CEOI-ST Industry Consultation Workshop

Summary Report

“Autonomous Remote Sensing”

2nd March 2016

London

As sensing applications become more sophisticated and ubiquitous, there is a growing interest in autonomous remote sensing (ARS) systems to improve our understanding and control of the world around us. This manifests itself in a wide range of applications across the aerospace, defence & security, maritime, oil & gas, process control, rail, road, space, survey, etc.

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

The meeting aimed to:

- Illustrate how Earth observation instruments are developing and the research focus for the next generation
- Brainstorm with industry representatives the key service, technology, and data needs for current and future products and services
- 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

Technical challenges were identified in the areas of Artificial Intelligence, Autonomy, Data, "Data as a Service", Decision Making, Human Interaction, Miniaturisation, Power, Reliability and Quality, Sensing Systems and Software Validation.

The meeting also highlighted changes in the way we consider and define Remote Sensing. Traditionally, remote sensing has been defined as the acquisition of information about an object or phenomenon without making physical contact, generally referring to the use of space based or aerial sensor technologies However, in recent years the definition has been extending significantly as the range of applications has developed into new fields. These new modalities include:

- ***Terrestrial Based Remote Sensing*** – instruments traditionally deployed on spacecraft or aircraft are now being deployed in ground based applications, e.g. for continuous monitoring of urban air quality or security threats.
- ***New Applications of Remote Sensing*** – there are growing requirements to analyse and monitor different structures such as tunnels or viaducts using remote sensing techniques in order to efficiently manage their construction and operation. The use of photogrammetry to measure and monitor tunnels is one example.
- ***Remote embedded Sensing*** – while remote sensing has traditionally been completely stand-off, this definition is now evolving to include the use of embedded sensors to remotely sense and monitor structures and environments which are hazardous or difficult to access. While the sensors are embedded at the point of interest, the data is transmitted to a central point for processing, analysis, and action. Examples are aero engine combustion chambers, rail track, and steel casting. The challenge being addressed is sensing / monitoring from a distance of environments which are difficult to access with conventional sensors / instruments due to distance, scale (1000 Kms), environment (temperature / radiation / pressure), etc.

The discussion highlighted this evolving landscape of deployment and applications, and covered a wide range of requirements for technology improvements and solutions.

CEOI-ST 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-ST programme.

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

Summary of Market Challenges

Markets	Challenges
Aerospace	"Data as a Service"
	Autonomous air systems
	Lightweight systems
	Data fusion of satellite, UAV and ground data
Defence & Security	Movement away from man-heavy to man-light operations
	Rapid refresh or continuous temporal monitoring
	Auto-collection of information
	Power harvesting / scavenging
	Rare events in very large data sets
Maritime	Autonomous operation and swarms of vessels
	Low light imaging of vessels at sea (possibly 3D?)
	Maritime / space co-working
Oil & Gas	Sensors & intelligence in the drill head
	Data communications from drill bit to well-head
	Automated data pre-processing seismic survey data, and techniques to identify bad data quality for rapid re-acquisition
Process Control	3D vision
Rail	Embedded remote sensing systems
	Trains used to check their own infrastructure with data capture while on the move
	Data download when travelling at 100m / sec
	Remote monitoring of tunnels under construction
	Condition monitoring of tunnels over long periods
Road	Data reduction
Space	Thermal infrared imaging
Survey	InSAR for survey
	3D mapping with defect analysis in tunnels
	Data management and analysis

Summary of Technical Challenges

Technical	Challenges
Artificial Intelligence	What needs to be sensed
	How to handle large data sets
	Monitoring of the sensing system
	Condition monitoring of the system / environment of concern
	Identifying complex new problems from large data
	Situational awareness
	Intelligent change detection
	Legal issues resulting from decisions based on AI/Neural Net analysis
Autonomy	Autonomous determination of when to sense, and selection of spectral bands
	Autonomous determination of spatial regions of interest
	Autonomous management of data processing, communications, self-forming networks, and navigation
	Autonomous scene selection
Data	How to extract value from huge volumes of data
	Techniques to flag anomalous events
	Selection of download products - final (data processed on-board), part processed data, or raw data
	Data fusion of own and 3rd party data a challenge.
"Data as a Service"	Acquiring appropriate data with sufficient "value add" to enable a viable business model
Decision Making	Identifying level of intelligence required on the platform to enable "decision making" or "decision support"
	Systems that make decisions and take actions faster than humans
Human Interaction	Ease of interaction of humans with autonomous remote sensing systems
	Trust in autonomous systems
	Accuracy and reliability of the data
Miniaturisation	Continuing to grow in importance
Power	Power harvesting / scavenging
Reliability and Quality	Reliability and robustness of ARS systems over long periods
	Quality of the data acquired over long periods
Sensing Systems	Minimising cost while maximising reliability and performance.
	Better understanding of system performance
	Large area, low light capture
	Wavefront sensing - possible links to autonomy - low flux imaging.
	3D laser imaging at very low flux for guidance, navigation & control
	Thermal emission spectrometry in remote sensing applications
	Sensor fusion for integrated situational awareness.
	Thermal imaging
	Co-temporal data fusion from different sensing
Software Validation	Software standards for effective validation and verification
	Certification