Science & Technology Facilities Council

Centre for EO Instrumentation

AIRBUS DEFENCE & SPACE

Technology Market Case Study No. 4 (Update)

Passive Microwave Component Technologies

The Idea

The UK is supporting development of passive microwave instruments for several space missions to gather key atmospheric data that will help improve weather forecasts and our understanding of climate change. The missions include the MetOp-SG programme, which has three passive microwave instruments - Microwave Sounder (MWS), Microwave Imager (MWI) and Ice Cloud Imager (ICI); STEAM-R, a passive, millimetre-wave limb-sounding radiometer proposed by Sweden; and ALiSS, a national/bilateral atmospheric sounding mission.

To enable the UK to present credible proposals to lead one or more of the above instrument projects, CEOI has funded the development of a range of innovative and/or critical enabling technologies. These include frequency selective surface (FSS) filters, meta-materials in sub-millimetre wave quasi-optical systems, a 165/183 GHz waveguide diplexer, FSS filters to separate 183 GHz and 166 GHz channels, radiometer technology to improve sensitivity / frequency performance / resource use, sub-harmonic single sideband image rejection mixer (SHIRM) technology, novel single-channel sideband-separating receivers, a focal plane design that avoids the need for mechanical scanning of the main antenna, and high-level system integration of UK receiver technology.

Support from CEOI

A range of CEOI funding programmes provided valuable resource to a team led by RAL-Space (part of the Science and Technology Facilities Council), working with Airbus DS, Queens University Belfast and others for the development of the above technologies:

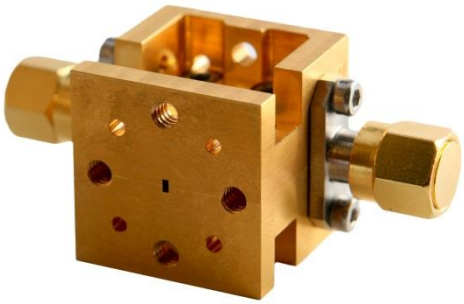
- development of radiometer systems with improved sensitivity, frequency performance and greater focal plane integration have extended applications in the millimetre wave region;
- the design and manufacture of critical sub-harmonic single sideband image rejection mixer (SHIRM) devices to achieve TRL 5. The devices needed to meet ESA requirements in order for the technology to be admitted to the STEAM-R mission, thereby demonstrating system level performance of critical receiver technology for STEAM-R. This activity also had relevance for the MetOp-SG Microwave Sounder;
- development of a prototype sub-millimetre wave FSS, demonstrating capability in FSS design, fabrication and spectral measurement up to 700 GHz. It also supported the STEAM-R Phase A Study by enabling further work on technology development activities and participation in the ESA PREMIER Phase A Study;
- development of key MetOp-SG instrument technologies to both position and strengthen the UK

consortium bid for the Phase B, C, D elements of the programme and directly in support of UK industry;

- a project to study a potential UK contribution to the Canadian/Sweden Atmospheric Limb Sounding Satellite (ALiSS);
- development of a 165/183 GHz waveguide diplexer to reduce complexity of the quasi-optical network in the MetOp-SG MWS Instrument;
- development of FSS filters required to separate different frequency channels in complex instrument quasi-optics networks. This also required the development of a new numerical model for finite FSS devices in order to provide high accuracy numerical predictions of beam propagation and reflection;
- development of novel on-chip filterbank spectrometers for hyperspectral sampling in 50-60 GHz region (O_2 temperature sounding line). This was achieved using a single spatial antenna coupled to filterbank, readout by superconducting Transition-Edge-Superconducting detectors.
- polymer-based 3D Printed Integrated Front-end Hardware for Atmospheric Science Observations using Multi-channel Microwave Sounder Payloads (3DPAMS)
- a study to investigate simplifications to the MetOp-SG ICI payload and for future instruments.

The Results

The work across industry and academia has strengthened UK expertise and capabilities in passive microwave instrumentation. The development of FSS technology at frequencies up to 700 GHz is state-of-the-art within Europe. The investment in the MetOp-SG passive microwave instrument technology has directly enabled the UK consortium to win highly competitive tenders for the supply of microwave components for three instruments (MWS, MWI and ICI).



The SHIRM Image Separating Mixer
Courtesy STFC-RALSpace

For the STEAM-R instrument, the specific technology outcomes include the development of a novel image separation mixer technology (SHIRM) and qualification at TRL-5, enabling the development of an optical design methodology to accurately predict antenna patterns for sub-millimetre radiometer instruments, and development of novel, generic filter technology with state-of-the-art low loss performance.

At the end of the programme, the technologies were at TRL Levels 3 - 5, with 26 papers / conference presentations being published and 5 PhD / Case studentships funded.

Wider Deployment

The single sideband image rejection mixer (SHIRM) has been deployed in an upgrade to the ESA MARSCHALS airborne limb sounder instrument and also in support of astronomy experiments. Moreover, it has potential for future commercial exploitation.

CEOI

The Centre for Earth Observation Instrumentation (CEOI) works with UK organisations, both academic and industry. Its objective is to develop a world leading, internationally competitive, national Earth Observation (EO) instrument and technology R&D capability through the teaming of scientists and industrialists. The CEOI is funded by the UK Space Agency with parallel technology investment from industry.

Further information regarding this project and other technology developments funded by CEOI can be found at www.ceoi.ac.uk. Alternatively, please contact:

CEOI Director,
Dr Chris Brownsword
Tel: +44 (0)7825762527
email: CBROWNSWORD@qinetiq.com