National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

AIRBUS

Centre for EO Instrumentation

Technology Market Case Study No. 2

Next Generation Synthetic Aperture Radar for Oceanography

The Idea

Synthetic Aperture Radar (SAR) is used in a wide range of applications, including topography (DEM generation with interferometry), oceanography (wave spectra, wind speed, ocean currents), glaciology (snow wetness, snow water equivalent, glacier monitoring), agriculture (crop classification and monitoring, soil moisture), geology (terrain discrimination, subsurface imaging), forestry (forest height, biomass, deforestation), Moving Target Indication (MTI), volcano and earthquake monitoring (differential interferometry), environment monitoring (oil spills, flooding, urban growth, global change), marine surveillance and military reconnaissance (shipping management, strategic policy, tactical assessment).

To support improved SAR performance for these applications, CEOI funded a team led by National Oceanography Centre with Airbus DS Ltd, in the development of a novel dual-beam interferometric SAR concept which offers the prospect of generating wide swath, high resolution, high precision maps of ocean surface current and wind vectors. As an innovative single spacecraft system with two simultaneous look directions, it retrieves directional information in a single-pass, avoiding the difficulties of short-timescale scene dynamics, synchronisation and baseline estimation associated with single pass interferometric SAR.

On-board processing of data generated by the instrument to Level 1 SAR products is necessary due to on-board data storage and downlink constraints. Along-track SAR interferometry relies on high-precision phase calibration that calls for very good knowledge of the interferometric baseline and of the platform attitude.

Support from CEOI

CEOI funded a number of projects to enable substantial progress to be made in developing these concepts:

- a study focussing on the science case for the instrument in the context of actual and planned oceanographic systems, and on the on-board processing required to manage large raw image data volumes of the SAR instrument;
- the development of the mission concept at instrument and system level to ensure a mature concept is available for submission to the Earth Explorer 9 mission call;
- the development of a software prototype of a Level 1 on-board processor, including the development of the on-board SAR processing algorithms to include highly squinted SAR using wavefront reconstruction algorithms;
- a study to investigate the ATI phase calibration approaches for the mission, including recommendations for the development of the antenna for the airborne demonstrator and the space-borne system.

The Result to Date

The sequence of studies has enabled the mission and instrument concept to be matured. Development of the on-board SAR processing techniques has been progressed, demonstrating the ability to generate Level 1 side looking and highly squinted SAR imagery using on-board digital signal processing techniques.

The airborne Proof-of-Concept study led to an Airbus DS airborne prototype being built and flown over Liverpool Bay. This provided experimental data to demonstrate the feasibility of the system and of its joint current and wind measurement principle. Thanks to CEOI, the L2 geophysical inversion for simultaneous current and wind vector retrieval was established, leading to recommendations for the instrument and mission design, and validation of the airborne Wavemill data against independent HF radar and in situ current measurements in Liverpool Bay (Fig2).

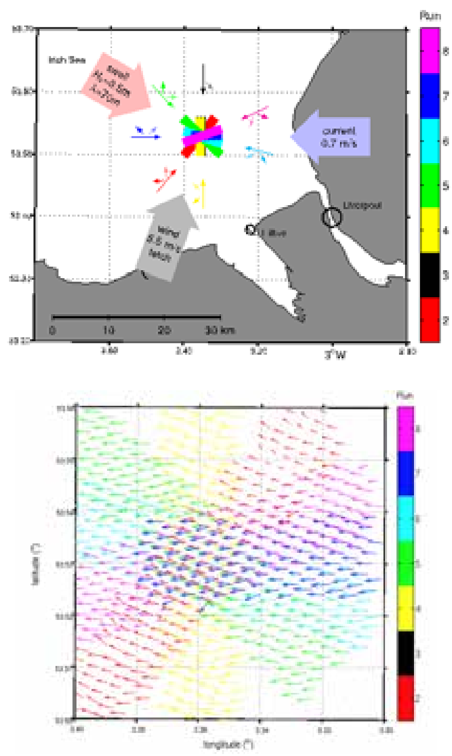

Fig. 2: (top) Location of Wavemill airborne proof-of-concept campaign in Liverpool Bay off the west coast of the UK (right) Retrieved current vectors from different runs of the star-pattern acquisition (from Martin et al., JGR, 2016)

One patent was published, TRL level 2 achieved for the technologies, and 4 scientific papers and conference presentations were published.

The Future

The next step for a space-borne system is to build an integrated breadboard in flight representative technology which combines the FPGA, memory and control functions. Some additional work is needed on the processing algorithms to generate the accurate radar echo time of flight data (needed for image focussing) from information on the platform's position and attitude. This problem is also relevant to the Doppler centroid technique for ocean current mapping with conventional SAR.

Further airborne campaigns are needed to develop the interferometric system, to experimentally demonstrate the feasibility and usefulness of dual-polarisation squinted data and to validate the geophysical measurements in a wider range of ocean current and wind conditions (e.g. swell). There are opportunities both for the development of an improved UK airborne system and for the UK to take a leading role in performing airborne campaigns with the ESA OSCAR airborne system.

The ESA and CEOI studies have led to a mature mission concept based on dual-beam ATI SAR which could be proposed as an ESA Earth Explorer mission.

The FPGA-based SAR level 1 processing could be used in a ground segment SAR archival and processing facility, to improve response time for users, or in an airborne SAR platform to transmit SAR imagery in real time for users.

The SAR processing and retrieval algorithms developed during the studies could be applied to conventional SAR to develop new capability for ocean surface current monitoring.

CEOI

The Centre for Earth Observation Instrumentation (CEOI) works with UK organisations, both academic and industrial. Its objective is to develop a world leading 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 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.

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