Development of Micro-satellite Technology at the Indonesian National Institute of Aeronautics and Space (LAPAN)

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Robertus Heru Triharjanto
Center For Satellite Technology, LAPAN
jl. Cagak Satelit km.4 Rancabungur, Bogor 16310, Indonesia
rtriharjanto@yahoo.com

ABSTRACT

The evolution of desain of LAPAN's micro-satellite will be presented in here. Micro satellite systems have been chosen for space technology development in Indonesia due to the cost effectiveness. Starting in 2003, LAPAN has implemented LAPAN-TUBSAT micro-satellite program, which has successfully carried its mission as experimental Earth observation satellite and capacity building tools. The satellite is currently serving its 5^{th} year of operation. Since 2008, LAPAN is preparing two satellites; named LAPAN-ORARI and LAPAN-IPB. The mission for LAPAN-ORARI is Earth observation using RGB camera, maritime traffic monitoring using AIS, and amateur radio communication (text & voice). The satellite will be launched as auxiliary payloads for ASTROSAT mission which has orbit of be 650 km circular at inclination of 8^0, expectedly before the end of 2012. The purpose of the project is to develop capability to design, Assembly, Integration and Test (AIT) process of micro-satellite in Indonesia. LAPAN-IPB will cary an experimental 4-bands multispectral imager, as well as AIS and communication for Amateur Radio Community, and to be flown by PSLV SSO mission expectedly before the end of 2013. The three projects shows LAPAN's micro-satellite bus development, that grow in complexity to accomodate more complex mission. The knowledge advancement is expected to prepare the Center for developing operational satellite for supporting the food security program in Indonesia.

I. Introduction

Indonesia is located approximately 5,150 km along the length of the equator (or about 1/8th of earth circumference), and the widest breadth is around 1,750 km, with more than 220 million population. With the extensive region with diverse geographical problem, the utilization of satellites is important for Indonesia to address solutions to the problems of the nation.

Despite the extensive of satellite technology use since 1970s, Indonesian satellite communication system is still purchased from other countries. The same with the remote sensing satellite system, which have been extensively used since 1980s. It is known that during the Aceh tsunami, the disaster management support is heavily dependent on foreign satellite services. Economically, in the long term, the technology dependency created great loss for Indonesia. In addition to that, the dependency made Indonesia prone to political pressure from technology supplier countries.

The development of micro-satellites has become an opportunity for LAPAN in developing its satellite program. The development of such satellites requires only limited budget and facilities, compared to the development of big satellites. Meanwhile, the capability to develop micro-satellite will brings LAPAN to the readiness state to implement a future space program that will have measureable economic impact, and therefore contribute to the country's sustainable development effort.

II. LAPAN-A1 Satellite

The development of LAPAN-A1, Indonesian 1st microsatellite which is also named LAPAN- TUBSAT, was started in 2003. Its Assembly Integration and Test was done in 2004-2005 in Technical University of Berlin, Germany. The satellite payload is a COTS video camera with 1000 mm lens, resulting into nadir resolution of 5 m and nadir swath of 3,5 km from 650 km altitude. In addition to that the satellite carries another video camera with 50 mm lens, resulting into 200 m resolution video image with swath of 80 km at nadir. The *uplink* and *downlink* for *telemetry*, *tracking and command* (TTC) is done in UHF and *downlink* for video is done in S-band analog. The satellite is successfuly launched to SSO of 635 km as auxiliary payload in *Polar Satellite Launch Vehicle* (PSLV) C7 from Sriharikota, India on January 10th, 2007, and now has entered its fifth year of operation and still in good condition.

Figure 1. 3-roda cement factory, West Java (taken by LAPAN-TUBSAT 25 May 2010)

III. LAPAN-A2 Satellite

Gaining experience in developing, launching, and operating micro-satellite as well as in developing and operating satellite's ground station, LAPAN continue in developing its 2nd satellite, named LAPAN-A2. The mission for LAPAN-A2 is Earth observation using RGB digital camera, maritime traffic monitoring, and amateur radio communication.

Since Indonesian territory is spread along the equator, LAPAN study the operation of satellite at low inclination orbit, so that the satellite may pass Indonesia as much as SSO orbit pass the North/South pole (14 times in 24 hours at 600 km orbit). The study shows that in order to be able to cover the entire Indonesia with surveilance camera oriented at nadir, the inclination needed is 10^0. Therefore, when ISRO announce that it would launch ASTROSAT mission which has orbit of be 650 km circular at inclination of 8^0, LAPAN decided to put the satellite as auxiliary payloads for the mission. With frequent pass over Indonesia, the missions are expected to be more useful.

The objective of LAPAN-A2 satellite project is to achieve the design, integration and operation of micro satellite in Indonesia. LAPAN-A2 main mission is Earth Observation using digital RGB camera (5 m resolution). In addition to that the satellite carry AIS (Automatic Identification System) receiver to monitor maritime trafic, a reaction wheel made by LAPAN for space proofing, and an amateur radio Automatic Packet Reporting System (APRS), as well as amateur radio voice repeater, for Indonesian Amateur Radio Organization (ORARI). Due to this cooperation, LAPAN-A2 is called LAPAN-ORARI.

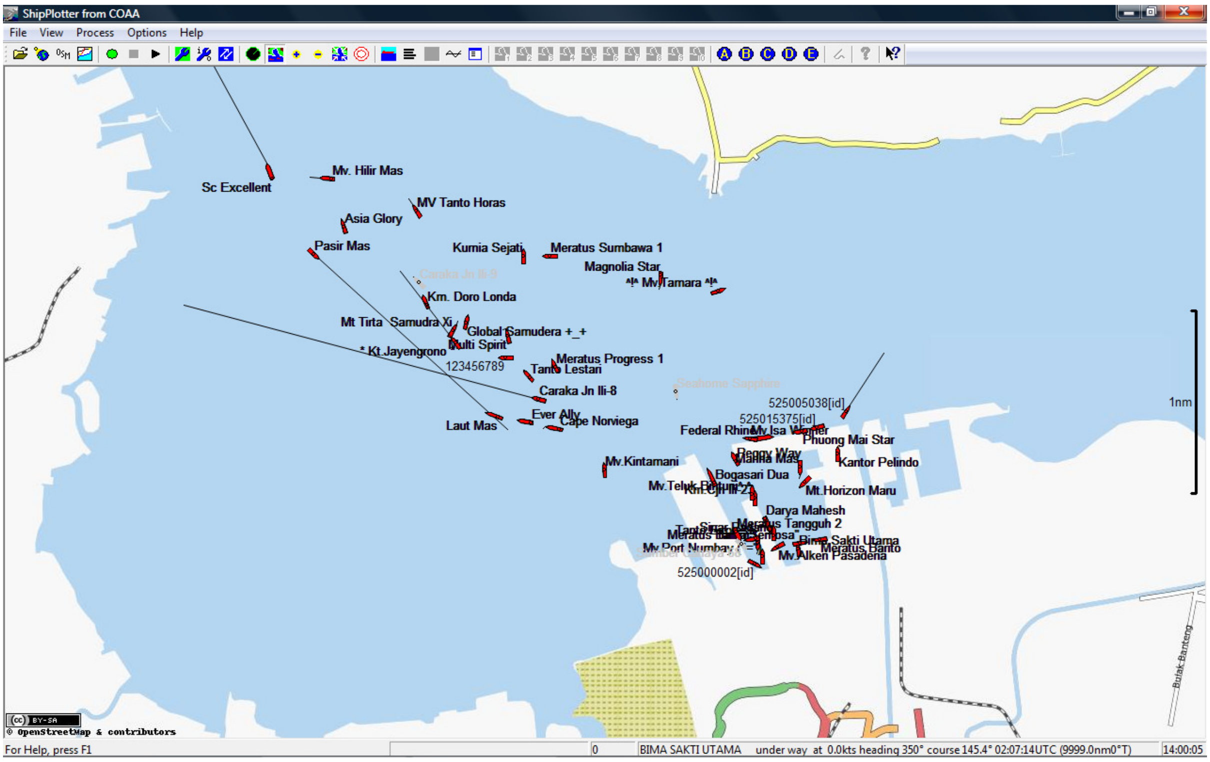

Figure 2. AIS payload test result, Surabaya, East Java, 2010

LAPAN-A2 satellite is planned to has two picture operation modes : automatic target pointing and interactive operation. The 1st mode will employ close loop process between Star Sensor, GPS, and the attitude control actuator. The 2nd mode is the same as the operation of LAPAN-TUBSAT, in which the video camera mode will be used to find the target, before the high resolution picture is taken.

IV. LAPAN-A3 Satellite

The objective of LAPAN-A3 satellite project is to support the national food sustainability program. Therefore the payload requirement is defined by Institut Pertanian Bogor (IPB). IPB in an academic institution that specialized in agricultural science and technology, which is awarded as national academic reference for Indonenesian food sustainability program. Based on such cooperation, the satellite is also named LAPAN-IPB satellite. The multi-spectral imager will serve the data acquisition related to crop growth/yield estimation as well as coastal environment monitoring, which are important for the food security management. The satellite is planned to be launched to SSO altitude 650 km by PSLV expectedly mid 2013.

The main payload of the satellite is a 4-band multi-spectral imaging line imager (using 4 Kodak 8023 sensor with spectral filter on 450 - 520 nm, 520-600 nm, 630-690 nm, and 760-900 nm) with 1000 mm Nikor Lens, to produce spatial resolution of 18 m, swath width of 110 km. The satellite will also carry digital camera similar to LAPAN-A2 with 1,6 m lens, so that it may provide image with 3,5 m resilution. In addition to that, the satellite will carry AIS and APRS to support global maritime monitoring mission and worldwide radio amateur community.

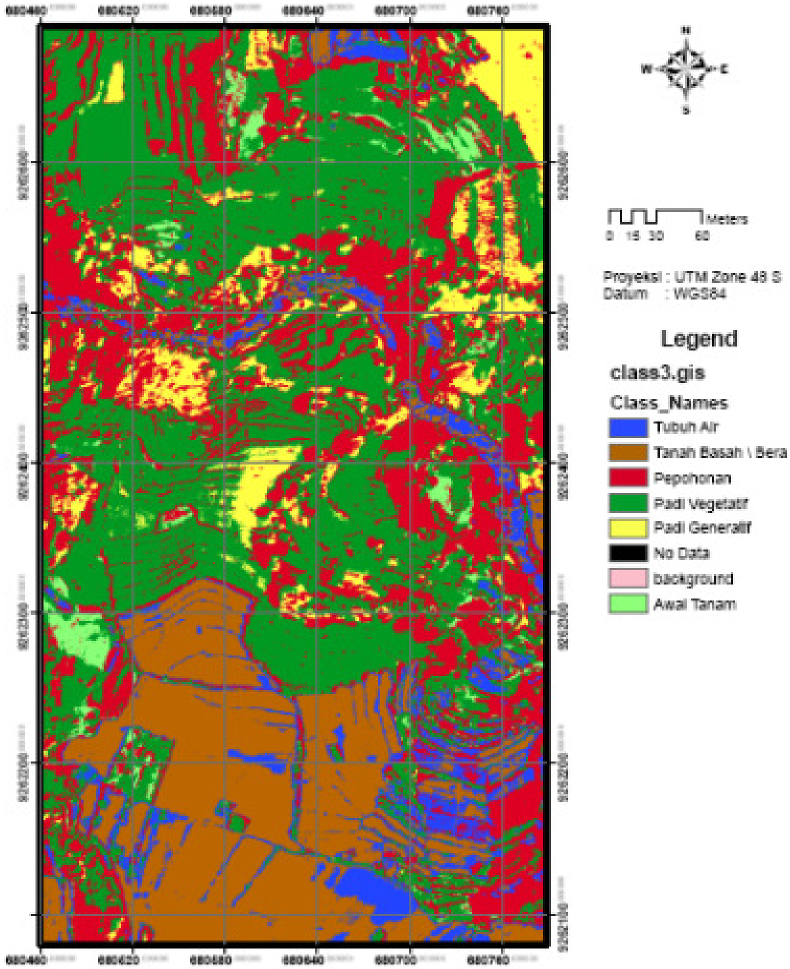

Figure 3. Multispectral imager flight test, Bogor, West Java, 2010

V. Upgrade on satellite bus

Table 1. Advancement in LAPAN's satellite bus

	LAPAN-TUBSAT	LAPAN-ORARI LAPAN-IPB
Power generation	4 Silicium solar panels (432x243 mm). Each panel has 34 cells in series, provide 14 W max power	4 GaAs Solar panels (465x262 mm). Each panel has 30 cells in series, provide 32 W max Power
Power storage	5 NiH2 batteries, configured in series. The batteries would provide nominal voltage of 12.5 V, 8 Ah capacity	3 Lithium-Ion batteries in paralel, 4 Cells per pack in series, 15 V Nominal Voltage, 17 Ah total capacity
Attitude sensor	1 CMOS star sensor	1 CMOS star sensor + 1 CCD star sensor

	4 solar panel + 2 solar cell sun sensor	6 solar cell sun sensor
Orbit determination	None	GPS
ACS mode	Manual drive mode & support anti-sun camera pointing mode (close loop main computer, -Z solar panel, and Wheel Drive Electronics	support automatic orientation of the camera to capture specific target location (close loop Star Sensor, GPS, main computer and Wheel Drive Electronics)
Payload data support	Analog data switch	solid state memory & multi-payload data handling system
Payload data transmision system	S-band analog	LAPAN-A2 : S-band analog & digital (6 Mbps) LAPAN-A3 : X-band digital (100 Mbps)

Table 1 shows that the capacity of LAPAN's satellite bus increases from its 1st generation to the next. LAPAN's 1st satellite weights around 55 kg, its 2nd generation weight arround 70 kg. Structural layout of each satellite is as follows.

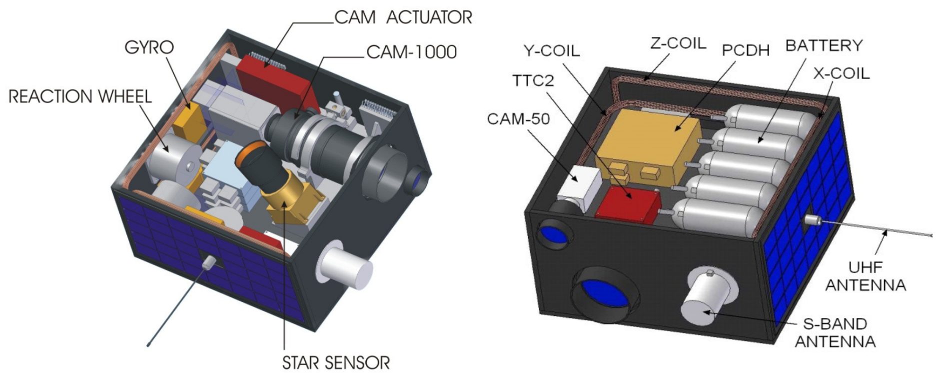

Figure 4. LAPAN-TUBSAT layout

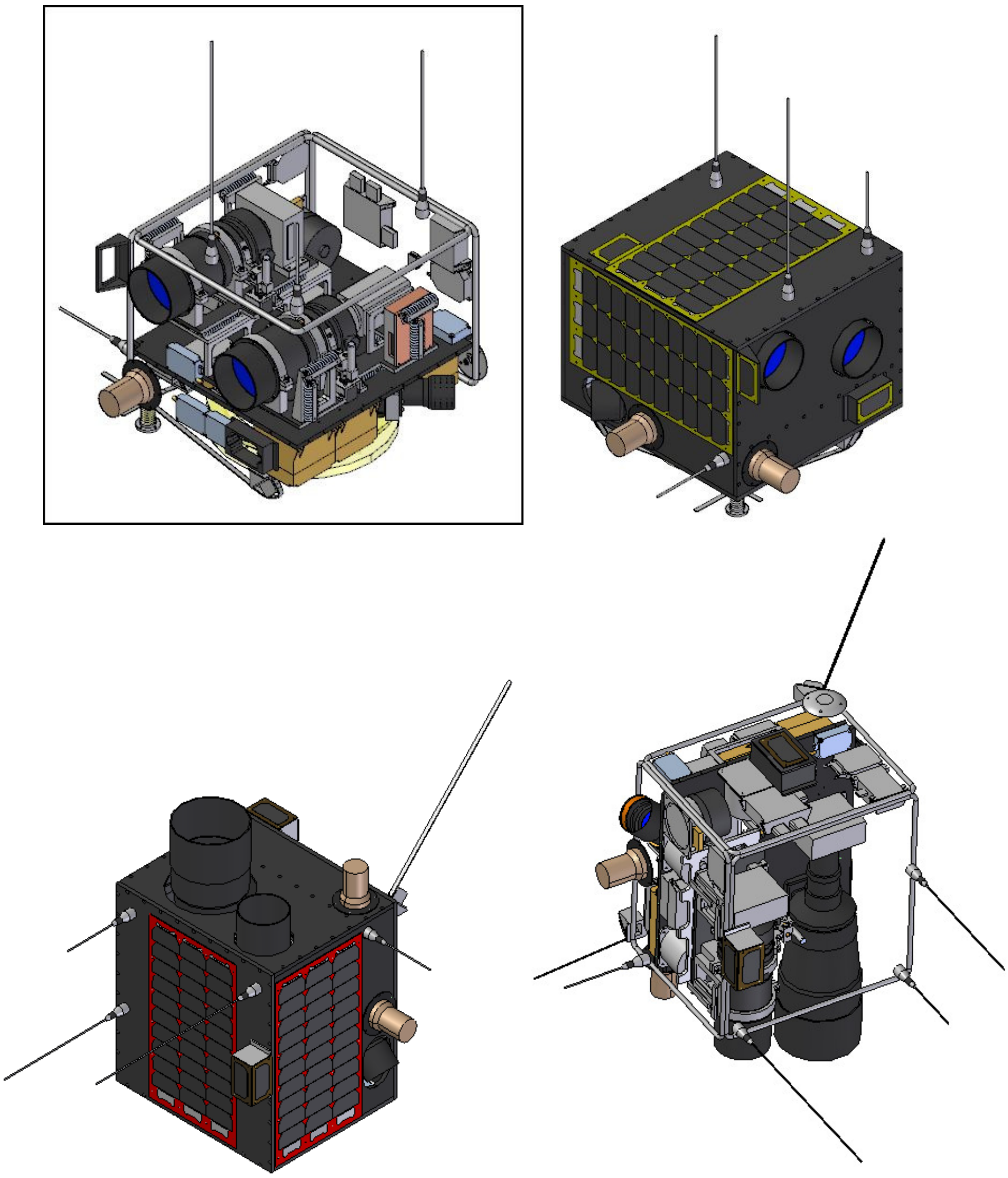

Figure 5. LAPAN-ORARI & LAPAN-IPB layout

The commonality in LAPAN's satellite buses are the mechanical packaging, i.e using the 2-shelves base, and star-configuration type computing system. Extrapolating the capacity of the Center for Satellite Technology for the next 5 years, LAPAN would be capable to develop 100 kg class satellite. Such satellite bus would be able to support battery capacity 34 Ah (at 15 V) and charging capacity 120 W, which will be able to serve more power demanding mission.

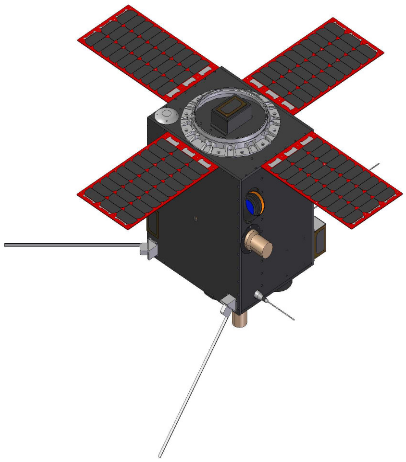

Figure 6. LAPAN's 100 kg class satellite

VI. Conclusions

From the facts above, it can be seen that LAPAN's satellite program is technology is growing, froim simple satellite for capacity building puposes to more complex satellite designed to serve more complex mission.

In developing its satellite program, LAPAN always involve partnership with other institution interestd in satellite tehnology. LAPAN will always looking for new partner, as well as maintain its current partner, to work together on its next satellite program.

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