RazakSAT – Technology Advent in High Resolution Imaging System for Small Satellite

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Abstract: Throughout the transfer of technology program and bilateral collaborative development, ATSB evolved from a low to high resolution imaging system for small satellite with the coming launch of RazakSAT. To exploit the imaging acquisition for Malaysia and other countries in the near Equatorial belt, the satellite will be launched in the Near Equatorial Orbit (NEqO) with inclination of 7 - 9° to take advantage of the imaging opportunities between 1 – 4 times daily and overcome the major obstacle for passive remote sensing, the cloud cover. The development of the satellite with bus of mass less than 200 kg and the Medium-sized Aperture Camera (MAC) payload of mass less than 50 kg is a technology advent for ATSB in high resolution imaging system for small satellite. The MAC provides an imaging swath width of 20 kn with ground strip imaging capability of 500 km in a single pass, spectrally covers the visible/infrared range by providing a panchromatic band and 4 multispectral bands with ground sample distance of 2.5 and 5 m respectively. The development of RazakSAT simultaneously pushes the development of expertise in various sub-systems in the space and ground segment, and facilities for future satellite program especially the next generation of imaging system for small satellites. The RazakSAT program benefits the nation through various applications that can be provided by the utilization of RazakSAT data, and in the advancement of space technology to support a sustainable space infrastructure program of Malaysia. The launch of the high resolution RazakSAT satellite with high passes in the NEqO enables higher imaging opportunity will provide data that complements data from other sensors.

Keywords: Small satellite, payload technology, space infrastructure.

1. Introduction

Throughout the transfer of technology program and bilateral collaborative development, Astronautic Technology (M) Sdn Bhd (ATSB) evolved from a low to high resolution imaging system for small satellite with the coming launch of RazakSAT. ATSB initiated the first imaging Earth Observation Satellite (EOS) for Malaysia when TiungSAT-1, a microsatellite of 50 kg mass was launched in September 26, 2000 (Norhan et al., 2002). The technology transfer program started with Surrey Satellite Technology Limited (SSTL) of United Kingdom was then continued to the bilateral collaborative development with SaTReC Initiative (SI) Co. Ltd., Republic of Korea to advance from 78m spatial resolution of the TiungSAT-1 to a higher resolution of 2.5m.

2. Mission Analysis

When other satellites can provide data temporally every few days for Malaysia, it would be a redundancy to develop a system with the same output and it would be better just to buy images from the existing provider. One of the remote sensing problems identified for the country is that data could not be made available due to high cloud cover and the revisit of some of those existing satellites could not satisfy the requirement. To exploit the imaging acquisition for Malaysia and at the same time for other countries in the near Equatorial belt (Table 1), the satellite will be launched in the Near Equatorial Orbit (NEqO) with inclination of 7 - 9° to take advantage of the imaging opportunities between 1 – 4 times daily and overcome the major obstacle for passive remote sensing, the cloud cover. Another requirement for most remote sensing applications now is the demand for high spatial resolution data. Driven by the requirement of remote sensing, RazakSAT mission is to fulfill the demand by providing a satellite with high revisit and high resolution data.

Table 1 List of Countries Covered by NEqO (9º inclination)

Continent	Countries
Asia	Malaysia, Indonesia, Thailand, India, Sri Lanka, Philippines, Maldives
Africa	Somalia, Ethiopia, Kenya, Tanzania, Sudan, Uganda, Rwanda, Burundi, Zaire, Gabon, Central African Republic, Nigeria, Chad, Cameroon, Guinea, Angola, Ivory Coast, Benin, Liberia, Sierra Leone
Latin America	Brazil, Peru, French Guiana, Surinam, Venezuela, Colombia, Guyana Ecuador, Panama

3. RazakSAT Spacecraft Development

The development of the satellite with bus of mass less than 200 kg and the Medium-sized Aperture Camera (MAC) payload of mass less than 50 kg is a technology advent for ATSB in high resolution imaging system for small satellite (Figure 1). RazakSAT (previously known as the Medium-sized Aperture Camera Satellite or MACSAT) is a small low Earth orbit satellite. It carries

the Medium-sized Aperture Camera (MAC) which is an electro-optical payload of a pushbroom camera type with 5 linear detectors (1 panchromatic, 4 multi-spectral). RazakSAT is planned to orbit the earth in NEqO orbit at a nominal altitude of 685 km and 9 degrees (targeted) inclination. RazakSAT provides a high number of passes (14 passes a day over Malaysia) for communication with the ground station.

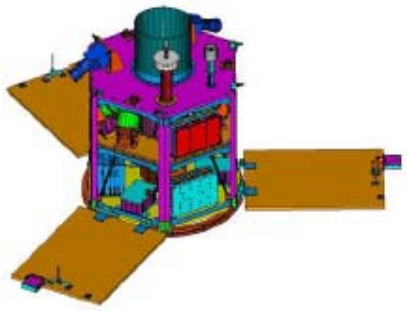

Figure 1 RazakSAT Configuration
(Source: Mazlan et al., 2003)

Table 2 RazakSAT General Specifications

Subsystems	Specifications
Altitude	685 km (nominal)
Inclination	7º-9º
Payload (MAC)	GSD: 2.5 m (PAN), 5 m (MS) Swathwidth: 20 km @ 685 km
Attitude Determination & Control Subsystem (ADCS)	Three-axis stabilisation based on four (reaction wheels). Pointing Accuracy: < 0.2º (2σ) Pointing Knowledge: 1 arcmin (2σ)
Electrical Power Subsystem (EPS)	GaAs/Ge solar cells on honeycomb substrate. NiCd batteries (18 Ahr) Peak Power Tracking (PPT) & constant current control. Solar Power: > 300W @ EOL
Command and Data Handling Subsystem (C&DH)	Two on-board computers. Telemetry and command interface modules. Analog Telemetry Channels: up to 90 Digital Telemetry Channels: up to 120
Telecommunication Subsystem (TS)	9600 bps/1200 bps S-band TT&C uplink 38.4 kbps/9600 bps/ 1200 bps S-band TT&C downlink.
Payload Data Management	32 Gbits On-board solid state memory. 30 Mbps X-band payload data downlink.
Structure & Thermal	∅ 1200 X 1200 mm Hexagonal shape. Mass: < 200 kg. Modular Structure. Passive & Active thermal control
Designed Mission Lifetime	> 3 years

RazakSAT will be launched using the Falcon 1 of SpaceX from the Omelek Island, Republic of Marshall Islands and the date would be announced in the near future.

3. MAC System Development

The MAC provides an imaging swath width of 20 kn with ground strip imaging capability of 500 km in a single pass, spectrally covers the visible/infrared range by providing a panchromatic band and 4 multispectral bands with ground sample distance of 2.5 and 5 m respectively. MAC is a pushbroom system with five linear detectors alingned in parallel on its focal plane (Figure 2) (Ad. Aziz et al., 2003).

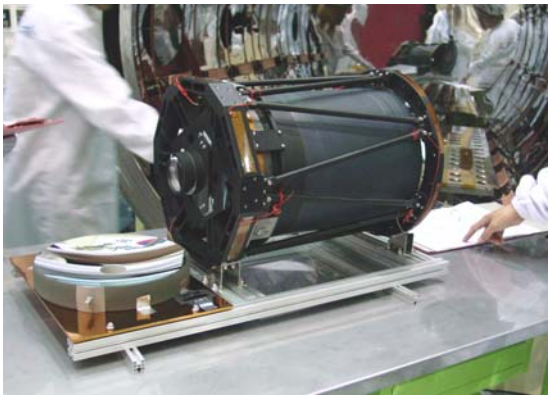

Figure 2 EM Telescope in Test Preparation
(Source: Ad. Aziz et al., 2003)

Table 3 MAC General Specifications

Spectral Bands 1 Panchromatic Band & 4 Multispectral Bands	Panchromatic Band	510-730 nm
	Band 1: Blue	450-520 nm
	Band 2: Green	520-600 nm
	Band 3: Red	630-690 nm
	Band 4: Near-Infrared	760-890 nm
Ground Sampling Distance (GSD)	PAN: 2.5 m MS: 5.0 m	at 685 km
Swath Width	20 km	at 685 km
Signal to Noise Ratio	> 70	
Quantization	> 8 bits	All bands
Signal Gain	Programmable	
Mass Storage	32 Gbits	(~500 km image strip
Mission Lifetime	> 3 years	MTF value

4. RazakSAT Data Program

As the output of RazakSAT is to provide satellite images, this would benefit the nation through various applications that could be provided by the utilization of the

data. The RazakSAT data program would be initiated by the Announcemnt of Opportunity to allow users to explore and exploit RazakSAT data in various applications. The program would be initiated through the call for research study to the Malaysian remote sensing user community during the launch and early operation of the satellite. The research would be divided into fundamental research study and operational application. The fundamental research study would cover the calibration and validation study of RazakSAT, sun's illumination effect for data acquired in the NEqO, and other topics that would be contributed by remote sensing experts. This would give the opportunity to experts to participate in the calibration and validation exercise for RazakSAT during the designed lifespan of the satellite of three years. The operational application would allow user to study under the remote sensing domains of application identified for the country generally agriculture, natural resources, environmental, cartography and topography, and finally marine. Remote sensing experts would specify in detail the research study under these domains of applications. The NEqO would also be a good platform as a feasibility study for synthetic aperture radar system to be utilized in the NEqO as climate is not a problem for active remote sensing.

5. Space Infrastructure Development

Generally, space missions include these basic elements: space element (spacecraft bus and payload); orbit and constellation; subject; command, control and communications architecture; mission operations; ground element; and launch element (Sitti & Norhan, 2004). Thus the development of RazakSAT program gradually pushes the development of all those elements and thus benefits the nation by helping the nation to move together in the advancement of space technology progressively supporting a sustainable space infrastructure program of Malaysia. The development of RazakSAT simultaneously pushes the development of expertise in various sub-systems in the space and ground segment, and facilities for future satellite program especially the next generation of imaging system for small satellites. ATSB have successfully manufactured several significant modules for RazakSAT. The manufacture of the Coarse Sun Sensor (CSS), Fine Sun Sensor (FSS), Magnetometer, Magnetorquer (MT), Telemetry and Command Module (TCM), On Board Computer (OBC), Battery Control Unit (BCU) and Pyro Electronics were carried out by ATSB in its own facilities previously at Technology Park Malaysia, Bukit Jalil, Kuala Lumpur. Satellite components that are suitable for the space environment have also been sourced from local vendors. Printed Circuit Boards (PCB) and the mechanical module boxes were manufactured locally by experienced local manufacturers with high precision machining capabilities. ATSB provide the necessary support to the vendors to enable them to achieve the standards required in their machining of components.

The new ground station in Sg. Lang, Banting under the ownership of National Space Agency (ANGKASA) will consist of a Mission Control Station (MCS) and an Image Receiving and Processing Station (IRPS). The MCS will perform mission plan, command generation, telemetry receiving as well as archiving and analysis. IRPS will archive images together with attitude and ephemeris telemetry data for post processing and distribution. The ground station would also equips facilities related to space technologies such as the spherical integrating sphere and other supporting equipments to facilitate the pre-flight calibration of MAC and thus would benefit future sensor development of ATSB and other research institutions or companies. The MCS plans and operates the entire space mission, including the configuration and scheduling of resources for both space and ground element. It also monitors and commands the satellite. MCS consists of two subsystems: Antenna and RF subsystem and Telemetry and Commanding subsystem. The MCS uses S-band uplink for telecommands and S-band downlink for telemetry reception. MCS base-band and telemetry and commanding facilities for RazakSAT will be incorporated into ANGKASA's antenna and RF facilities. Image Receiving and Processing Station (IRPS) receives image data from the satellite via X-band link. IRPS can be categorized into three main subsystems which are Antenna and RF Subsystem (ARS), Receiving and Archiving Subsystem (RAS) and Search and Processing Subsystem (SPS). The Antenna and RF Subsystem performs tasks like satellite tracking, receiving RazakSAT signals via X-band link, demodulating and bit synchronizing RazakSAT signals. Receiving and Archiving Subsystem will ingest the demodulated and bit-synchronized signals to the receiving and archiving server, records signal into disk arrays and perform real-time image display. The Search and Processing Subsytem will generates the image products and catalogues, manage image data and database, generates schedule for new imaging and provide web service for catalogue browse.

Images would also be received by Malaysian Centre for Remote Sensing (MACRES) ground station and RazakSAT data would be distributed by MACRES. This would also provide opportunity for other ground stations in the NEqO belt to receive and distribute RazakSAT data like any other commercial satellite data currently available.

6. Summary

Like any other commercial imaging satellites orbiting the Earth in the Sun scynchronous, the launch of the high resolution RazakSAT satellite with high passes in the NEqO enables higher imaging opportunity for Malaysia to overcome cloud cover could provide data and complements data from other sensors. The MAC would be a good benchmark for future mission to improve to a higher and better resolution spectrally and spatially for passive remote sensing. The establishment of the space

system infrastructure through expertise, facility and other elements of the space system architecture are not only to provide the basis for ATSB to move to the frontier but with anticipation to contribute in space technology through various collaborations, transferring of technologies, providing products and services with and to other parties locally and internationally.

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