RESEARCH STRATEGIES FOR REMOTE SENSING DEVELOPMENT IN MALAYSIA

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Abstract

Space technology is a major strategic tool at present and in the future due to the unique global capabilities that it brings. It will help society overcome several threats to the quality of life on earth or even in human life itself. In that sense, space technology is fundamental to sustain security in all its forms - political, economic, military, and ecological – in a truly global approach. In this paper, one aspect of space technology, i.e. remote sensing is addressed. It includes the current status of remote sensing technology and applications, some priority settings and implementation strategies.

1.0 Introduction

Remote sensing technology and applications development in Malaysia has been spearheaded by the National Remote Sensing Committee (NRSC) since its formation in 1977 under the Economic Planning Unit, Prime Minister's Department. The role of NRSC is to formulate policies towards the development and application of remote sensing technology in the country. The NRSC comprises government resource agencies, universities and state planning agencies. The National Remote Sensing Program (NRSP) was implemented in 1988 with the objective to strengthen national capacity to operationalize remote sensing and related technologies in the main stream of national development planning. The NRSC oversees the implementation of NRSP.

The Malaysian Centre for Remote Sensing (MACRES) was established in 1988 to develop remote sensing and related technologies to operationalize their applications for socio-economic development, natural resources, environmental disasters management, and strategic planning of the nation. MACRES acts as the secretariat of NRSC. The Malaysian Ground Receiving Station (MGRS) located in Temerloh became operational since 2003, receiving data from SPOT, Radarsat, Landsat and NOAA. The MGRS will benefit users who require real-time or near real-time data for monitoring environmental impact and natural disaster occurrences. In September 2000 Malaysia launched its first microsatellite TiungSat-1 for meteorology, earth observation, digital communication and space experimentation. This will be followed by RazakSat expected to be launched in October 2005 which will carry high resolution medium aperture camera for earth observations.

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2.0 Overview

Remote sensing covers all techniques related to the acquisition, analysis and use of data from satellites, such as Landsat, SPOT, Radarsat, ERS, NOAA, Meteosat and from airborne sensing. The main objective of remote sensing is to map and monitor the earth's resources and environment.

The early applications of satellite remote sensing were for meteorological applications using TIROS/NOAA since 1960's. Remote sensing for land resource and environmental studies started in the early 1970's with the launch of the Landsat series of satellites. Most of these satellites operate using the optical wavelength of the electromagnetic spectrum. The major drawback of using optical imagery is the cloud cover problem inherent in tropical areas. In the early 1990's the use of microwave (radar) satellite data gained prominence which can overcome the cloud cover problem. At present, both optical and microwave data compliment each other for various applications. However, the repeat capabilities of each satellite is not sufficient for operational remote sensing applications.

2.1 Current Status of Remote Sensing Applications

Since the launch of the first remote sensing satellite for earth's resources and environmental monitoring, i.e. Landsat-1 in 1972, the data received has been used in various land and marine applications. The spatial, spectral, radiometric and temporal resolutions are the limiting factors to a wide range of applications. Since the launch of SPOT-1 in 1986 with better spatial resolution and stereo capability, it was possible to enhance the applications in areas such as topographical mapping. Since then, many satellites have been launched with better spatial and spectral resolutions and hence broadening the applications of the data. Therefore, more detailed information can be obtained from these data. The spectral, spatial and temporal resolution of some major satellites that have been launched are given in Appendix I. Future satellites and sensors that will be launched are given in Appendix II.

These satellites are mostly near-polar orbiting satellites which have a longer revisit capability. This restricted the use of the satellite data for many applications which need real-time or near real-time data. The constraints in obtaining timely data have made it difficult for operational applications of the data for decision making process. Previously, satellite data has been purchased from neighbouring ground stations which further delayed the delivery of the data for operational applications. Now, with the establishment of MGRS at Temerloh under MACRES, data may be obtained in a shorter time for some operational applications. Table 1 provides the general temporal data requirements by discipline (Star, 1991).

Table 1: General temporal data requirements by discipline.

Discipline	Average Temporal Revisit
Archaeology	Yearly
Cartography	Yearly
Infrastructure mapping	Yearly
Forestry-Geology	Monthly
Agriculture	Weekly to bi-weekly
Hydrology	Weekly
Oceanography	Weekly to monthly
Marine pollution	Hourly to daily
Natural Disasters	Hourly to daily
Environmental monitoring	Hourly to daily
Meteorology	Hourly to daily

In Malaysia, Research and Development (R&D) activities in remote sensing started in the late 1980's. These activities were undertaken by universities, research institutes and government departments mainly through the IRPA mechanism of the Ministry of Science, Technology and Innovation. Most of these R&D works focused on land and sea applications. However, some departments have carried out R&D using their own funds on specialized areas. Appendix III illustrates the requirements of the temporal, spatial and spectral resolutions of remotely sensed data for various applications in Malaysia. In this paper, temporal resolutions of satellite data is categorized into real-time and near real-time for extracting "dynamic" information that changes quickly with time. Information that do not change fast such as landuse, geological mapping, etc on the other hand, requires non real-time data.

In most developed nations, remote sensing has been used widely in many operational applications, namely in natural resource management, environmental protection & conservation management and national strategic planning. These include the use of all types of remote sensing data (imaging and non-imaging) acquired using sensing systems from low, medium to high spatial, spectral and temporal resolutions producing regional to farm level range of information. However in Malaysia, these applications are confined to only a few agencies.

3.0 Benchmarking

The advancement of remote sensing technology and applications varies widely between developed, developing and under-developed countries. In this paper, emphasis is given in comparing the status and capabilities of remote sensing in Malaysia with that of countries which are slightly more developed, i.e. Japan, India and China.

3.1 Satellite and Sensor Technology

In terms of satellite technology, Japan, India, and China have advanced programmes and capabilities in the making of satellite and sensors for remote sensing, including satellite launching facilities. An overview of major remote sensing satellites, sensors and capabilities of various countries including Japan, India and China are given in Appendix I.

In the case of Malaysia, TiungSat-1 microsatellite has been launched in September 2000 carrying payloads for meteorology, earth observation, digital communication and space experimentation. The next national satellite is RazakSat, expected to be launched in October 2005 which will be placed in near equatorial orbit carrying medium aperture camera for earth observation at 2.5 and 5 m spatial resolution in panchromatic and multispectral mode, respectively.

However, a dedicated satellite programme for remote sensing applications with good spatial, spectral and radiometric resolution has not been made with specific mission to fulfill remote sensing user communities. In this respect, Malaysia is lagging behind the above countries. Furthermore, no efforts have been made to plan a series of satellite programme for remote sensing applications unlike the above countries (e.g. IRS-1, IRS-2, etc of India). Although Malaysia has a ground receiving station (MGRS), the Malaysian users still depend on data transmitted by foreign satellites for natural resource management, environmental protection & conservation management and national strategic planning.

In terms of sensor development, Malaysia also lacks in a well coordinated effort with input from user community (government agencies and private sectors). Also, announcement of opportunities for involvement of user communities in various applications using satellite/airborne sensor system that have been developed is lacking.

3.2 Remote Sensing Applications

Operational remote sensing applications have been restricted due to various factors, including : (i) the lack of remote sensing expertise in various organizations which reduce aspects related to operational remote sensing, (ii) timely data for operational use, and (iii) lack of national standards and procedures for extraction of information and its reliability.

Most of the applications of remote sensing in Malaysia have been confined to natural resource programmes (e.g. NAREM, SIM, etc) only but very minimal in environmental protection and conservation management. All the above programmes have been given importance in India, China and Japan.

3.3 Industry

In developed countries, space applications including services for extracting of information for various applications have been shared equally by both government and private agencies. In fact, value added products are continuously generated by the private sector to ensure marketability and wider usage by the user community. However, in Malaysia, outsourcing of similar projects from government agencies to the private sector has been very minimal, due to the lack of adequate linkage between both government and private sector. This has in turn reduced the development of remote sensing technology and its applications within the private sector. The major role of the private sector is in selling of remote sensing system (hardware and software) and system's maintenance services.

4.0 Priority Setting

The priority setting for remote sensing technology and its applications are outlined below.

1. Awareness program for remote sensing technology and its applications at various levels in government agencies, private sector and secondary schools.
2. Human resource development in remote sensing (capacity building).
3. Increase frequency of data acquisition over areas of interest by receiving more data from various earth observation satellites to fulfill operational requirements.
4. Acquisition of suitable hardware/software and other relevant equipment for analysing present remote sensing data sets and ground validation.
5. Establishment of standards / procedures for information extraction for various remote sensing applications so that their reliability, uniformity and integrity can be known and hence can be used as expert opinion in accordance with United Nations Remote Sensing Principles (Principle I to XV).
6. Continuous remote sensing programmes/projects at federal, state and local government to assist decision making in natural resource management, environmental protection & conservation management and national strategic planning.
7. Real-time or near real-time data transmission infrastructure to users so that timely data can be received by users to assist in decision making for operational needs. Comprehensive requirement analysis for receiving timely data should be established for each user agencies.
8. Airborne remote sensing programmes should be strengthened to complement satellite programmes. Timely data for localize sites can best be acquired by airborne missions.
9. Launch continuous satellite programmes carrying relevant earth observation payloads which address national needs.

10. Configure orbit for Malaysian remote sensing satellites to acquire more frequent data for areas over Malaysia or establish constellation of satellites in suitable orbiting planes to ensure frequent revisit capability.

5.0 Implementation Strategies

The implementation strategies for the above priority settings are given below.

1. Awareness program for remote sensing technology and its applications
   a. Schools through topic in existing curriculum/syllabus, i.e. Physics, Geography.
   b. Aggressive awareness through main stream media on the technology as well as R&D activities.
   c. Series of awareness programmes for decision makers.

2. Human resource development (capacity building)
   a. Establishment of suitable employment scheme in the government civil service for graduates in remote sensing or related technologies to improve the operational requirements of remote sensing technology for decision making, e.g. secondment, cadre post, etc.
   b. Formal and non-formal education/training programmes at various levels.

3. Increase frequency of data acquisition for operational applications
   a. Identify temporal requirements of users in various applications.
   b. Mechanism for data integration from various satellites/sensors.
   c. Upgrade existing satellite data receiving facilities (if necessary).

4. Acquisition of hardware/software and equipment
   a. Funding/budget.
   b. Market survey of hardware/software and equipment to suit user requirements.

5. Establishment of standards/procedures
   a. Comprehensive user requirement survey for various applications.
   b. Central agency to verify, compile and disseminate standards/procedures (e.g. through a special committee).

6. Continuous remote sensing programmes/projects
   a. Identify relevant programmes to cater national needs.
   b. Implement suitable pilot projects.

c. Implement "actual" projects based on results and experiences gained from pilot projects.

7. Real-time or near real-time data transmission infrastructure
   a. Assessment of existing infrastructure to transmit data from receiving station to users.
   b. Identify agency that will implement the mechanism to develop suitable infrastructure (e.g. fibre optics, VSAT, etc.).
   c. Build the necessary infrastructure.

8. Strengthen airborne remote sensing programmes
   a. Identify user requirements.
   b. Identify suitable airborne sensor systems.
   c. Airborne remote sensing system acquired by central agency.

9. Continuous satellite programmes for earth observations
   a. Identify user requirements.
   b. Establishment of special committee to study user requirements.
   c. Establishment of special committee to develop suitable sensor systems.
   d. Establishment of special committee to study and propose series of satellite programmes.
   e. Application development and research opportunity programmes.

10. Configuration of Malaysian remote sensing satellites
   a. Establishment of special committee to study suitable satellite orbit for frequent data acquisition.
   b. Study of suitable constellation of satellites for future development.

6.0 Concluding Remarks

In this paper, the current status of remote sensing applications as obtained from relevant user agencies are reported. Some priority settings and implementation strategies for the advancement of remote sensing applications are given. Some of these priorities and strategies are not comprehensive. It is hoped that this paper will provide some initial information for further discussion.

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APPENDIX I

Past and Current Sensor Systems for major remote sensing satellites

Mission	Country	Launch Year	Instrument	Spatial Resolution (meters, at nadir)					Swath (km)	Repeat Cycle (days)
				PAN	VNIR	SWIR	TIR	SAR/band		
PAST SENSOR SYSTEMS										
Landsats 1-4	USA	1972-92	MSS		80				185	18
		1982-	TM-4,5		30	30	120		185	16
Nimbus-7	USA	1978-86	CZCS		825	825	825		1536	6
NOAA 6-11,15	USA	1978-2001	AVHRR		1.1km	1.1km	1.1km		3000	0.5
SEASAT	USA	1978	SAR					25/L	100	3
SPOT-1, 3	France	1986-1996	2xHRV	10	20				60	26
MOS-1	Japan	1990-1996	MESSR		50				100	17
			VTIR		900		2.7km		1500	
Almaz-1	Russia	1991-1992	SAR					15/S	40-280	
JERS-1	Japan	1992-98	OPS		18				75	44
			SAR					18/L	75	
ADEOS-1	Japan	1996-1997	AVNIR	8	16	16			80	41
			OCTS		700	700	700		1400	
ADEOS-2	Japan	2002-2003	GLI		250	250	1000		1600	4

APPENDIX I (Continued)

Mission	Country	Launch Year	Instrument	Spatial Resolution (meters, at nadir)					Swath (km)	Repeat Cycle (days)
				PAN	VNIR	SWIR	TIR	SAR/band		
CURRENT SENSOR SYSTEMS										
IRS-P2	India	1994	LISS 2		36				132	24
NOAA-14	USA	1994	AVHRR		1100	1100	1100		3000	0.5
Resurs-O1 N3	Russia	1994	MSU-SK		170		600		600	2-4
ERS-2	ESA	1995	AMI-SAR					30/C	100	35
GOES-9	USA	1995	Imager		1000, 4000				Hemisphere	0.02
IRS-1C	India	1995	PAN	6					70	24
			LISS 3		23	70			142-148	24
			WiFS		188	188			774	24
Radarsat	Canada	1995	SAR					10-100/C	50-500	16
IRS-P3	India	1996	MOS		500				200	5
			WiFS		188	188			770	
GOES-10	USA	1997	Imager		1000, 4000				Hemisphere	0.02
Meteosat-7	Europe	1997	VISSR	2500			5000		Hemisphere	0.02
OrbView-2 (SeaStar)	USA/Orbimage	1997	SeaWiFS		1100-4500				1500-2800	16
TRMM	USA/Japan	1997	TMI					6-50km	790	0.067

APPENDIX I (Continued)

Mission	Country	Launch Year	Instrument	Spatial Resolution (meters, at nadir)					Swath (km)	Repeat Cycle (days)
				PAN	VNIR	SWIR	TIR	SAR/band		
CURRENT SENSOR SYSTEMS										
SPOT-4	France	1998	2xHRV-IR	10	10, 20	10, 20			60	26
			Vegetation		1000	1000			2200	
Landsat-7	USA	1999	ETM+	15	30	30	60		185	16
Ikonos-2	USA: Space Imaging	1999	Ikonos	1	4				11	3
CBERS	China/Brazil	1999	CCD	20	20	20			120	26
			IR-MSS	80		80	80		120	
			WFI		260	260			900	5
Terra (EOS AM-1)	USA/Japan	1999	ASTER		15	20	90		60	16
			MISR		240, 480, 960, 1900				370-408	
			MODIS		250, 500, 1000	500, 1000	1000		2300	2
EROS-A	Israel: Imagesat	2000	EROS-A	2					14	4
NOAA-16	USA	2001	AVHRR		1100	1100	1100		3000	0.5
Jason-1	USA/France	2001	ALT					2000/K	NA	10
Quickbird-2	USA: DigitalEarth	2001	Quickbird	1	4				22	4

APPENDIX I (Continued)

Mission	Country	Launch Year	Instrument	Spatial Resolution (meters, at nadir)					Swath (km)	Repeat Cycle (days)
				PAN	VNIR	SWIR	TIR	SAR/band		
CURRENT SENSOR SYSTEMS										
ENVISAT-1	ESA	2002	AATSR		1000	1000	1000		512	35
			ASAR					30/C	100	
NOAA-17	USA	2002	AVHRR		1100	1100	1100		3000	0.5
SPOT-5a	France	2002	HRG	5	10	20			60	26
			Vegetation		1000	1000			2200	
Orbview-3	USA: Orbimage	2003	Orbview-3	1	4				8	3
BILSAT	Turkey:BILTEN	2003	BILSAT	12	26				55,25	4
IRS-P6	India	2003	LISS 3		24	24	24		140	24
(RESOURCESAT-1)			LISS 4	6	6	6	6		24-70	
			AWiFS		60	60	60		740	
CBERS-2	China/Brazil	2003	CCD	20	20	20			120	26
			IR-MSS			80	80		120	
			WFI		260	260			900	

APPENDIX II

Future Sensor Systems for major remote sensing satellites

(Note: future launch dates are only approximations)

Mission	Country	Launch Year	Instrument	Spatial Resolution (meters, at nadir)					Swath (km)	Repeat Cycle (days)
				PAN	VNIR	SWIR	TIR	SAR/band		
NOAA-18	USA	2004	AVHRR		1100	1100	1100		3000	0.5
ALOS	Japan	2004	AVNIR-2	3	10-15				35, 70	45
			PALSAR					10,100/L	70-350	
Radarsat-2	Canada	2004	SAR					3-100/C	10-500	24
SPOT-5b	France	2004	HRG	5	10	20			60	26
			Vegetation		1000	1000			2200	
EOS AM-2	USA	2004	MISR		240, 480, 960, 1900				370-408	9
			MODIS		250, 500, 1000	500, 1000	1000		2300	2
Almaz-1b	Russia	2005	MSU-E2		10				24	3
			MSU-SK		170			600	300	
			SROMN		600	600	600		1100	
			SAR-3					5-7/X	20-30	
			SAR-10					5-30/S	20-170	
			SAR-70					30/L	120-170	
			SLR-3					5-700/X	450	

APPENDIX II (Continued)

Mission	Country	Launch Year	Instrument	Spatial Resolution (meters, at nadir)					Swath (km)	Repeat Cycle (days)
				PAN	VNIR	SWIR	TIR	SAR/band		
OSTM	USA/France	2006	ALT					2000/K	NA	10
HYDROS	USA	2009	MOIST					40000/L	1000	3
ARIES-1	Australia	TBD	ARIES	10	30	30			15	7
Resurs-O2	Russia	TBD	MSU-SK		170		600		600	4

APPENDIX III

Temporal, spatial and spectral resolutions requirements for some remote sensing applications in Malaysia

Applications	Temporal Resolution			Spatial Resolution	Spectral Resolution
	Real-time	Near Real-time	Non Real-time		
Forestry	• Forest fires			Low & high	TIR, Visible
		• Logging activity		Medium & high	Visible, NIR, MIR
			• Forest inventory	Medium	Visible, NIR, MIR
			• Forest types and boundary	Medium	Visible, NIR, MIR
			• Species	High	Visible, NIR, MIR
			• Canopy density	Medium & high	Visible, NIR, TIR
			• Biomass	Medium & high	Visible, NIR, MIR, radar
			• Logging track	High	Visible, Laser
			• Biodiversity	Medium, high	Visible, NIR, MIR, TIR, radar
Agriculture		• Crop vigor		Medium to High	Visible, NIR, MIR, TIR, radar
		• Nutrient contents		Medium to High	Visible, NIR, MIR, TIR, radar
		• Soil moisture		Medium to High	Visible, NIR, MIR, TIR, radar
		• Pest and disease control		Medium to High	Visible, NIR, MIR, TIR, radar
		• Early warning system		Low to High	Visible, NIR, MIR, TIR, radar
		• Precision agriculture		High	Visible, NIR, MIR, TIR, radar

APPENDIX III (continued)

Applications	Temporal Resolution			Spatial Resolution	Spectral Resolution
	Real-time	Near Real-time	Non Real-time		
			• Landuse	Medium to high	Visible, NIR, MIR, TIR, radar
			• Crop type	Medium to high	Visible, NIR, MIR, TIR, radar
			• Yield estimation	Medium to high	Visible, NIR, MIR, TIR, radar
Environment	• Oil spills			Medium to high	Visible, radar
	• Turbidity			Medium to high	Visible, NIR
	• Haze			Medium to high	Visible, NIR
Disaster	• Landslides			Medium to high	Visible, NIR, MIR, TIR, radar
	• Flood			Medium to high	Visible, NIR, radar
Meteorology	• Cloud formation			Low	Visible, NIR, MIR, TIR, radar
	• Cloud types			Low	Visible, NIR, MIR, TIR, radar
	• Water vapour contents			Low	Visible, NIR, MIR, TIR, radar
	• Storm/typhoon hurricane			Low	Visible, NIR, MIR, TIR, radar
	• Hot spots			Low to medium	Visible, NIR, MIR, TIR, radar
	• Volcanic ash			Low	Visible, NIR, MIR, TIR, radar
	• Sea surface temperature			Low	Visible, NIR, MIR, TIR, radar
	• Rainfall estimation			Low	Visible, NIR, MIR, TIR, radar

APPENDIX III (continued)

Applications	Temporal Resolution			Spatial Resolution	Spectral Resolution
	Real-time	Near Real-time	Non Real-time		
Oceanography / Fisheries	• Chlorophyll & phytoplankton			Low to medium	Visible, NIR
	• SST studies for fish forecasting			Low	TIR
	• Fish forecasting			Low to medium	Visible, NIR, MIR, TIR
		• Wave height		Low to medium	Radar
		• Wavelength and direction		Low to medium	Radar
			• Bathymetry	Medium	Visible
			• Sea bottom features	Medium	Visible
Geology			• Hydrogeology	Medium	Visible, NIR, MIR, radar
			• Structure mapping	Medium	Visible, NIR, MIR, radar
			• Geomorphology	Medium to high	Visible, NIR, MIR, radar
			• Mineral exploration	Low to medium	Visible, NIR, MIR, radar
			• Terrain mapping	Medium	Visible, NIR, MIR, radar

APPENDIX III (continued)

Applications	Temporal Resolution			Spatial Resolution	Spectral Resolution
	Real-time	Near Real-time	Non Real-time		
Mapping			• DEM	Medium to High	Visible, NIR, radar
			• Map updating	Medium to High	Visible, NIR, radar
			• Ortho Image map	Medium to High	Visible, NIR, radar
			• District and state structure plans	High	Visible, NIR, radar
			• Mapping of environmental sensitive area	Medium to high	Visible, NIR, MIR, TIR, radar
			• Target recognition	High	Visible, NIR, MIR, TIR, radar

Note :

* Real-time = information extracted immediately after data received by ground station.

** Near Real-time = information extracted within a day after data received by ground station.

*** Non Real-time = information extracted within reasonable period depending on types of information.