How does CEOI support science missions?

Paul Monks and Mick Johnson

Aim

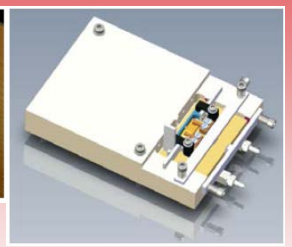
To think about the most effective ways to develop concepts and technology for science missions.

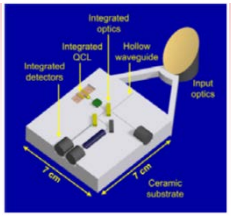
What do we do towards EE?

- Challenge Workshops
  - Assess needs and technology → Horizon scanning
- Technology Funding
  - (GEI) Pathfinder to Flagships
  - Mission studies
  - Technology Roadmaps
- Strategic direction
  - Indicative Missions → whiteboards
  - Bilaterals and EOMAG

(Some) CEOI developments

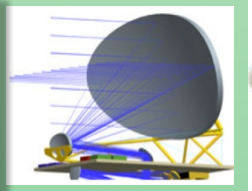
LIDAR & Laser Heterodyne Radiometry (LHR)

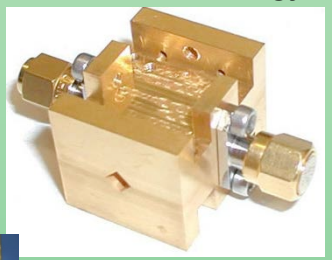




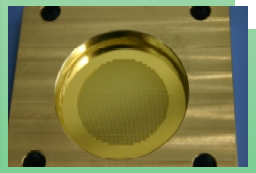
Hollow waveguide implementations
QinetiQ, Hollow Guide Ltd & RAL Space

Sub-millimetre wave technology



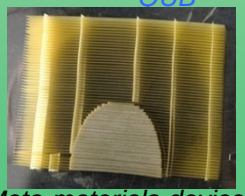


320-360 GHz sideband separating mixer showing (above left) the STEAM-R radiometer (SSC)
RAL Space, Airbus & QUB



Frequency Selective Surface
QUB

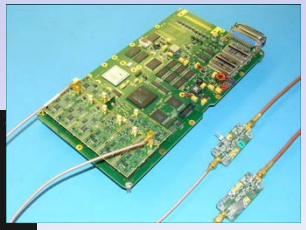
Wide-band spectrometer
STAR-Dundee



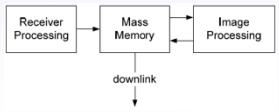
Meta-materials devices
Airbus, QMC

Microwave technologies

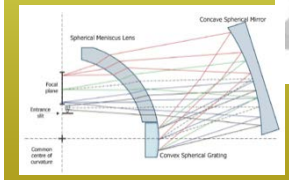
GNSS Reflectometry



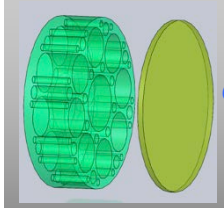
SSTL + NOC, Universities of Surrey & Bath



Compact concentric spectrometer for space and terrestrial use
U of Leicester & SSTL

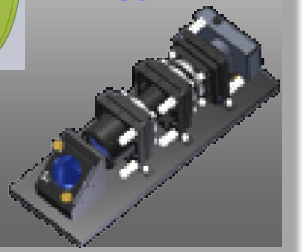


Optical instrumentation



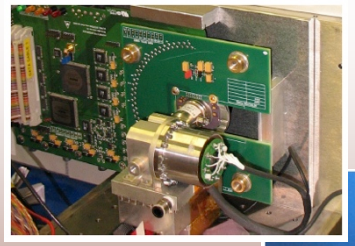
Lightweight mirror technologies
Gooch & Housego + SSTL

Microslice hyperspectral imager
U of Durham



Fourier Transform Spectroscopy with 2D TIR detectors

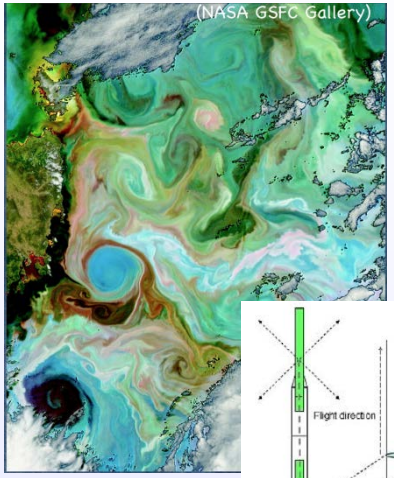
Airbus, SELEX & RAL Space

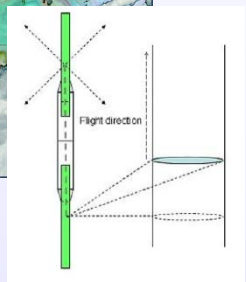


TIR Imaging for clouds
UCL

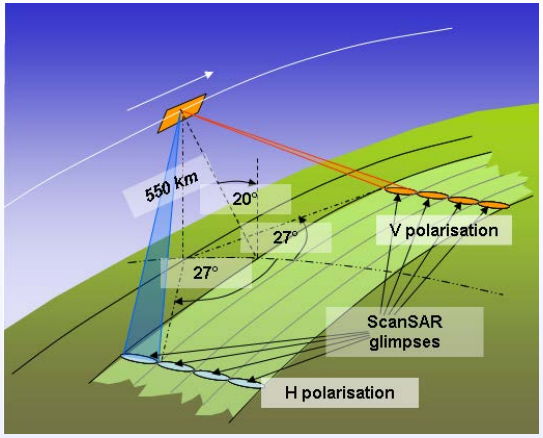
Future Mission Workshop

Mission/Area	Presenter
Wavemill	Christine Gommenginger (NOC)
Carbon Missions	Hartmut Boesch (Uni Leic.)
Super-SAR	Tim Wright (Uni Leeds)
CitySat	John Remedios (Uni Leicester)
Wivern	Byron Richards (Astrium)
ICEMUSIC	Peter Hargrave (Uni. Cardiff)
Sentinel Convoy Study	Nick Leveque (Astrium)
HW-LHR	Damien Weidmann (RAL)
Polar Geo EO	Malcolm Macdonald (U Strathclyde)
ERB	Phil Evans (MetOffice)
TwinSat	Dave Walton (UCL)
MicroWat	Karl Atkinson (Astrium)
Ocean Mesoscale	Mike Cutter (SSTL)
Sea State Monitoring	Martin Unwin (SSTL)
LOCUS	Brian Ellison (STFC)
Truths	Paul Green (NPL)
Daily Planet	Mike Cutter (SSTL)

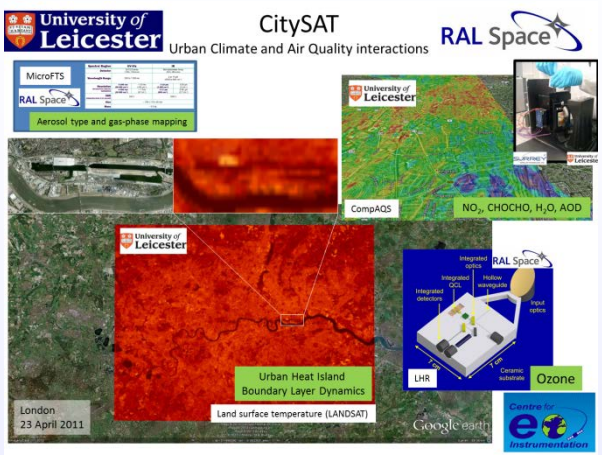




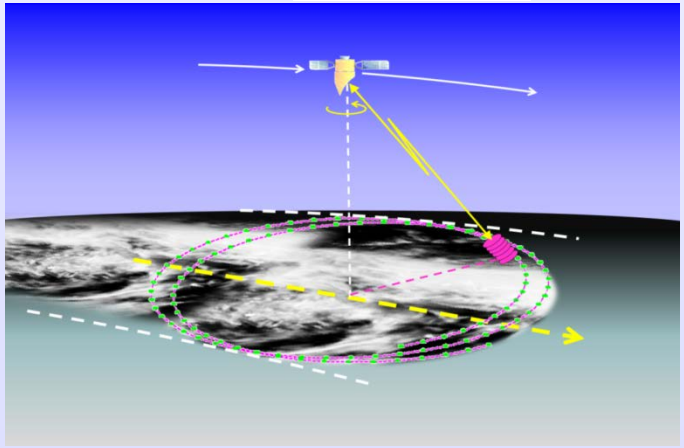
Wavemill



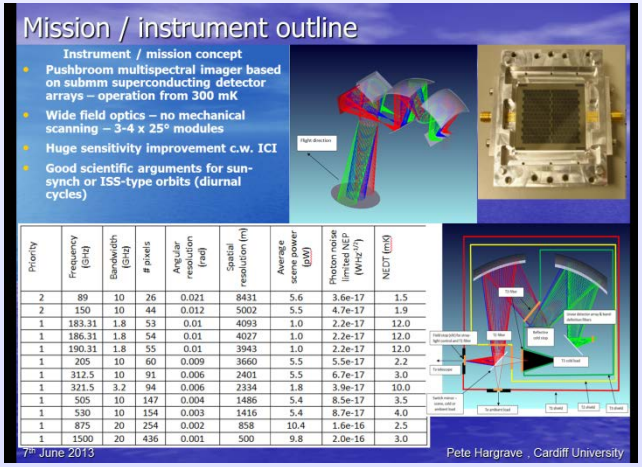
Super-SAR



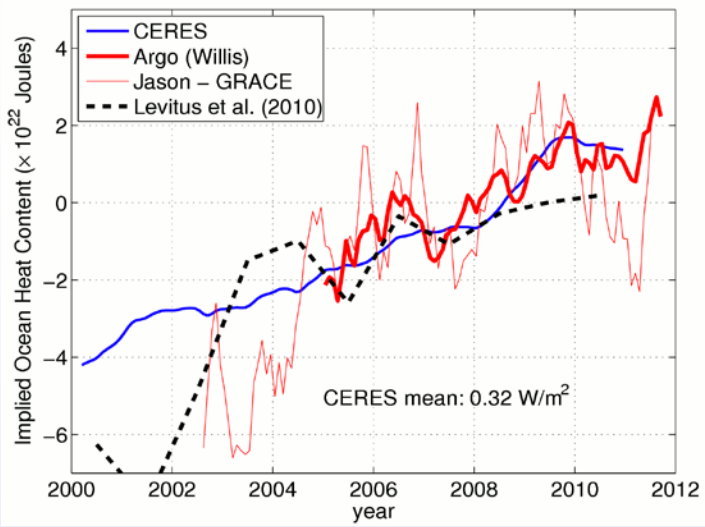
City-SAT



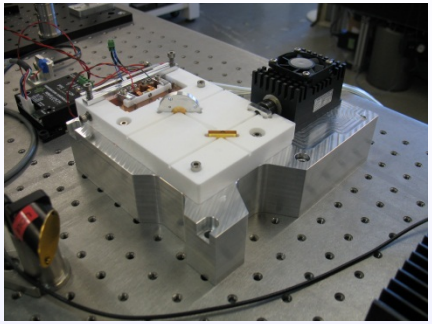
Wivern



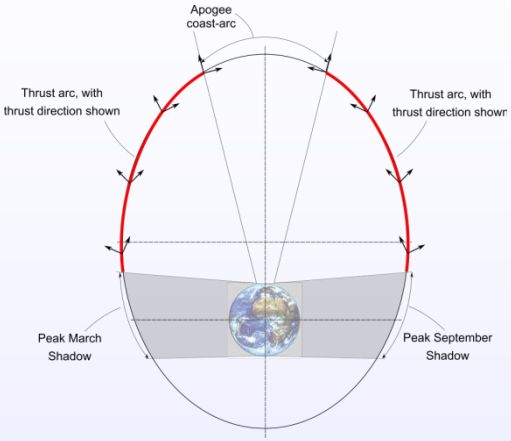
IceMusic



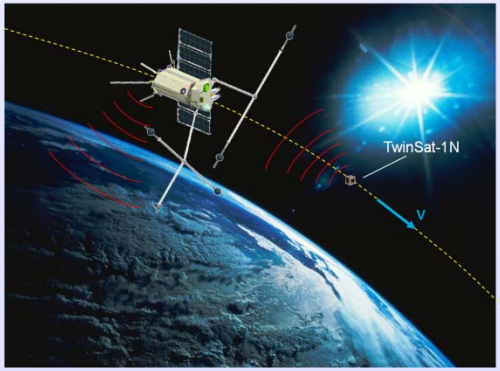
Sp-ERB



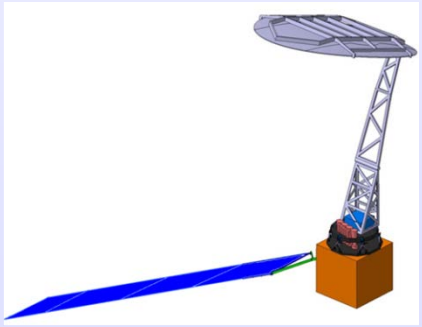
On-Demand Emission monitoring



POTO

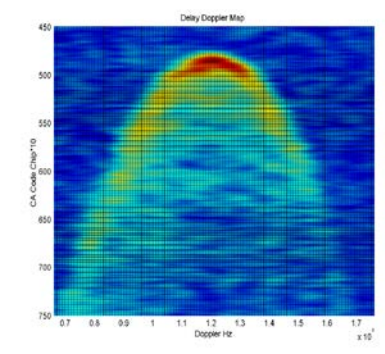


Twin-Sat

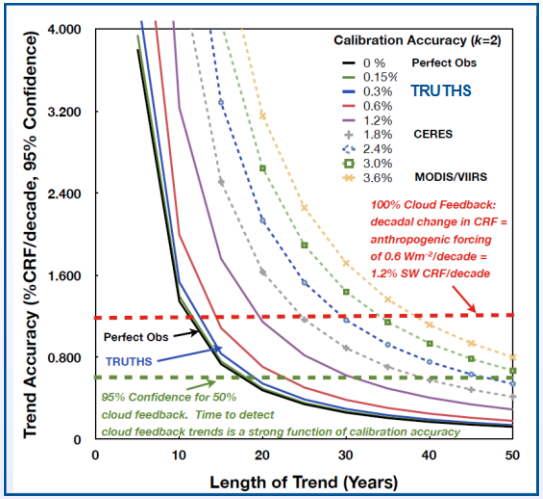


Microwat

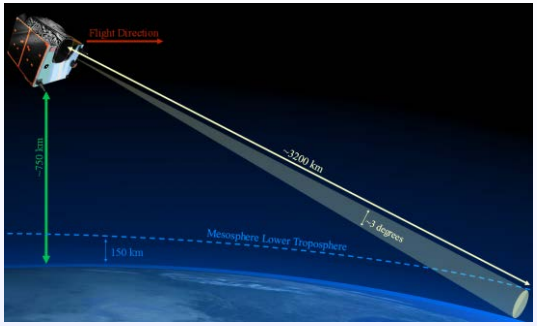
Ocean Mesoscale Monitoring



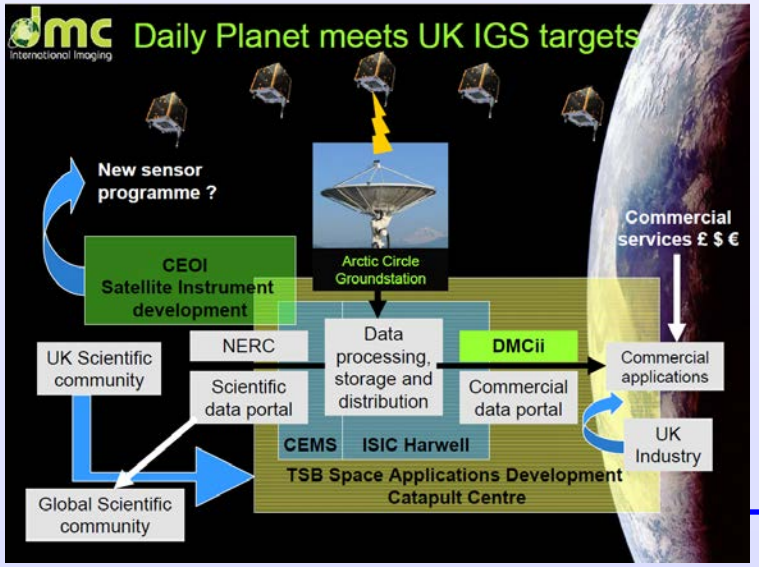
Sea State
GNSS-R/RO



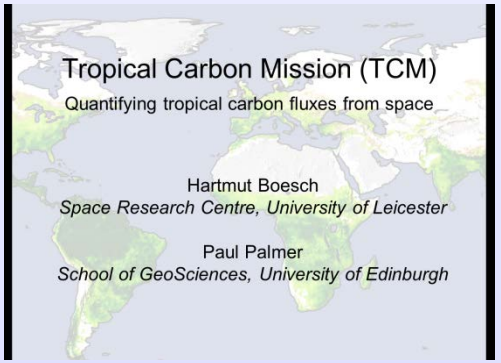
Truths



Locus



Daily Planet



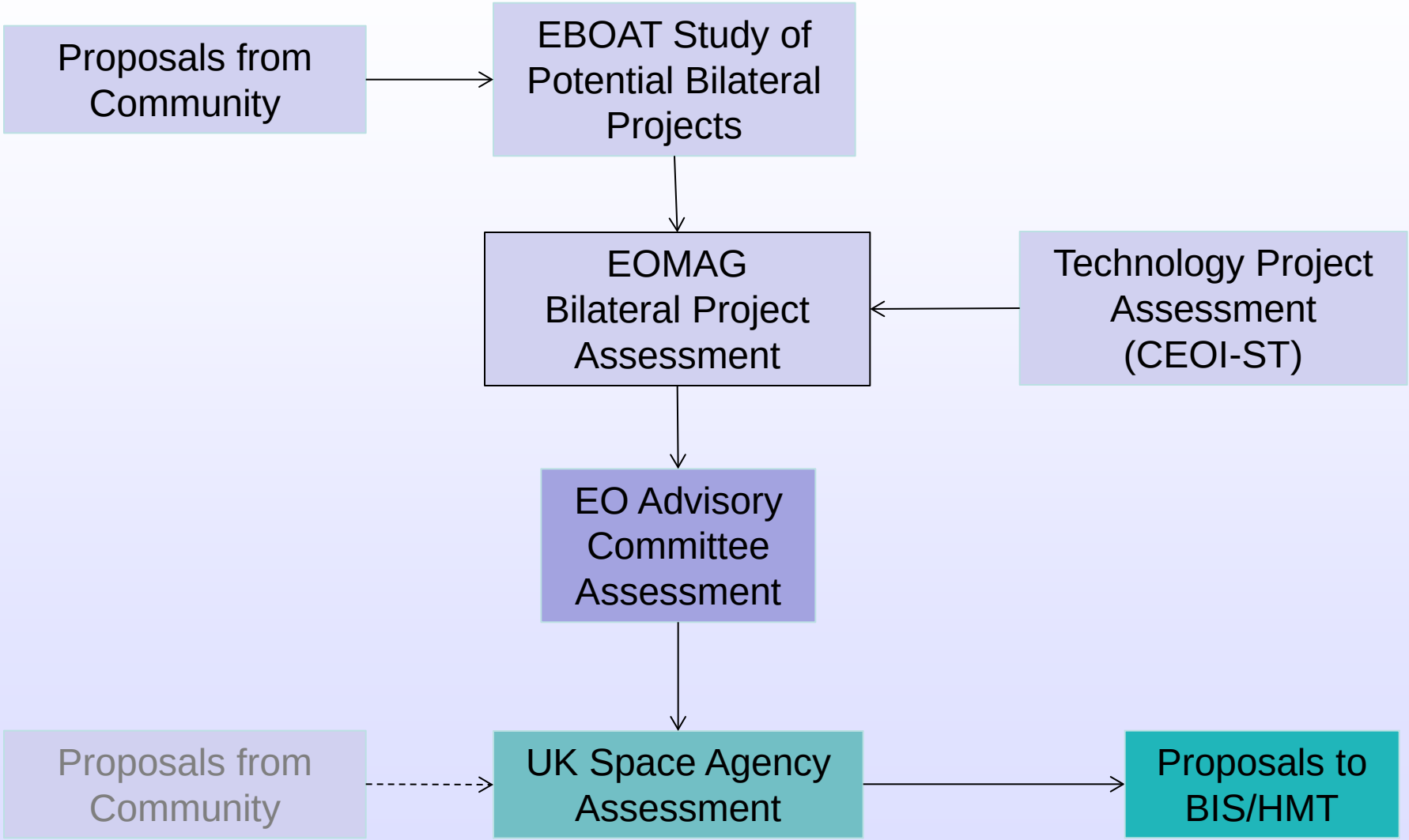
Tropical Carbon Mission

EOMAG – a blueprint for science missions?

EOMAG Objectives

- EOMAG peer reviewed potential EO projects
  - working group of the EO Advisory Committee
- The main tasks were to advise and make recommendations on:
  - advising on the medium and long-term EO priorities for the UK, taking account of the interests of the scientific, industrial and commercial aspects of the EO community;
  - assessing the priorities for the UK community for future bilateral EO missions, instruments and EO technology developments;
  - the necessity for technology development activities prior to implementation

Bilateral Project Opportunities



EOMAG:
Report and Recommendations

- 13 missions scored highly in the EOMAG assessment process
  - *3 are 'ready to go', i.e. could be implemented relatively quickly if funding available*
  - *3 are approaching maturity, with studies and R&D in progress*
  - *A further 4 were seen as having good potential, but require more work to bring to maturity*
  - *2 were seen as suitable for ESA Explorer missions*
  - *One was seen as a highly innovative technology demonstrator*

Ready for Blue Board

Mission	Description	Bilateral strength	Bilateral partners
ALiSS	A mission to profile the upper troposphere and lower stratosphere (UTLS) region with high vertical resolution	3 4	Canada – funding to be raised Sweden – funding available
CHRIS4ER	A mission to measure terrestrial and coastal ecosystems, mineral mapping, and monitoring of inland waters and coastal phenomena	2	Canada, China and others, but relationships not developed
CompAQS	A mission to measure key environmental gases for air quality monitoring and forecasting, particularly NO_2, linked to significant economic impacts through human health	2	Partners identified, but relationship not developed (China, Netherlands etc)

Bilateral strength:

4: established partners with funding
3: established partners, no funding at present
2: candidates identified; some evidence of bilateral interest from specific countries
1: candidate partners identified, no relationship at present other than ESA
0: no bilateral partner

Maturing – assess for Blue Board when ongoing work complete:

Mission	Description and Current Development Activities	Bilateral strength	Bilateral partners
LOCUS	A mission to investigate composition of the mesosphere and lower thermosphere using measurements in the 1-5 THz range. This has just completed an ESA IOD mission study, and has technology developments underway under CEOI-ST funding. It is recommended that it is reconsidered when the latter is complete.	1	ESA at present. Interest in THz from China.
TRUTHS & TRUTHS ON ISS	A mission to establish SI-traceable measurements for detection of decadal climate change. A mission study is currently underway under CEOI-ST funding, and it is recommended that it is reconsidered when this is complete	2	Potential partners (eg Swiss) identified, but no formal relationship in place
SWAINSAT	A mission to measure sea-surface roughness. The next steps for implementation of the GNSS reflectometry are well established through the current TechDemoSat mission and the selection of SGR-ReSI for the CYGNSS mission. The status should be re-assessed once progress with the measurement concept is established.	3	USA funding CYGNSS. Similar missions in the US, Europe and elsewhere are in discussion

Good potential – not yet mature

Mission	Description and Recommended Development Activities	Bilateral strength	Bilateral partners
HeATED	A mission to monitor global fires. This requires further technology development of the detector and optics	1	Russia, Australia, Germany and Canada identified
Video from Space	Video and still imaging at high resolution. Requires a concept study, building on the internal SSTL/Airbus market study, to assess best approach to providing video in space. This is a new market which is rapidly evolving, which needs to be taken into account.	2	CNES identified
NovaSAR-X	An X-Band SAR mission. Requires work to identify the potential market and to confirm that a low-cost X-Band SAR mission with adequate performance can be implemented with UK-led technology components.	1-2	Potential customers known to SSTL which could form the basis for a bilateral
UK-Brazil in Space	An imaging mission focused on Brazilian forestry, especially the Amazon. The proposed satellite constellation can also be applied to humanitarian and commercial activities, including global disaster response, agricultural services and urban growth monitoring. Requires work to strengthen UK benefits, including the UK community interested in working with INPE	4	Brazil is strongly positioned as a credible partner

Earth Explorer Class Missions

Mission	Description and Recommended Development Activities	Bilateral strength	Bilateral partners
NeoSAR-L	Multi-purpose mission to monitor parameters such as soil moisture, biomass, maritime activities. A mission level feasibility study is required to confirm that a viable and affordable mission can be implemented with UK-led technology components	1	NASA, ISRO, INPE (Brazil), CONAE (Arg.), Australia, DLR, identified as potentially interested parties.
WIVERN	A mission to measure global wind fields. This is most likely to be implemented as an ESA Earth Explorer mission; however development of specific technologies funded by UK will enhance its readiness.	1	ESA

Technologies

Technology (1, 2,...,n)	1
Item	Sub Harmonic Image Rejection Mixer (SHIRM)
Description	A Schottky diode image separating mixer device to separate upper and lower sidebands of the spectrum for millimetre-wave sounders, allowing normally overlapping spectral components to be separated. [illegible] Canada/Sw[illegible] under await
Owner	RAL Space
Current space TRL	5, following align with device has [illegible] the Jungfrau
CEOI-ST developed?	Yes
Next steps	Ready to en[illegible] plan and required.

Technology (1, 2,...,n)	1
Item	Compact hyper-spectral imager with range extended into the SWIR region.
Description	An evolution of the existing CHRIS hyperspectral imager with a wide band sensor instead of two imaging chains. The extension of the spectral range to SWIR is a significant advance.
Owner	SSTL
Current space TRL	Basic instrument has b[illegible] at TRL 9. The critical[illegible] detector (Sofradir – [illegible] tested to TRL ~3 and g[illegible]
CEOI-ST developed?	Yes (SWIR imager desi[illegible]
Next steps	The detector & FPA n[illegible] for space deployment[illegible] needs to be integ[illegible] performance of the [illegible] wavelength range has[illegible] study and business pla[illegible]

Technology (1, 2,...,n)	1
Item	Compact concentric UV/VIS Imaging Spectrometer for air quality/atmospheric chemistry applications – CompAQS.
Description	A compact and high performance UV/VIS imaging spectrometer has been achieved using a concentric lens and mirror configuration. The instrument is ideally suited to nadir monitoring of atmospheric pollutants such as NO_2, using the DOAS technique. From LEO the instrument should achieve a spatial resolution of 1-2km, and a spectral resolution of better than 0.5nm.
Owner	SSTL and the University of Leicester
Current space TRL	TRL 4. TRL-4 or 5? The instrument has been deployed terrestrially for city-scale monitoring from rooftop installations (CityScan), and has recently been flown on a light aircraft with excellent results.
CEOI-ST developed?	Yes
Next steps	The instrument requires re-engineering for space deployment and full qualification. A phase A study and business plan is required.

EOMAG recommendations

- Urge the Agency to put in place a funded national or bilateral programme
- Three missions “ready” for implementation (ALiSS, CHRIS4ER and CompAQS)
- Three missions approaching maturity (LOCUS, TRUTHS and SWAINSAT)
- UKSA (through the CEOI-ST) should fund mission and business studies
- EO mission concepts be refreshed on an annual basis.
- Business plans be developed for each mission
- ESA Earth Explorer missions should be assessed by a separate process.

What for EO Science Missions?

- UK concepts for EE9 (and beyond)
- Do we need to move to portfolio approach
  - Why? – gives UKSA idea of needs for political and technical (CEOI) support
- Do we need a process like EOMAG?
  - Would it be better than free for all?
- What can CEOI (and UKSA) do?
  - Strengthen UK academic and industrial teams