Foreword

Significance of RISAT-1 in ISRO's Earth Observation Programme

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The Indian Space Research Organisation (ISRO) began its space-based Earth Observation Programme in an experimental mode with Bhaskara-1 in 1979, from a low earth orbiting platform. Operational Earth observation activities from a geostationary platform began with the Indian National Satellite (INSAT) series (since 1982) with Very High Resolution Radiometer (VHRR) payload. The Indian Remote Sensing (IRS) satellite series, since 1988, has been providing Earth observation data in a wide range of spatial, spectral, radiometric and temporal resolutions using push-broom technology optical imaging sensors. The data from these optical sensors have contributed to various application activities encompassing resource monitoring, agricultural crop-yield forecasting, prospective fishing-zone identification, cyclone monitoring and tracking, weather monitoring and forecasting, cartography and disaster management, etc.

However, space-based Earth observation in the optical domain is constrained by cloud cover and during monsoon period over the Indian region it becomes a severe limitation. This significantly restricts the capability to provide useful inputs for resource and disaster monitoring from space. Microwave imaging sensors – by virtue of their ability to see through the clouds – can overcome this constraint and enable establishing an effective Earth observation capability from space.

The launch of Radar Imaging Satellite-1 (RISAT-1) on 26 April 2012 with a C-band Synthetic Aperture Radar (SAR) on-board, marks the initiation of a new class of Earth observation imaging products and services. RISAT-1, the indigenous space-based radar imaging mission of ISRO, is capable of observing the Earth at any time of the day as it carries its own source of illumination.

Imaging products of SAR are complementary to optical imaging, avoiding information duplication. In other words, while optical sensors give information regarding frequency selective absorption and reflection properties, SAR signals are sensitive to structural shapes and dielectric properties of the objects being imaged. SAR hardware can be configured for exploring object sensitivity to polarization diversity and phase angle. Coupled with this sensitivity and being transparent to cloud cover, SAR images find applications in crop assessment during monsoon, imaging in perennially cloud-covered regions, disaster management, soil moisture, forestry, geology, oceanography, bathymetry, etc.

Another notable advantage of SAR technology is that the resolution of the system is independent of height or range, limited only by available transmitted power and consequent signal-to-noise ratio. Because of the nature of processing, geometric accuracy of the images is not affected by angular accuracy of the satellite and is limited only by the knowledge of orbital positional accuracy of the satellite and Digital Elevation Model resulting in repeatable location accuracy of the images.

RISAT-1 has been built with state-of-the-art technology and is endowed with many SAR imaging modes like conventional stripmap, high-resolution sliding spotlight, wide swath scanSAR, etc. It can be operated in single or dual polarization or in quad polarization modes, providing imaging ability from 1 m to 50 m resolution over 10 km swath to 225 km swath.

Its configuration of dedicating separate set of power amplifiers for V and H polarization transmission, has made it a unique spaceborne Hybrid Polarimetric Sensor. The other operational spaceborne SARs like on Radarsat-2, TerraSAR-X or CosmoSkymed, are equipped with specific linear polarimetric mode which is usually operated within the restricted coverage of 20° to 30° incidence angle, because of doubling of pulse repetition frequency (PRF) and usually a specific imaging mode is dedicated for linear polarimetric operation. However, in the hybrid polarimetric operation of RISAT-1, signal is transmitted in circular polarization and the received signal is digitized in two orthogonal polarization chains. This ensures conventional PRF of operation without any increase in data rate. Hybrid polarization in RISAT-1 can be activated for any imaging mode (spotlight/stripmap/scanSAR) and can be operated over any incidence angle ranging from 12° to 55°. Its dual polarized antenna elements are fed by an array of transmit–receive (TR) modules, controlled by more than 300 processors and powered by miniaturized pulsed electrical power conditioners.

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RISAT-1 comprises around 1400 subsystems, including 300 processors. The active array subsystems are large in number and less on design variety. Each of the subsystems requires rigorous space grade fabrication and qualification. Fabrication and characterization of each of these subsystems are typically spread over 5–6 weeks. Industrial production and space qualification of the subsystems were carried out by the Indian industry based on in-house designs of ISRO. These industries had limited exposure to space-grade electronics and therefore in the spirit of partnership, they had to undergo a rigorous regime of training in space-grade fabrication processes, qualification methods and documentation processes. This also helped in the development of indigenous source of RF Monolithic Microwave Integrated Circuits (MMICs), TR modules, Application Specific Integrated Circuits (ASICs), miniaturized power supply and printed antenna array. RISAT-1 effectively acted as a catalyst in expanding the indigenous industrial base for production of space-grade SAR subsystems.

ISRO used its in-house pool of ingenuity in conceptualizing, engineering and realizing the SAR system of RISAT-1, which is a vastly complex payload with significant level of flexibility in reconfiguration to meet different imaging requirements and ease of operability. This was possible because of large on-board software spread over 300 processors. The characterization of the system itself was unique, where all the 126 beams have been characterized with precision. This resulted in calibration and quick operationalization of the system.

Realization of state-of-the-art radar imaging satellite RISAT-1 needed significant developments in the spacecraft capabilities to accommodate large weight, power and transmission data rates. For example, the data rate of transmission was increased six fold from 110 to 640 Mbits. Though weighing 1858 kg, RISAT-1 is heaviest among ISRO's remote sensing satellites, it is the lightest satellite compared to those belonging to the same class.

Data products from RISAT-1 have already been released to users from 19 October 2012. RISAT-1 imaging products are expected to enhance the application potential of SAR data not only in India, but also globally in many important resource applications and disaster management situations. Radio Detection and Ranging (RADAR) data from space platforms have already made a significant mark world over because of the ability of the radars to make observations during the day or night, look through cloud cover and achieve resolution and observe details that are difficult for optical and infrared sensors. Many operational modes and hybrid polarimetric capability of RISAT-1 are expected to open up newer avenues, as it provides many more observable parameters like amplitude, phase and state of polarization enabling many new scientific studies leading to diverse and novel applications using microwave data.