

## Building EOS capability for Malaysia – the options

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**Abstract:** Earth observation satellite (EOS) is currently a major tool to monitor earth dynamics and increase human understanding of earth surface process. Since the early 80s, Malaysia has been using EOS images for various applications, such as weather forecasting, land use mapping, agriculture, environment monitoring and others. Until now, all EOS images were obtained from foreign satellite systems. Realising on the strategic need of having its own capability, Malaysia embarked into EOS development programs in the early 90s. Starting with TiungSAT-1, a micro-satellite carrying small camera, then followed by RazakSAT, a small satellite carrying 2.5 m panchromatic (PAN) medium-aperture-camera, the current satellite program development, the RazakSAT-2, designed to carry a 1.0m high resolution PAN and 4.0m multi-spectral camera, would become a strategic initiative of the government in developing and accelerating the nation's capability in the area of satellite technology and its application. Would this effort continue until all needs of the remote sensing community being fulfilled by its own EOS? This paper will analyze the intention of the Malaysian government through its National Space Policy and other related policy documents, and proposes some policy options on this. Key factors to be considered are specific data need of the EOS community, data availability and the more subjective political motivations such as national pride.

### 1. Introduction – the EOS applications in Malaysia

Earth observation satellite (EOS) is currently a major tool to monitor earth dynamic and increases human understanding of the earth surface process as well as the atmospheric dynamics. The early applications of remote sensing (RS) sciences and applications in Malaysia were initially for meteorological applications using TIROS/NOAA in the 60s. RS applications for land resources and environmental studies started in 70s with the availability of images from the LANDSAT series of satellites. For an equatorial region such as Malaysia, the main limitation of optical-base images was due to continuous cloud cover over the region and severe raining seasons especially at the beginning and end of year. In the 90s, the use of radar EOS images mainly from the RADARSAT satellites manages to overcome some of the problem. Currently both the optical and radar images are widely used, however, repeat capabilities of each satellite is still not sufficient for operational RS purposes [4].

For some time, satellite images from the LANDSAT and SPOT satellite series, are the most widely used EOS images for various land and marine applications. The SPOT satellites with



better spatial resolution and stereo capability have enhanced applications in areas such as topographical mapping. Current QuickBird (0.6m), WorldView-2 (0.5m) and GeoEye-1 (0.5m) sub-meter resolution images has enabled details mapping such as utilities to be carried out. Most of these applications are done post-processed.

For many operational RS applications, of which mostly decision making-related such as disaster-related monitoring and real-time surveillance, where real time or near-real time data supply are needed, these data are not sufficient. Apart from its insufficiency in repeat imaging capabilities, these satellites are mostly polar-orbiting or in Sun Synchronous Orbiting (SSO), hence with longer revisit time, further restricting the use of EOS images for operational purposes. Other shortcomings on the current supply of EOS images includes data availability, normally long-period of delivery, data suitability and data price.

## **2. The EOS program – the capacity building way**

Demand of EOS images for various RS applications is ever increasing in both public and commercial sectors, with dominance in the public sector. EOS images and RS applications has become an important administrative tool. Ironically, as highlighted earlier, until now, all EOS images were obtained from foreign satellite systems.

Realising on the strategic need of having its own capability, Malaysia has embarked into the EOS development program since early 90s. Starting with TiungSAT-1, a micro-satellite carrying small camera, then followed by RazakSAT, a small satellite carrying 2.5 m panchromatic (PAN) medium-aperture-camera (MAC), the current satellite program development, the RazakSAT-2, designed to carry a 1.0m high resolution PAN and 4.0m multi-spectral camera, would become a strategic initiative of the government in developing and accelerating the nation's capability in the area of satellite technology and its application.

The question to ask (1) would be; what is the direction of the country on EOS? Would this capability building effort continue until all needs of the RS community being fulfilled by its own EOS?

EOS is normally a government-led program [6], as part of a technology capability building effort, with key objective of this initiative is to fulfill part-of the domestic RS user community requirement on specific spectral frequency and spatial resolution need. It may be mixed also with the more subjective, political motivations such as national pride.

There are debates on whether government in developing countries should just rely on EOS images globally available or the need to own and operate their own satellites [7]. The general conclusion would be to adapt the earlier option, but there are subtle realities, however, that

challenge this conclusion. It is true that EOS data are available from the international community which can be shared with countries that do not own satellites, including also from commercial providers that sell high resolution satellite imagery.

The problem remains, however, that developing countries cannot always get the data they need when they need it [7]. This may be because the data collected by other countries does not account for the technical requirements of a particular user in a developing country, such as temporal frequency, spatial resolution, spectral frequency or geographic coverage. Also, organizations from developing countries that wish to share international data may be obliged to establish bilateral agreements with each data producer and keep those agreements up to date in order to ensure access (through licensing agreement), which generally an expensive exercise. Meanwhile, high resolution optical data, which is particularly useful for projects in urban planning, is mainly available from commercial providers and could be very expensive.

Long term solution for the country in fulfilling the need of local RS community is much needed. In the absent of any official policy stand of the government, this could be difficult to answer. This paper will analyze the intention of the Malaysian government in this issue, through its National Space Policy and other related policy documents, and proposes some policy options on this. Key factors to be considered are specific data need of the RS community, data availability and the more subjective political motivations such as national pride.

### **3. The EOS program roadmap - the basis**

#### *The satellite development program*

Malaysia has ventured into satellite making since mid-1990 through the purchase of its first two communication satellites, MEASAT-1 and MEASAT-2 from Boeing Ltd. The MEASAT satellites are owned by Binariang Sdn. Bhd. (now Measat Satellite System Sdn. Bhd.), a private entity providing satellite communication-based services in the country as well as globally. Although it is a commercial purchase, some local engineers were sent to Boeing during the development period, to acquire some level of knowledge and know-how in satellite making.

The real transfer-of-technology (ToT) program in satellite technology was done with Surrey Satellite Technology Ltd. (SSTL), United Kingdom in the 90s. 10 engineers from Malaysia were attached with SSTL throughout the development of TiungSAT-1, a micro-satellite which was launched in 2000 and operated for more than 3 years. This project was undertaken by the Space Science Studies Division (BAKSA), a division then under the Ministry of Science, Technology and Environment (MOSTE) Malaysia. Subsequently, a government-linked company (GLC), Astronautic Technology Sdn. Bhd. (ATSB) was formed as a special vehicle to continue undertaking the task of capacity building in satellite technology for the nation.

The National Space Agency (ANGKASA) of Malaysia (incorporating BAKSA) was formed in 2003 to spearhead the development of the space sector for the country. Utilizing grant from ANGKASA, ATSB developed RazakSAT (2004-2009), an R&D remote sensing satellite jointly with a South Korean company, SatRecl. RazakSAT, carrying a MAC was successfully developed, launched, going through its Launch and Early Operation Phase (LEOP) and operated for about eight months. Unfortunately it ceased operation in mid-2010 due to some components malfunctioned, believed to have been caused by the excessive exposures to the solar radiation particles in the region of the South Atlantic Anomaly. During the course of the development and operations of RazakSAT, about 100 engineers and scientists were involved, plus few tenths more of expertise in related areas such as satellite operations and image processing.

The current EOS development program, the RazakSAT-2 satellite, is a continuation of the nation's strategic capacity building initiatives in satellite technology. A development project under ANGKASA (2013-2015), with ATSB as the main contractor, the intended outcome of this project is not only an operational high resolution remote sensing satellite, but achieving the total spectrum of the capacity building aspects in satellite technology for the country.

#### *The National Space Policy*

Although work on the development of such policy has started way back in 2005, until now (2013) the National Space Policy (NSP) for Malaysia has not been officially endorsed. It is supposedly the strategic document that charted the way-forward and providing the framework of development in the space sector for the country [6].

The document envision on building the nation's capability to embrace space as a strategic sector for the national wellbeing towards achieving Vision 2020 and beyond. This could be achieved by developing the country's potential in the space sector to support the development of the new economy, and strengthening the national security. The listed objectives of the policy are;

1. To build up space infrastructure and industry for economic benefit and safeguarding the nation's sovereignty.
2. To empower the civil society in enriching their quality of life through information from innovative application of space technology.
3. To capitalize/harness on space as the frontier for new knowledge generation towards contributing to scientific and technological advancement.
4. To ensure critical mass of talent in space related sector to support the realization of the space policy.



Fig.1: The National Satellite Program Development.

### *The National EOS program*

The NSP draft outlined the direction of the satellite program development for the country until 2020. These are under Program 3: Accelerating Space Technology and Infrastructure Development, with related plan of action in the National Satellite Program Development that includes the EOS Program, the National Communication Satellite Program and the Global Navigation Satellite System (GNSS) Program.

Under the EOS program, it is outlined that;

*'The Malaysia's EO satellite series (RazakSAT) should be continued because it will play a very important role in resources investigation and the monitoring of environment disasters. EO satellite data can be applied to numerous fields as agriculture, forestry, water resources, land use, cartography, mineral exploration and ocean investigations. The technology and expertise acquired in developing the EO satellite can then be applied to the development of the more sophisticated communication satellite'.*

#### **4. The EOS capacity building program - to build or to acquire?**

The current EOS development program, the RazakSAT-2 satellite, is a continuation of the nation's strategic capacity building initiatives in satellite technology. A development project under ANGKASA (2013-2015), with ATSB as the main contractor, the intended outcome of this project is not only an operational high resolution remote sensing satellite, but achieving the total spectrum of the capacity building aspects in satellite technology for the country.

The question to ask (2) would be; would this effort of capacity building continue until all needs of the local RS community being fulfilled by our own EOS?

The ability of a nation to drive innovation and economic progress depends on its science and technology capacity. This was the thought process for the development of the National Science



and Technology Policy (NSTP), the second NSTP (NSTP II) and the National Action Plan for Industrial Technology Development (Fadzilah and Krishna, 2007). The ability shall include all factors including the manpower and personnel to conduct research and to carry out the technological development, infrastructure, investment, institutional arrangement and regulatory framework.

Satellite technology development has long been recognized worldwide as an indicator of science and technology ability. It has been the domain of technologically advanced countries and regions such as the United States, Europe, Japan and recently China. However an increasing number of developing countries, Malaysia included, have started to enter this strategic sector especially through joint development of small satellites. It is known that engineering knowledge and work experience gained in these satellite programs is often directly transferable to other technology fields.

Several issues of pertinent that could lead to certain policy options are highlighted as follows.

*i. Digital Earth and EOS*

As the country moves towards a fully developed nation by 2020, digital-economy adoption requires the setting up of digital infrastructures such as the Digital Earth (DE). DE, or technically known as the Spatial Data Infrastructure (SDI) would enabled the full capitalization of geospatial data among users and data providers in the country [1].

An EOS, as providers of the basic data to an SDI, in the form of various satellite images, would be an important component in the realization and maintenance of the country's SDI. China for example has placed great importance on the development of Earth observing satellites [3]. The four satellite series in China, which include resource satellites, environment satellites, meteorological satellites and ocean satellites, have been developed within the past few decades. They have also planned to have more high-resolution remote sensing satellites for building their next generation DE.

*ii. Building the EOS program – who's job is it?*

The development and operation of an EOS system requires a significant commitment. Without a clear return on the investment, and an expensive venture as such, it is the government financial mechanism that would be the best one to support such implementation. The private sector on the other hand, is expected only to involve in the downstream applications of it, in further enhancing the justification of such program. In fact, most EOS program implementation is a not-for-profit making venture, but more of a national need, i.e. more on the justification of strategic need, rather than economy. Again, China has clearly shown that it is the government's job to do it [3].

*iii. Fulfilling the domestic RS community need and sustaining of the EOS program*

As the case elsewhere, local RS community certainly has a wide range of EOS image needs. A recently conducted user requirement survey [5] has indicated that slightly more than 50% of demand are in utility, infrastructures and engineering works. This clearly indicates that images of higher resolution (1m or better) are much needed by the local RS users. On the signal side, optical images are still the preferred choice for such applications, for ease of use and cost. For this need, the optical payload was chosen in the current government EOS program development, the RazakSAT satellite series. As such, it is important for the EOS program to be continued and sustained by the government. The survey has also indicated that the next EOS program development for the country would be satellites carrying radar payload.

*iv. The operational needs of EOS*

It has been mentioned earlier that the business of getting data from foreign service providers are faced with issues such as data unavailability, or data available does not account for the technical requirements needed such as temporal frequency, spatial resolution, spectral frequency or geographic coverage. Another major shortcoming of current foreign EOS services is the ability to provide the needed image at the needed time for operational purposes. This is understood simply due to the nature of the EOS operational perimeter. With most EOS flying at SSO, the repeat visit could well be more than a week, hence for an operational purposes, such as monitoring a forest fire, the gap in imaging opportunity, is just too long. Even with multiple of EOS available, this gap is still a major cause. In addition to that, for most operational applications, where optical images are preferred, continuous cloud cover would add on to the problem.

*v. To sit on the upper bench – the ability to contribute*

EOS images have been integrated in disaster-management initiatives such as the Sentinel Asia, and UN-SPIDER, where Malaysia is a member. These initiatives works on a mutual cooperation, with members of the consortia contributes in assisting other members stricken by disasters, through data obtained via their infrastructures, for example, supplying images from their EOS. Within such an arrangement, the ability to contribute would indirectly give the member-country the credits. The more significant the contributions are, the more credit it will get. It is time for Malaysia, a leading member country of ASEAN, to have our own EOS – else the country is merely recipient of these initiatives or end users!

## 5. The options

To ensure full capitalization of the sector, it seems that the way forward is to build the country's capability in EOS, mainly in the small satellite missions. So far, this seems to be the current strategy of the Malaysian government. With full awareness that these will not targeting to make the country independent from using foreign satellite images (which even space faring nations is not doing), but having the capability to develop, launch and operate critical and the much needed EOS mission. In implementing this strategy, we believe both options of acquiring some and built some should be taken.

Under the NSP draft, it has been outlined that the direction of the EOS program development falls clearly under Program 3: Accelerating Space Technology and Infrastructure Development, where the EOS Program development is one of the three satellite development program to be pursued. Another important program in the NSP is one under Program 1: Exploring Space for New Knowledge & Scientific Discovery, where it is indicated that a specific orbital designation is to be favored, i.e. on enhancing the Near Equatorial Orbit (NEqO).

With these, we like to propose options for the development of the EOS program in the country, such as follows.

### *i. To continue with the EOS capacity development program*

Currently we have the capability and capacity to design and develop (assemble, integrate, test), small (<1 ton) satellite bus and related sub-systems. We are also capable to launch (utilizing launch service provider) and operate such system. As for RazakSAT, the optical payload, an MAC was jointly developed with foreign technology partner, SatRecl a South Korean company. For RazakSAT2, it is still to be jointly developed with a foreign technology partner. We need to have R&D on payload development, either optical, radar, hyper-spectral or others. These would then complete the capacity building process.

### *ii. To continue with the RazakSAT satellite series*

The optical payload would still be the preferred payload for most applications. For this, the RazakSAT satellite series (optical payloads) should be continued. Once the RS community built up applications using the RazakSAT2 imageries, the dependency on the continuous supply of the image will be established, and then it will be the responsibility of the government to ensure continuity of such service. Planned spatial resolution of 1.0m panchromatic and 5.0 m multi-spectral of RazakSAT2 would seem to satisfy majority domestic RS users. Future camera resolution should be determine prior to new mission development.



*iii. To have radar satellite program*

Being at the equatorial region, having a continuous cloud cover is a challenge. A radar payload satellite would greatly enhance the imaging needs of the local RS community. Limiting the satellite mass to be less than 1 ton, which we already have capability of then the development would be focus only to the payload of the mission. That would probably a mini-version radar. This could be targeted as the next development after the RazakSAT2 program.

*iv. To continue pursuing the utilization of the NEqO*

Malaysia has pioneered the NEqO with RazakSAT. The NSP draft has also recommended the pursuance on the capitalization of NEqO. NEqO simply gives the opportunity in high imaging repeatability for Malaysia, hence giving a huge advantage for operational RS applications such as forest fire monitoring. With a repeat of about 14 times vicinity imaging per day (including night time of course!), this could really enhance the monitoring operations.

The coming RazakSAT2 satellite unfortunately will fly the SSO. These decision is temporarily taken in consideration of several reasons, amongst them could be due to;

- The need to optimize ROI of RazakSAT2. With SSO orbit, capability to image the entire globe, hence increasing the potential of economic earning to the country.
- That the local RS communities are customs to commercial image processing software which is mainly based on the SSO images. Hence, non-SSO images (such as NEqO) posed difficulties for them.
- Local researchers are still not ready to capitalize NEqO images that have variation in sun-angle, shadows and sun-illuminations.

These are but challenges that have to be overcome by local RS experts and users before the next missions NEqO EOS could be realized.

## **6. Conclusions**

The country has made the right policy in developing its local capability in the EOS program. Although it does not aim to make the country independent from using foreign satellite images but rather having the capability to develop, launch and operate critical and the much needed selected EOS mission. It is still the role of the government to ensure the successful implementation of this strategic initiative. Full capability is almost achieved except for some areas such as payload. With the acceptance and implementation of the National Space Policy, these could well be achieved by 2020.

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