUS payload optics and support infrastructure
- Final stage is to characterise the end-to-end performance of the LOCUS payload.





Optical bench design

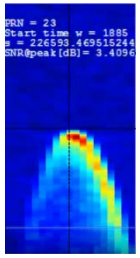
GNSS Reflectometry

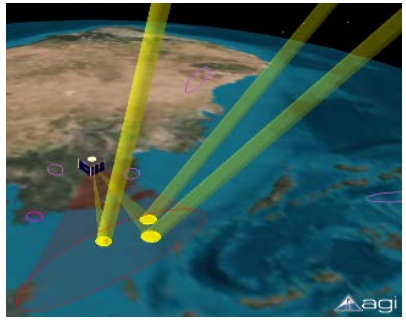
SSTL and NOC

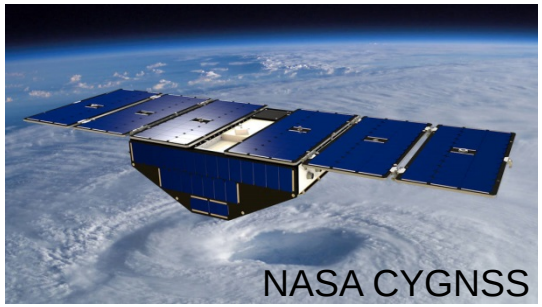
- Instrument developed by SSTL
  - With support from CEOI & ESA
  - Flown on UK TechDemoSat-1, July 2014
- Measures GNSS signals scattered off ocean
  - Measure of sea roughness
  - => Estimate wind speed
  - Also reflections off soil and ice
  - Data available at www.merrbys.org
- Small instrument ~ 2 kg, 9 watts
- NASA CYGNSS mission
  - Uses SGR-ReSI as payload
  - 8 satellites measuring winds inside hurricanes using GPS signals
  - Launch due 12th December 2016

TDS-1

SGR-ReSI







Elements of a EO Technology Strategy

Markets

- Develop technologies in readiness for ESA and other institutional flight programmes
- Target high volume spacecraft opportunities, including operational series / constellations
- Mature technologies for commercial mission opportunities which are timely, low-cost and fit for purpose

Capability

- Strengthen established areas of UK capability
- Continue to encourage academic/industrial partnership to pull through innovation

Implementation

- Support development of future EO mission concepts
- Support airborne and IOD demonstrations

UK EO Capability

Technology Theme	Technology Lines of development	Organisations involved	Breakdown by type			
		Total	Industry	SME	Academic	Government
UV/Visible	22	13	3	1	6	3
Passive Microwave	27	16	2	6	6	2
Radar	19	9	3	1	3	2
IR	12	9	4	2	2	1
LIDAR	4	2	0	1	1	0
Support technologies	7	6	3	1	1	1

Next CEOI Technology Call

- The10th CEOI Call for EO Technologies will be released in December
- There will be 3 main themes:
  - New and innovative ideas for EO technology development
  - Achieving higher TRL through airborne demonstration
  - Development of EO CubeSat flight model payloads aimed at potential commercial services
- Up to £2M available, projects up to 18 months.
- The 11th CEOI Call is likely to be issued in mid-2017, with a focus on strategic objectives

Conclusion

- Exciting new programmes available
  - Major new opportunities in EO for ESA, Copernicus and commercial missions
- Continuing need for lower-cost, compact EO payloads.
- UK well placed to take a lead in many future missions
- CEOI programme is there to support UK EO instrument teams
- Next funding call released soon!
- Contact
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  - www.ceoi.ac.uk