

**Centre for
EO Instrumentation**



**CEOI Industry Consultation Workshop
Summary Report**

Millimetre Wave, Microwave and THz Remote Sensing

27th November 2019

London

1. Introduction

Following grant support for a number of projects to companies developing millimetre wave, microwave and THz remote sensing technologies (30MHz to 3THz), CEOI ran the Workshop to inform senior industrial technical directors and managers, and to further explore potential uses in wider industrial applications.

The consultation brought together industry representatives and leading academics in this emerging field. Attendees were from aerospace, communications, defence, environmental, healthcare, instrumentation, and oil & gas organisations. It provided a fascinating opportunity for participants to contribute ideas, identify future needs, learn, discuss, and network.

The outputs will inform the focus of future CEOI and UKSA funding programmes. Specifically targeting remote sensing applications, the meeting aimed to:

- Understand potential market developments and applications in millimetre wave, microwave and THz remote sensing and their market drivers;
- Identify key barriers and technical challenges to their implementation;
- 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.

To set the scene three academic presentations were given:

- THz Sensors & Instruments for Imaging, Trace Gas Detection & Other Industrial Applications (Dr Alexander Valavanis – University of Leeds)
- Microwave, Sub-millimetre & THz Sensing for Environmental, Industrial and Security Applications (Prof Peter Hargrave – University of Cardiff)
- THz technologies for remote sensing (Prof Brian Ellison – STFC RAL Space)

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

2. Conclusions from the Meeting

There is interest in the potential for millimetre wave, microwave and THz remote sensing in a range of sectors, including environment, healthcare, instrumentation and security. This will require the development of new types of sensors operating in the THz region, and the data provided may complement or supersede existing sensing modalities.

Future remote sensing applications with potential include:

- **Medical:** tissue biopsies; wound monitoring by imaging through bandages; identifying malignant tissue and breath analysis for condition diagnosis



- **Security:** identification of gaseous emissions with higher spatial resolution to unambiguously identify sources; detecting concealed objects and analysing behaviour in real-time;
- **Environment:** soil moisture detection from space at higher spatial resolution; crop monitoring, particularly of flood and drought conditions; detection of trace gases
- **Laboratory/Field Instrumentation:** THz frequency range mass spectrometer; industrial gas analysers; fingerprinting change in chemical processes; identification of toxic classes of chemicals;
- **Structural Monitoring:** Stand-off detection to monitor structure safety; detecting minute temperature changes in metal structures in surveys of oil and gas facilities
- **High Altitude Platforms (HAPS):** development of new THz remote sensing detectors

There are several considerations which may limit the applications, including:

- Advantages of THz solutions over existing optical and other solutions are not yet proven
- At ground level, line broadening by atmospheric pressure may limit the measurement of some gaseous species.
- Atmospheric attenuation of the signal at higher frequencies is more severe, limiting applications and absorption by water vapour is a major issue.
- The THz sensors need cooling which adds significant power and cost overheads to such systems.
- Although all the remote sensing systems developed under CEOI are **passive** sensing systems, there are reported to be possible health implications of **active** THz sensing systems in healthcare and security applications (see Appleby, R. and Chamberlain: *Physics and Applications of Terahertz Radiation for review*)

In spectrum allocation and regulation there is a tension between remote sensing and communications applications. As the use of adjacent frequency bands continues to grow, it will become increasingly necessary to develop remote sensing sources and detectors with excellent out-of-band rejection characteristics.

3 Conclusions for the CEOI Technology Strategy

CEOI will continue to support development of relevant Earth Observation technologies for space sector, and to continue to look for non-space applications. 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 CEOI projects and programmes can be found at <https://ceoi.ac.uk/>. You can also contact the CEOI Director, Professor Mick Johnson: Tel: +44 (0)1438 774421 or email: mick.johnson@airbus.com.