Centre for EO Instrumentation

CEOI Industry Consultation Workshop

Summary Report

"Miniaturisation of High Performance Remote Sensing Instrumentation"

22nd May 2018

London

1. Introduction

The next generation of instruments for space needs to be smaller, lighter, with lower power budgets, while also having higher sensitivity, specificity, resolution and accuracy. As a result, the space instrumentation sector is evaluating and trialling a wide range of sensing techniques and engineering approaches to achieve these challenging objectives. It is not alone in this interest and many of these new approaches have applicability across a wide range of other sectors.

The round-table consultation brought together industry representatives from a range of sectors to discuss and provide input on market trends, challenges and opportunities that will inform CEOI's strategy for the next generation of Earth observation / remote sensing instruments.

The meeting aimed to:

- Illustrate how miniaturisation techniques for high performance remote sensing in Earth observation instruments are developing and the research focus for the next generation
- Brainstorm with industry representatives the wider issues of remote sensing that CEOI funded projects can learn from or contribute to solving
- Investigate the possibility of brokering relationships with interested parties along the supply chains for promising new applications / markets
- Create opportunities for attendees to network across the different communities

The meeting was held under Chatham House rules; attributions of individual comments were not recorded and the input from the participants has been synthesised into a composite of views from the meeting. This report summarises those views, which will be incorporated, along with the science needs, into the CEOI strategy for the next generation of Earth observation / remote sensing instruments.

The initial round table introductions from the delegates identified a wide range of challenges and application interests in miniaturisation of high performance remote sensing. These challenges and interests were explored more deeply in the main discussion.

2. Summary of Meeting Discussions

The participants came from a broad cross section of industry and saw a wide range of opportunities and challenges in miniaturisation of high performance remote sensing instrumentation. This section synthesises the discussion and highlights the key points raised.

Challenge/Opportunity	
Market Drivers	• The small / cube sat revolution is driving the need for miniaturisation of remote sensing instruments for space. Lower payload size, mass and power result in lowest cost through impact on host satellite structure requirements and launch costs.

	• In non-space deployments (airborne and UAVs), weight (not size) is the key driver as it impacts on regulatory approval (drones), fuel consumption, mission time, etc. • Miniaturisation opens up other potential new applications using the benefits of low power, small size, covert operation, etc. • The end market is data services, but the value of the data or image to end customers can be very variable.

Market Threats	• As new launch technologies and platforms are developed, they may:
	  ○ reduce requirements for miniaturisation;
	  ○ be a "gamechanger" using smaller payloads combined with lower launch costs to enable new concepts;
	  ○ make high performance larger satellites more affordable reducing the market for small satellite constellations.
	• It is not clear where the balance point between system performance, launch costs and platform / instrument costs will end up.

Markets - Performance Trade-offs	• Trade-offs will be application specific and include:
	  ○ performance v benefits in size, power, mass and cost. Is it better to have many relatively low performance instruments giving large volumes of lower quality data, or a single, high quality, high resolution instrument giving excellent data?
	  ○ physical limitations such as spatial resolution (diffraction limited);
	  ○ SNR v limited spectral range (in hyperspectral applications);
	  ○ focused observations at specific regions to increase temporal data acquisition rates.
	• Lower quality data can be useful if uncertainties are properly quantified so that probabilistic modelling can be applied.
	• Larger amounts of data will inevitably transfer costs down the product chain.
	• Artificial Intelligence may be a partial solution but is not the panacea.

Deployment Platforms	• There is now a seamless spectrum of deployment platforms for remote sensing instruments, from large geostationary satellites, through nano/small satellites and HAPs (high altitude platforms) to UAVS (unmanned aerial vehicles (drones)) and ground-based platforms. This enables temporal requirements of applications to be addressed more cost effectively. • However, each has its advantages and limitations, e.g. drones and HAPS have mass, range and on-board power limitations. • The different platforms also provide opportunities to gather "signals (data) of opportunity'' (e.g. from cars, drones, etc.) which will enable new, pervasive (remote) sensing capabilities

Data - Quality	• Data quality must be matched to application need (e.g. spatial resolution, SNR), required fidelity and acceptable uncertainty • Methods to identify the quality of data are needed. Cross calibration could be used to upgrade lower quality data. • Merging multiple data sources is currently expensive and time consuming. Can increasing use of AI improve or transform costs? If so, how can AI systems be certified, especially if systems are continually learning/ changing?
Technology Enablers	• COTS technologies are a major enabler and "game-changer" for low cost space systems with major performance improvements.
Radar	• Commercial applications for radar data are not well established, probably due to high costs of SAR data. New SAR satellite constellations may address this, but not yet proven. • The wider commercial value of SAR data alone is still not proven, especially as the data can be difficult to interpret. Will combination / fusion with optical images provide more useful information? • Cheap radars are now on the horizon with miniaturization and application of new semiconductor technologies. The development of passive bistatic radar opens up opportunities for applications requiring stealth and / or low power. Both developments enable deployment on platforms with low power budgets such as cubesats, HAPS and UAVs. • Development of UHV radar systems deployable on smaller platforms such as drones will open up applications in underground survey / mapping and covert observation.
Thermal IR	• Thermal IR (8-15 µm) is a largely unexploited section of the EM spectrum in commercial space markets even though it is an application rich area with lots of potential (street level imagery, mining, etc.). • The major adoption barrier is high cost of detector systems and key bottleneck to miniaturization is the need of coolers with their associated high mass and power. Other solutions (uncooled microbolometer array, QUIPS, and Type 2 Superlattices) are relatively immature and require further development. • There are significant non-space applications for TIR, including the nuclear sector for monitoring waste sites, but there is insufficient data to validate applications at the moment.

In conclusion:

- Remote sensing is on the cusp of a revolution, enabled extensively by miniaturisation
- However, data quality is still an issue to be resolved
- Artificial Intelligence could be transformative, but how?

- Exploitation of SAR and TIR sensors could open up major new application areas and markets.
- We are moving to an era of “more for less and better”

3 Conclusions for a UK Technology Strategy

CEOI will continue to support development of these technologies for Earth observation from space, and to ensure that opportunities are pursued for technology transfer to/from non-space developments. The inputs and conclusions of the workshop, as summarised in this report, will provide an important input into the strategy development process for the CEOI programme.

Further information about this technology and others funded by the CEOI can be found at www.ceoi.ac.uk. You can also contact the CEOI Director, Professor Mick Johnson: Tel: +44 (0)1438 774421 or email: mick.johnson@airbus.com.