RAZAKSAT™ IMAGE RECEIVING AND PROCESSING STATION (IRPS)

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ABSTRACT: RazakSAT™, a mini-class satellite that is scheduled to be launched in the Near Equatorial Orbit (NEqO) in 2007 was designed for Malaysia by ATSB, equipped with a payload of push-broom type that provides Ground Sample Distance (GSD) capability of 2.5m for panchromatic and 5m for multi-spectral bands. Although the satellite was designed to provide higher imaging opportunity for Malaysia to overcome cloud cover, this would also benefit other countries in the ±9° from the Equator to take advantage of receiving and utilizing the data for large scale mapping of 1:25,000 in various applications by having the RazakSAT™ Image Receiving and Processing Station (IRPS). The RazakSAT™ IRPS has three main subsystems: (i) Antenna and RF subsystem (ARF); (ii) Receiving and Archiving subsystem (RAS), and (iii) Search and Processing subsystem (SPS). The antenna and RF subsystem is fully optimized in design within a compact, economical and low maintenance of 5.5m system. Although configured for RazakSAT™, the station is fully multi-mission capable, offering unmatched flexibility in various modulation schemes at any bit rate up to 470 Mbps. The unique hexapod pedestal is compatible by design with both polar and equatorial orbiting satellites. The RAS subsystem which is the key to receive RazakSAT™ data in real-time is equipped with a special receiving card. The received data will then be pre-processed by the software and stored for post-processing. Search and processing subsystem manages the image processing, catalogue web-browsing, user information, and scheduling process. With capabilities of processing up to four level (radiometric correction, systematic correction, precision correction and ortho-rectified), SPS gives standard processing level for RazakSAT™ data. RazakSAT™ imaging can be scheduled using Pass Scheduling Software (PSS) in IRPS and sent automatically to RazakSAT Mission Control Station (MCS). The station is based upon current state of the art technologies for unmanned operations.

1 INTRODUCTION

RazakSAT™, a mini-class satellite that is scheduled to be launched into a Near Equatorial Orbit (NEqO) (Figure 1) in 2007 was developed for Malaysia by ATSB. The satellite is equipped with a payload of push-broom type that provides Ground Sample Distance (GSD) capability of 2.5m for panchromatic and 5m for multi-spectral bands. The satellite was designed to overcome cloud cover over Malaysia by providing higher revisit and imaging opportunity at 9° inclination. By having the RazakSAT™ Image Receiving and Processing Station (IRPS), other countries in the

±9° along the Equator (Table 1) would benefit in receiving and utilizing the data for large scale mapping of 1:25,000 in various remote sensing applications.

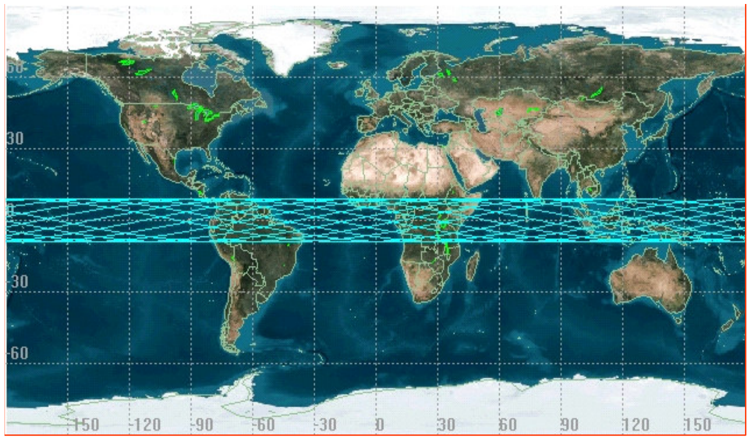

Figure 1: RazakSAT™ Near Equatorial Orbit (NEqO)

Table 1: Countries under RazakSAT™ coverage

Continent	Countries
Asia	Malaysia, Indonesia, Singapore, Thailand, Brunei, 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

2 RAZAKSAT™ CHARACTERISTICS

The primary payload, Medium-sized Aperture Camera (MAC), is a push-broom type camera with 2.5m of Ground Sampling Distance (GSD) in a panchromatic band and 5m of GSD in four multi-spectral bands (Red, Green, Blue and Near-IR bands). The satellite platform is a mini-class satellite. Including MAC, the satellite weighs less than 200 kg. The spacecraft bus is designed to support payload operations for a 3 years mission life. The payload has 20km in swath width and a signal quantization of 8 bits. 32 Gbits of solid-state recorder is implemented as the mass image data storage.

3 SYSTEM OVERVIEW

The RazakSAT™ IRPS has three main subsystems, (i) Antenna and RF subsystem (ARS); (ii) Receiving and Archiving Subsystem (RAS), and (iii) Search and Processing Subsystem (SPS). ARS performs the following: (i) tracking the RazakSAT™; (ii) receiving RazakSAT™ X-band downlink signals, and (iii) demodulation and bit-synchronization of RazakSAT™ signals. RAS performs the following: (i) ingest the demodulated & bit-synchronized signal to the RAS; (ii) records the signal into disk arrays, and (iii) displays the receiving signal on monitor in real-time. SPS performs the following: (i) generates image products and catalogues; (ii) manages image data and database, and (iii) provides Web-service for catalogue browsing. Figure 2 shows the system hardware configuration for receiving RazakSAT™ data. The X-band signal from RazakSAT™ shall be tracked and received by the Hexapod antenna. The signal will then be amplified and down-convert to Intermediate Frequency (IF) before ingested to High rate Data Receiver (HDR) for demodulation of QPSK signal and bit synchronization. Digital output from

HDR will be ingested to RAS for recording and real-time display. After preprocessing in RAS, RazakSAT™ data will be transfer to a RAID in SPS for archiving, image product generation and web-based catalogue browsing.

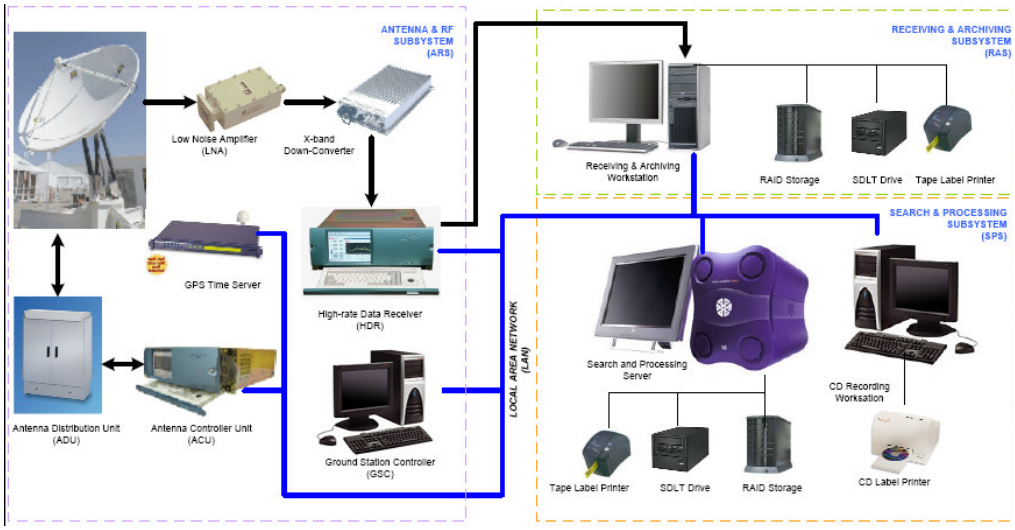

Figure 2: System Hardware Configuration

4 ANTENNA AND RF SUBSYSTEM (ARS)

The ARS is the link between the remote satellite and computer LAN. The ARS receives satellites signal, amplifies and demodulates it up to the reconstruction of bit stream. Although configured for RazakSAT™, the station is by nature multi mission. The Cortex HDR demodulator, the heart of the ARS, is able to demodulate all known remote sensing satellites in X-band which are already in operation in Space or prepared to be launch in the next following years. The number of satellites that can be received is not limited. The configuration of the system is so simple that the operator does not require assistance from the manufacturer to add a new satellite. The HDR receives the image signal at Intermediate Frequency (IF) frequency, and digitize it directly at IF level. After conversion, all the processing, including spectral processing, frequency conversions, demodulations, is digital, thanks to extensive use of FPGAs. The HDR can process any signal, in any classical modulation, with any decoding, for any bit rate between 1 and 470 Mbps. In order to cope with all kind of data processing system, the ARS delivers images signals both at Emitter-Coupled Logic (ECL) and at Ethernet TCP/IP levels.

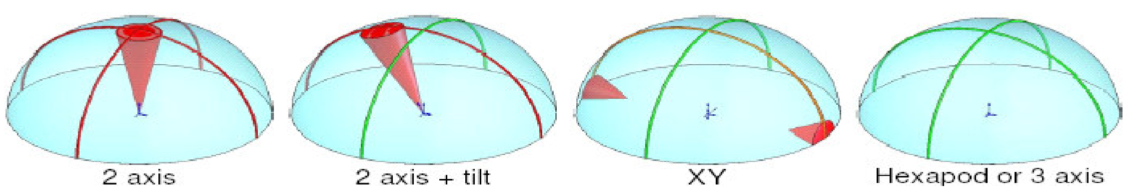

Figure 3: Antennas Coverage for Polar and Equatorial Orbits

The antenna is mounted on the unique **HEXAPOD** pedestal, offering full hemispherical coverage, for any satellite trajectory (including both polar and equatorial orbits). The hexapod is cheaper, lighter, as resistant and accurate as classical pedestals, and can be delivered with shorter lead time. The complexity of full motion antennas has been moved from the mechanics to the software. The ACU software converts in real time spatial coordinates into jack's lengths, and vice versa. On link budget performances side, the antenna is uniquely optimized (83% illumination efficiency), providing high G/T. Thanks to the combined effect of exceptional RF and HDR demodulation performances, the station provides comfortable link budget margins for most of satellites, making it suitable for reception in equatorial zones.

Table 2: ARS Main Characteristics

Subject	Unit	Specification
Antennasize	m	5.5
G/T	dB/K	31.8 at 8200 MHz, 10° elevation, clear sky, 20°C
Azimuth range	°	Unlimited, without need of rotary joint or cable wraps
Elevation	°	0 / 180
Number of channels		Two simultaneous channels with one HDR. Can be extended at will.
Bit rate	Mbps	1 to 470Mbps
Modulations		BPSK, O/S/A/U-QPSK, 8PSK, GMSK
Decoding		programmable Viterbi, Reed-Solomon (CCSDS and DVB), 4D TCM (trellis)
Filtering		Auto adaptative
Demodulation losses	dB	Less than 0.7 dB at 300 Mbps QPSK
Link budget margin, clear sky	dB	RazakSAT : 4 dB , Radarsat : 6 dB, Envisat : 6 dB, Spot 5 : 11 dB, Aqua: 16 dB

The ARS is fully automatic. Based on ephemeris data provided by the RAS, the ARS automatically computes visibility periods and pointing data, configures all the parameters of the station according to the satellite to be received, acquires and tracks the ordered satellite passes. The quality of reception is measured and provided into an automatically generated pass report. The required annual system maintenance is reduced to the minimum. There is no need for calibration at any level, thanks to the extensive use of digital technology. The hexapod, as simple as possible on a mechanical point of view, does not need maintenance, dismounting nor regular cleaning. Only oil and grease refill in the dedicated tank is necessary. The operation cost of the station is thus reduced significantly, which, in the long run, is of an utmost importance.

5 RECEIVING AND ARCHIVING SUBSYSTEM (RAS)

The RAS subsystem which is the key to receive RazakSAT™ data in real-time is equipped with a unique Data Receiving Card (DRC).

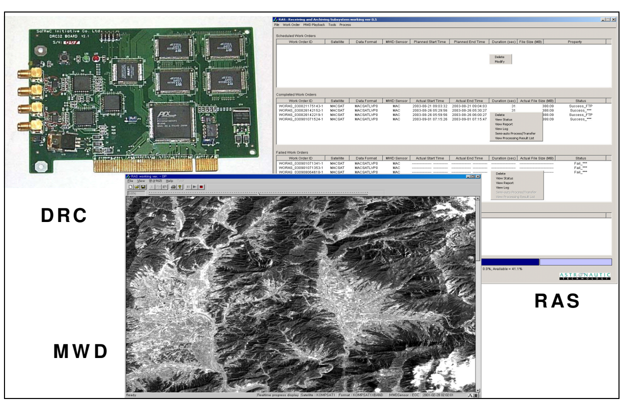

Figure 4: Data Receiving Card (DRC), Receiving and Archiving Software (RAS), Moving Window Display (MWD)

The mission and function of RAS are: (i) to receive RazakSAT™ data from ARS and record the received data to RAID; (ii) process received data in real time and performs Moving Window Display (MWD), and (iii) transfer the received and process data automatically to SPS.
RAS has additional mission and function which to do scheduling, modify and delete work orders. Mainly, RAS consists of DRC, RAS software, Workstation and RAID storage. A DRC

function is to receive RazakSAT™ data in serial ingested by ARS and perform serial to parallel data conversion. The data from DRC will be store in RAID through Peripheral Component Interconnect (PCI) bus in the computer. RAS software was developed in Windows environment and function to schedule the work order, perform a pre-processing (formatting) of RazakSAT™ data. This formatted data will then be transferred to the SPS. Besides, RAS software can perform Moving Window Display (MWD) while receiving RazakSAT™ data to help the operators analyze the quality of the image.

6 SEARCH AND PROCESSING SUBSYSTEM (SPS)

The SPS manages the image processing, catalogue web-browsing, user information, and scheduling process. SPS is the main engine for catalogue and product generation (CAP), catalogue browsing (CBS) and archive management (AMS). SPS is also responsible for order management, media formatter (MFS), system and information management (SIMS) and network management (NMS). SPS perform the image processing for RazakSAT™ data through CAP. Capable of up to four level processing (radiometric correction, systematic correction, precision correction and ortho-rectified), SPS gives standard processing level for RazakSAT™ data. CAP also functions to do cloud assessment in automatic, semi-automatic and manual.

Table 3: IRPS Image Processing Level

<table>
<tr><th>Level</th><th>Description</th><th>Radiometric Correction</th><th>Geometric Correction</th><th>Format</th></tr>
<tr><td>0</td><td>Radiometric corrected</td><td rowspan="4">Eliminates radiometric errors and distortion</td><td>Without geometric correction</td><td rowspan="4">Raw or GeoTIFF</td></tr>
<tr><td>1</td><td>Systematic corrected</td><td>Removes geometric distortion based on satellite ancillary data. Geometric error < 1 km Root Mean Square (RMS) equal to geo-location error of the satellite at nadir viewing condition</td></tr>
<tr><td>2</td><td>Precision corrected</td><td>Removes geometric distortion based on Ground Control Points (GCP). Geometric error < 2 pixels RMS at nadir viewing condition</td></tr>
<tr><td>3</td><td>Ortho-rectified</td><td>Removes geometric distortion based on Ground Control Points (GCP) & Digital Elevation Model (DEM).</td></tr>
</table>

CBS is a tool for searching catalogues to check the presence and the quality of image products. CBS provides functions for search and browse the image catalogues in the database of IRPS. In addition, users can place process orders by which the requested products are generated and provided by IRPS.

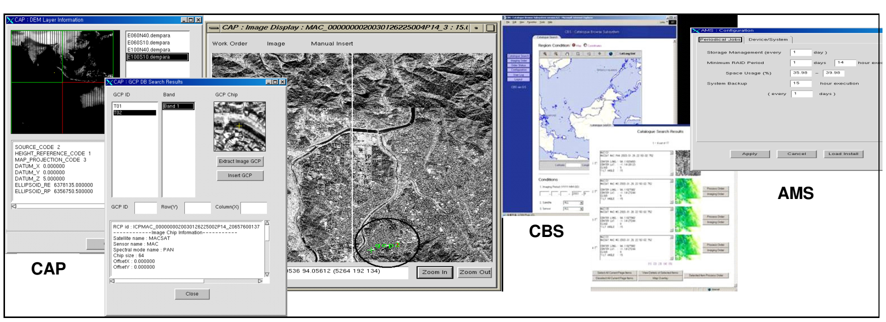

Figure 5: Catalogue and Product Generation (CAP), Catalogue Browsing (CBS), Archive and Management (AMS)

Moreover, users can place imaging orders by which the operator of IRPS plans the imaging tasks of RazakSAT™. AMS manages the pass data by migrated the data from a high-speed and high-cost storage device to a low-speed and low-cost storage device and vice versa in order to minimize the operational cost as well as maximize the efficiency and reliability of the system. High-cost" means that the price for unit storage (byte) is relatively high (e.g. RAID). Low-cost" means that the price for unit storage (byte) is relatively low (e.g. tape). In addition, AMS generates and manages the backup of the system database. All these software have been developed and work in SGI machine with IRIX 6.5 platform. RazakSAT™ imaging can be scheduled using Pass Scheduling Software (PSS) in IRPS and sent automatically to RazakSAT Mission Control Station (MCS).

7 CONCEPT OF OPERATION

Generally, satellite data users place imaging orders with the IRPS. The IRPS will submit a schedule request to the Mission Control Station (MCS) of ATSB. The MCS will then uplink command to RazakSAT™ to carry out imaging activity based on the imaging plan. The MCS will also provide the IRPS with a mission timeline for data downloading. The IRPS will be activated to receive data downlinks from RazakSAT™ based on the mission timeline. Upon receiving the satellite data, the IRPS will perform processing and formatting according to users' request. The image product will then be delivered to the users.

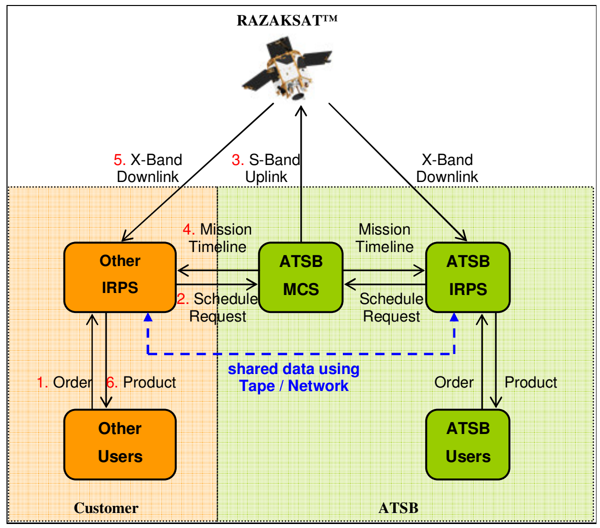

Figure 6: RazakSAT™ IRPS Concept of Operation

8 CONCLUDING REMARKS

The IRPS is based upon current state of the art technologies for unmanned operations. Benefit from having the IRPS system is to enable direct data acquisition from RazakSAT™, distribution and early utilization of data to for various remote sensing applications. Other countries in the equatorial zone would benefit from the IRPS which comes with the Hexapod pedestal antenna that is cheaper, lighter, as resistant and accurate as classical pedestals, and can be delivered within 1 to 1 ½ years and offers full hemispherical coverage for any satellite trajectory thus making it compatible by design for both polar and equatorial orbiting satellites.

9 REFERENCES

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