Centre for
EO Instrumentation

Ten New Projects Selected in the CEOI Twelfth Open Call

The UKSA Centre for Earth Observation Instrumentation (CEOI) announces ten new space instrumentation development projects, of value totaling £2M, with additional investment funding from industry. Together, these projects will advance the state of the art of UK space Earth observation and will position the project consortia for new commercial and scientific missions and exports in Europe as well as globally. Projects are in 3 categories:

- Pathfinder projects, which aim to develop novel instrumentation ideas to a laboratory proof of concept level;
- FastTrack projects, which aim to develop successful Pathfinder and similar developments to a higher Technology Readiness Level (TRL) to demonstrate suitability for spaceflight;
- Flagship projects, to raise TRL of projects which are more mature, of strategic importance to the UK, and are nearing readiness for spaceflight.

Pathfinder projects:

- A University of Glasgow team will develop a novel flat lens for infrared wavelengths based upon metamaterial sub wavelength microstructures. These flat lenses could in principle save weight and allow new instrument geometries, allowing higher performance in smaller spacecraft. The UK would have a lead in this area if successful.
- An In-Space team is preparing Babel, a software defined S-band radio (SDR) receiver. The project is coupled to a 6U cubesat flight opportunity (Faraday-1) and the technology could be tested in space this year. The Babel radio will perform experiments using emissions from ship radar, ground radar and 4G/5G networks. As part of the experimentation the mission will demonstrate geolocation techniques, which have the potential to benefit multiple EO missions in the future.

Fast Track projects:

The first 3 projects are concerned with instrumentation for microwave remote sensing of the atmosphere from space. The microwave measurements are vital for numerical weather prediction and analysis of the chemical trace components in the atmosphere, including pollutants.

- **HYMAS-X**: A partnership between the Universities of Cambridge and Cardiff is developing a new detection technique for hyperspectral millimeter-wave sounding of the atmosphere (i.e. many spectral channels in this microwave region). This instrumentation allows the upwelling radiance from the Earth to be measured from which vertical profiles of temperature and humidity can be determined. These are vital for accurate numerical weather prediction. The vertical resolution (i.e. the quality) of the profiles increases as the number of microwave channels increases. The new technique uses a miniature monolithic microwave integrated circuit (MMIC)

featuring on-chip filter banks which provide 100s of low-noise spectral channels in a small volume. However, the devices must be supercooled to liquid helium temperatures. Potential benefits include highly accurate weather forecasting and a new class of microwave sounders with imaging capability allowing new kinds of EO mission, both commercial and scientific.

- **3DPAMS**: A team led by the National Physical Laboratory, is using 3D printing of polymers in the design of components for microwave sounders. The use of 3D polymer printing can lead to standardization of components such as complex waveguide structures which are difficult to engineer using traditional techniques, thereby reducing costs and mass, leading to smaller satellites and the savings of £Ms. The plastic components can be plated with metal (known as 'electroless deposition'), and hence achieve the same or better performance than traditionally machined metal structures at a fraction of the mass and cost.
- **META-TEL**: Microwave instruments for atmospheric sounding normally use large focusing mirror assemblies to introduce the upwelling radiation into the instruments. These 'fore optics' systems are large, complex and heavy. As an alternative, one can construct 'quasi-optic' lenses from dielectric materials which reduce the complexity, but these are large, thick and heavy objects. The META-TEL project, led by Cardiff University will exploit metamaterial techniques (i.e. sub wavelength microstructure) to create a thin and perfectly flat lens which has all the advantages of a quasi-optic lens, but without the weight penalty. It allows low mass instrument designs with greatly improved focal plane arrangements, leading to new mission options, both commercial and scientific, access to smaller spacecraft, and lower costs.

There are 2 projects related to gravity field measurement which also address quantum aspects of cold atoms.

- **LEGO:** A project led by the University of Surrey will develop a new miniaturized stabilized laser system largely based upon commercial off-the-shelf (COTS) components. The stabilisation system and the laser will all fit into a 3U form factor and will be stabilised to atomic transitions in Rubidium vapour. The laser will enable gravity-sensing missions, either based upon inter-satellite ranging measurements using small low-cost spacecraft, or as a component in a quantum gravimeter using atom-interferometry.
- **CAGE:** This project, led by Teledyne e2v Ltd will also address space gravity measurements using quantum gravimeters based on cold atom techniques. Space gravity measurements underpin many EO applications including hydrology, oceanography, solid Earth, glaciology, climate science, and oil and gas prospecting. The high-resolution and sensitivity promised by quantum gravimeters would also allow the sensing of subsurface structures. The current project will develop the design of a pathfinder mission for a quantum gravimeter in space, using ultra-miniaturisation of key components. The project will bring together the key technology partners in the UK, who will work with the potential user community to maximise the commercial and scientific benefit of a future high-resolution gravity mission.

Other developments include a project on mid-infrared imaging, and another project aimed at guaranteeing the autonomous operation of smaller satellite constellations.

- There is strong user demand for a new generation of imaging missions in the mid-infrared (MWIR). High resolution MWIR imagery can reveal temperature signatures linked to fires, volcanoes, human activity, weather, and environmental issues. Leonardo are working with Surrey Satellite Technology Limited (SSTL) to adapt their SuperHawk COTS MWIR detector for use in space. The primary aim is to enable SSTL's DarkCarb mission concept. If successful, the collaboration will allow DarkCarb and other low-cost satellite constellations which can monitor the Earth continuously at these mid infrared wavelengths. This will allow SSTL to market commercial imagery missions from visible, near infrared, through mid-infrared, and through to microwave (with the NovaSAR mission). It will also provide Leonardo with a strong new market for its SuperHawk detectors.
- Craft Prospect Limited are leading a project to assess how a degree of on-board autonomy for very small spacecraft, based on industry standards, could be deployed using existing off-the-shelf hardware. The aim is to provide assurance to operators and users of small satellite constellations that in-orbit satellite operations, planning, control and maintenance are working correctly and efficiently. The team will consider the use cases of potential customers and will fit them into a framework which allows these applications to be intelligently and successfully conducted in space. They will test the framework on these use cases first in simulation and then on drone flights.

Flagship project

- **SERMON (Spectroscopic-system for EnviRonmental MONitoring):** STFC RAL Space is leading a team including the UK Met Office, STAR-Dundee and the JCR Systems, to develop an airborne hyperspectral (i.e. multiple frequency channel) microwave imager which will substantially improve numerical weather forecasting through detailed spectral profiling of the atmosphere. Multiple channels are necessary to both detect and resolve important features in the molecular spectra of oxygen and water vapour. To achieve this goal, SERMON will use an ultra-compact multi-band radiometer system that possesses excellent radiometric sensitivity and exquisite spectral resolution, and that is capable of being deployed on a small/nano satellite, or even on a High Altitude Pseudo Satellite (HAPS) platform. This requires the integration of key subsystem modules that include low noise amplifier technology and compact ultra-high-speed digital backend processing. The completed instrument will be demonstrated aboard the UK Facility for Airborne Atmospheric Measurements (FAAM) which is funded by the Natural Environmental Research Council (NERC) and managed by the National Centre for Atmospheric Science (NCAS). The airborne trial will deliver scientific data and prove that the instrument is able to meet its design goals in a realistic measurement scenario, thus establishing a 'fast-track' for SERMON to evolve into a future spaceflight opportunity.

Note to editors:

The CEOI was created in 2007 with the aim to develop key capabilities through the teaming of scientists and industrialists. The CEOI is a partnership led by Airbus DS together with the University of Leicester, STFC Rutherford Appleton Laboratory and QinetiQ.

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