Presented at the 18th Asia-Pacific Regional Space Agency Forum LAPAN-A2 : Indonesian Near-Equatorial Surveilance Satellite

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LAPAN-A2 : Indonesian Near-Equatorial Surveilance Satellite

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Abstract

The paper presenting LAPAN-A2 project, which is LAPAN's second microsatellite. The mission for LAPAN-A2 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. The purpose of the project is to develop capability to design, Assembly, Integration and Test (AIT) process of micro-satellite in Indonesia. The paper presents the desain of the satellite, the satellite development and operation facilities established in Indonesia, as well as the satellite operation plan.

I. Project background : Indonesian space program

In Indonesia, limited space program approach is currently chosen due to cost constrain. The Indonesia space program requirement is to utilize advance space technology and its application for sustainable development of national prosperity and resilience. Via its space agency, LAPAN, Indonesia put the effort to build its capacity in space technology, among others in satellite technology, in which the Center for Satellite Technology is in-charge.

The development of micro-satellites has become an opportunity for LAPAN in developing its space 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.

The development of LAPAN-TUBSAT, Indonesian 1st microsatellite which is also named LAPAN-A1 in internal documentation, 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.

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.

II. LAPAN-A2 Satellite

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 (video/matrix RGB camera surveillance). In addition to that the satellite carry AIS (Automatic Identification System) receiver to monitor maritime trafic, a reaction wheel made by LAPAN (LPN-001) 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).

II.1. The Satellite Bus

LAPAN-A2 bus is developed based on LAPAN-TUBSAT bus, with several enhancements, i.e :

a) Global Positioning System (GPS) receiver to acquire satellite orbital elements, since NORAD tracking service may not available for low inclination orbit. The unit will also define the exact time and position of video image capturing.
b) Redundance star sensors to acheive satellite attitude knowledge during earth observation data acquisition. 2 CCD-based Star Sensors are positioned on the satellite in 90^o direction to ensure star visibility.
c) On-board solid state memory for storage of camera payload data when taken outside ground station coverage (and transmitted later on to ground station).
d) Utilize triple junction type solar panels and higher storage capacity-to-mass lithium-ion batteries.
e) 6 sun sensors for coarse attitude determination

Other than that, LAPAN-A2 satellite bus uses the same attitude control actuator as in LAPAN-TUBSAT, which consists of 3 pairs of Reaction Wheel (RW) – Laser Gyro and 3 Air Coils.

The Attitude Determination and Control System will support automatic capturing the earth target. In such operation, the camera operation and satellite pointing maneuver will employ close loop process between Star Sensor, GPS, and the attitude control actuator, which are managed by the satellite main computer and the attitude control computer (called Wheel Drive Electronics).

The communication system in LAPAN-A2 is the same as in LAPAN-TUBSAT. Its Telemetry, Tracking and Control (TTC) uses UHF system and its payload video data downlink use S-band system.

The structural configuration of LAPAN-A2 is the same as in LAPAN-TUBSAT, i.e. box-type structure with 47 cm in length (x axis) and 50 cm (z axis) in width, which is became the baseline of the structural design. The dimension is chosen to accommodate the longest component, spacecam with 600 mm medium format Pentax lens. Like in LAPAN-TUBSAT, 2 shelves system, called upper compartment and lower compartment to fit all the components inside. The height of the upper compartment (based on its placement in launch vehicle) is the height of the lens and its mounting platform. This compartement is utilized to put all the ‘tall’ component, such as batteries. Meanwhile the lower compartments is used to placed the ‘short’ components such as the electronics. The total height of the structure is 36 cm, which left dimension for AIS's VHF antena for not exceeding the PSLV height envelope.

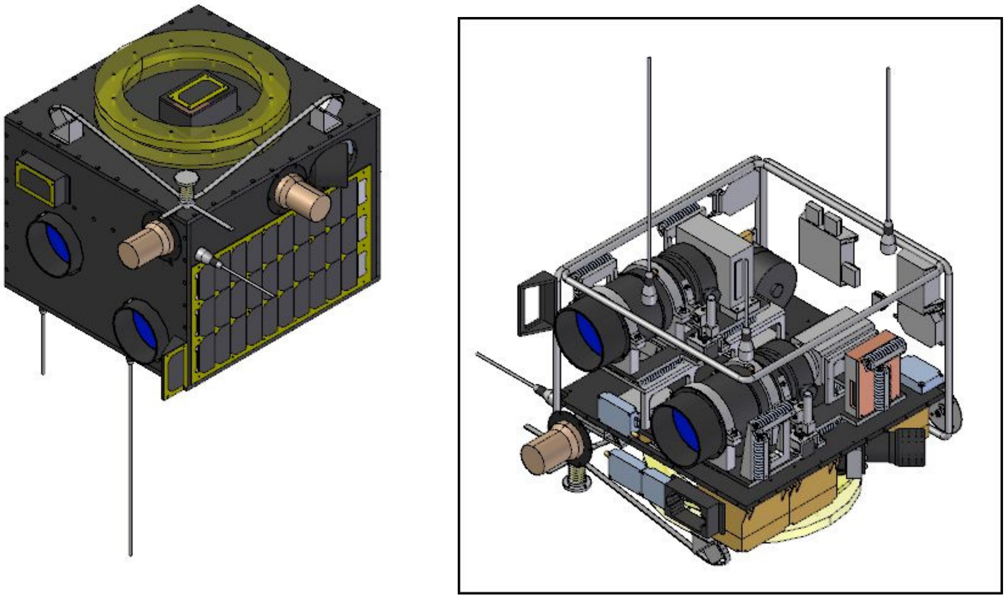

Figure 1. LAPAN-A2 structure and the placement of satellite components

II.2. The Payload

The succes of LAPAN-TUBSAT mission shows that high resolution RGB camera on satellite is very useful. In LAPAN-TUBSAT, the high resolution images has the best resolution of 5 m in 3,5 km wide of photo, which is achieved from COST 3CCD video camera and 1000 mm casegrain lens. In LAPAN-A2, the envelope is to be pushed further by utilizing medium format camera. The medium format RGB camera used in LAPAN-A2 is Theta SpaceCam with 600 mm lens. At 650 km altitude, the camera will give best resolution of 6 m and coverage of 12x 12 km (per frame). The agility of LAPAN-TUBSAT bus (ability to look off-nadir) and the high tolerance on illumination variation on the camera increase the prospect of the mission.

Figure 2. LAPAN-TUBSAT capture of Surabaya (East Java) shipyard in 2008

Indonesia is the largest archipelago in the world. Its teritorial water is about 5,8 milion km^{2} of 75% from its territory. International Maritime Organization (IMO) has defined that the sea route thru Indonesian teritory from Malaka strait down to Sunda strait is the 1st international safe passage, and the route thru Sulawesi strait down to Lombok strait as the 2nd international safe passage. Due to that, hundreds of ships passed Indonesian seas daily. The maritime traffics monitoring, at the moment, is still counting on the coastal stations and patrol boats. The range of the coastal station is typically 30 nm (56 km) and about the same for patrol boats. Therefore, the coverage for Indonesian waters is still very limited. The limitation brought many maritime law violations and reduce the safety level of Indonesian water. Therefore, the use of satellite-based maritime monitoring system is the proper solution for Indonesia.

AIS (Automatic Identification System) is a system that can monitor ships, based on GPS and VHF digital communication. It is regulated by IMO to be installed in ships weighing 300 tons and above. By placing AIS receiver on the satellite, its coverage will be larger compared to the one usually placed on the seashore by maritime authority.

The development of satellite-based AIS has been done since 2007 by the US military experimental satellite TACSAT-2. At the moment, commercial entities like Orbcomm, Com Dev, SpaceQuest dan Kongsberg Seatex has developed satellite AIS receiver. SpaceQuest has flown AprizeSat 3 and 4. Orbcomm has provided global AIS system, after its join development with US Coast Guard. Kongsberg Seatex in cooperation with Norwegian Defence Reasearch (FFI) has flown

AISSat-1. The sama payload has only ben tested in *European Space Laboratory* at *International Space Station* (Columbus AIS program). The similar AIS will also be flown in LAPAN-A2. The payload is expected to be able to data capture 2000 ships in its maximum coverage of 100 km swath.

Indonesia is unfortunately experience many natural disasters, susch as earthquakes, tsunamy, volcano eruption, and floods. Experince shows that during disaster or in its immediate aftermath, communication infrastructure is often damaged, and therefore, limits the abality to coordinate the aid effort. Satellite based telecommunication system is usually the only means of communication. In this light, LAPAN-A2 carry amateur radio short text messagerepeater (APRS) and voice repeater. The Automatic Packet Reporting System (APRS) and the voice communication payload is developed by LAPAN using the heritage of LAPAN-TUBSAT UHF/VHF radio and COTS APRS modem. The amateur radio payload primary application is a for communication use in disaster mitigation and relief efforts.

II.3. Development facilities

In order to develop (asembly, integration and test / AIT) LAPAN-A2 in Indonesia, several facilities need to be established. One of the critical facilities for satellite AIT is structural dynamics (vibration) laboratories. In 2009, LAPAN upgraded the vibration laboratories at Sentra Teknologi Polimer, BPPT, in Tangerang. The laboratory is initially used to test automotive components. The upgrade has made it possible to measure natural frequencies and provide dynamics loading to 100 kg class satellite as per reqirement of satellite launcher.

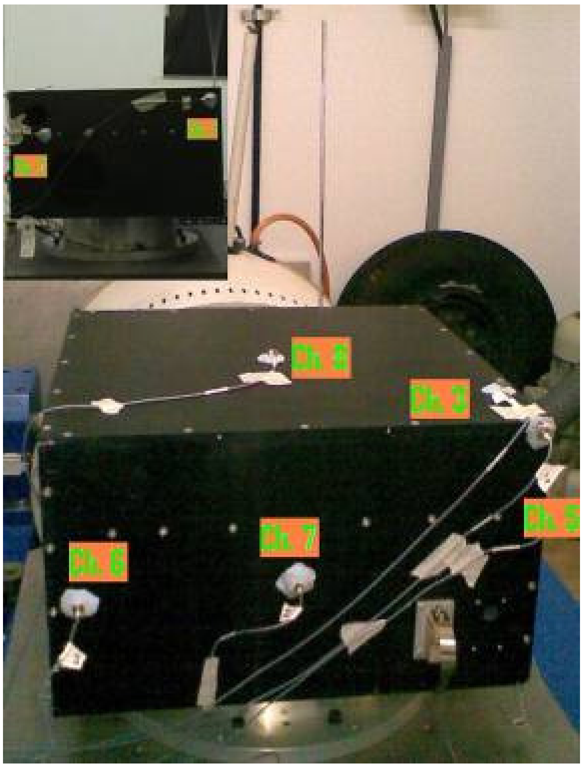

Figure 3. Qualification Test of Micro-Satellite Vibration Test Facilities

The AIT process will involve mechanical and electrical integration. Therefore, facilties like in-house manufacturing facilities is established at LAPAN's Center of Satellite Technology in Rancabungur, Bogor.

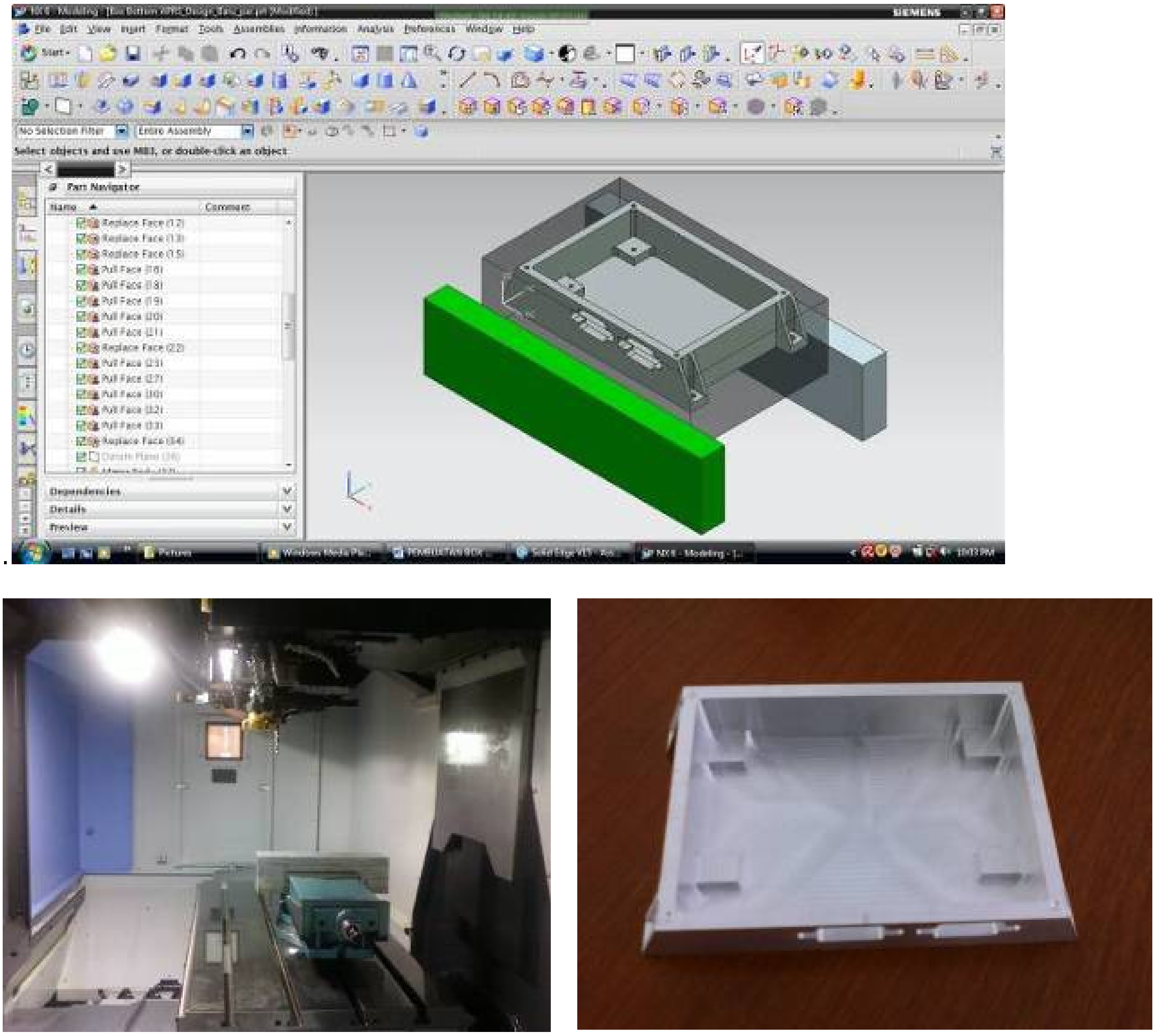

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Figure 4. The manufacturing of APRS mechanical packaging

II.4. The Satellite Operation Plan

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.

In the early orbit phase the satellite will be operated at open loop or interactive mode for characterization. After the characterization process is completed the satellite will be run at closed loop or automatic as normal mode.

In addition to the operation mode, like in LAPAN-TUBSAT, LAPAN-A2 also has its hibernation (tumbling) mode for its maintenance purposes.

LAPAN-A2 satellite will be launched as auxiliary payload on Indian Space Research Organization (ISRO) Polar Satellite Launch Vehicle (PSLV) Astrosat mission at 2nd semester of 2012. The orbit will be at 650 km altitude and at 8^{o} inclination.

LAPAN is currently operating a network of ground stations to operate LAPAN-TUBSAT. It consist of ground station in Rumpin and Rancabungur (Bogor), Bukittinggi (West Sumatra), Pontianak (West Borneo)and Biak (Papua). In the network, Rumpin is the main control station. In addition as research ground station, Rancabungur function as back-up for Rumpin, to ensure the reliability of Western Indonesia coverage. A self-made receiving antenna is installed in Bukittinggi, to cover the far Northwest of Indonesia such as Aceh province. Another self-made receiving antenna is installed in Pontianak and Biak, to cover the satellite operation in Central and Eastern part of Indonesia. In the future, another station will be established in Pare-pare, Celebes, to further cover central part of Indonesia.

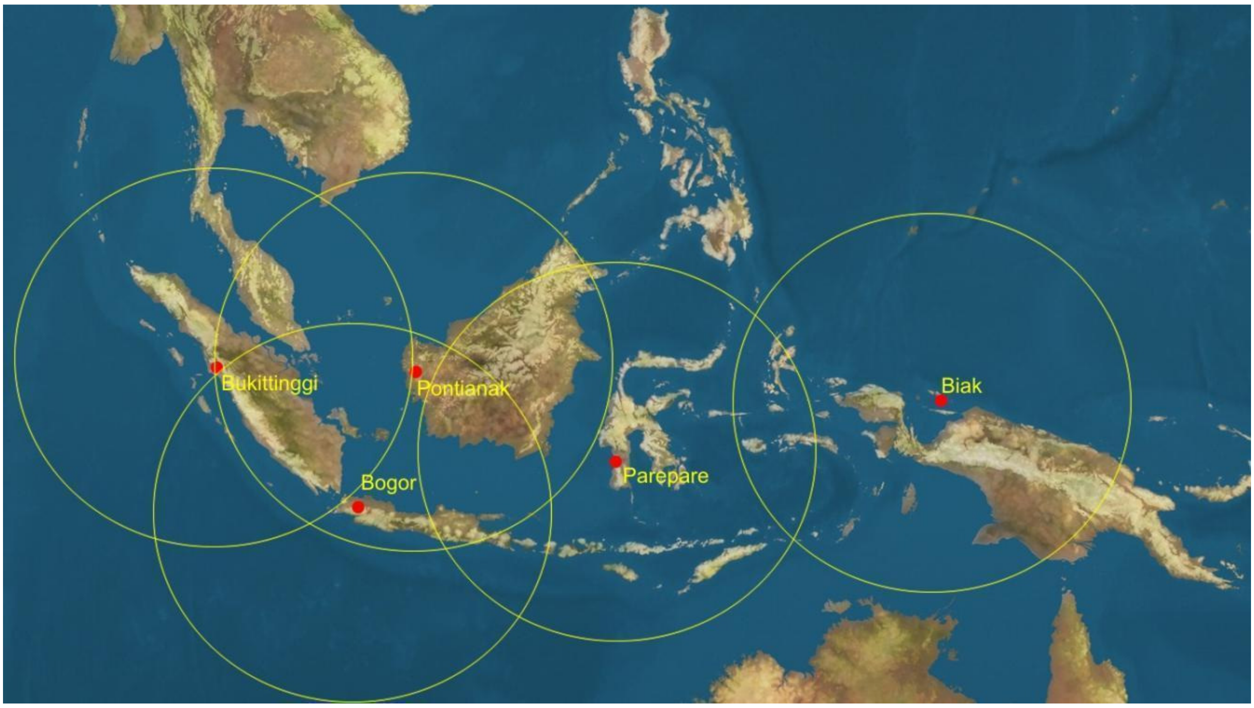

Figure 5. Location of LAPAN's ground station

Figure 6. LAPAN's micro-satellite groundstations

Table 1. Access time of LAPAN's groundstation for Satelit at Equatorial Orbit with 8^{o} inclination

	Total Durasi Acces (min)	**Number of contact with duration > 13 min**
Bukittinggi	197	14
Rumpin/Rancabungur	191	10
Pontianak/Biak	197	14

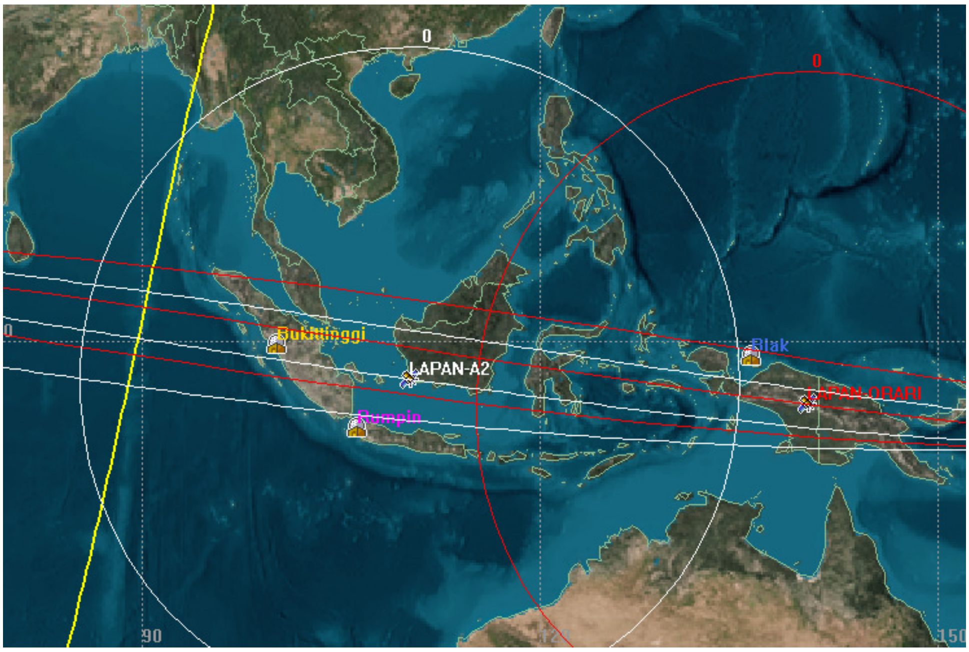

Figure 7. Prediction of LAPAN-A2 passes over Indonesia

III. Conclusions

LAPAN-A2, the microsatellite that will be launch at low-Earth, near-equatorial orbit is an ideal vehicle to conduct surveilance for Indonesia, which has wide teritory along the equator. The satellite will pass Indonesian teritory every 97 minutes for the mostly contact maximum duration. The surveilance missions are conducted by the RGB camera and AIS receiver. In addition to that, LAPAN-A2 has the ability to provide emergency communication mission using amateur frequency. LAPAN-A2 will become the 1st satellite with camera, AIS, and APRS payload that will fly in near equatorial orbit.

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