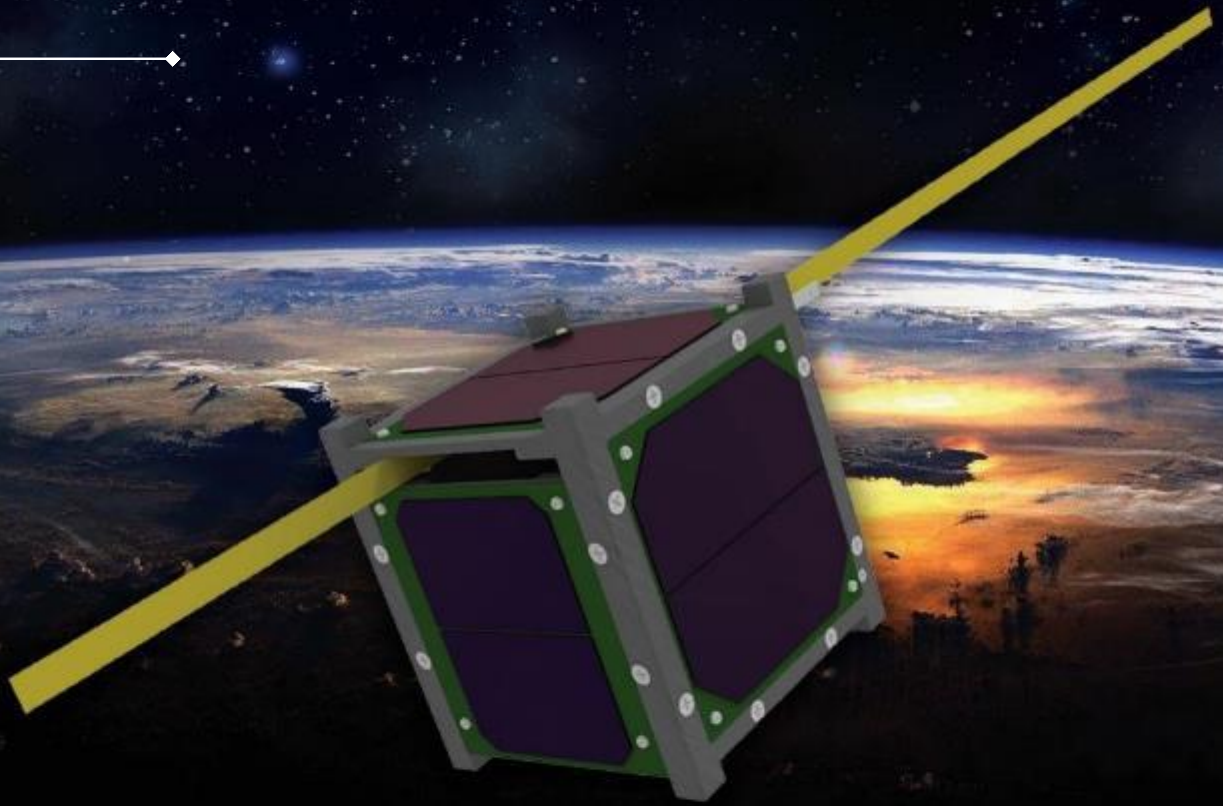
SURYA SATELLITE - 1 / SS-1

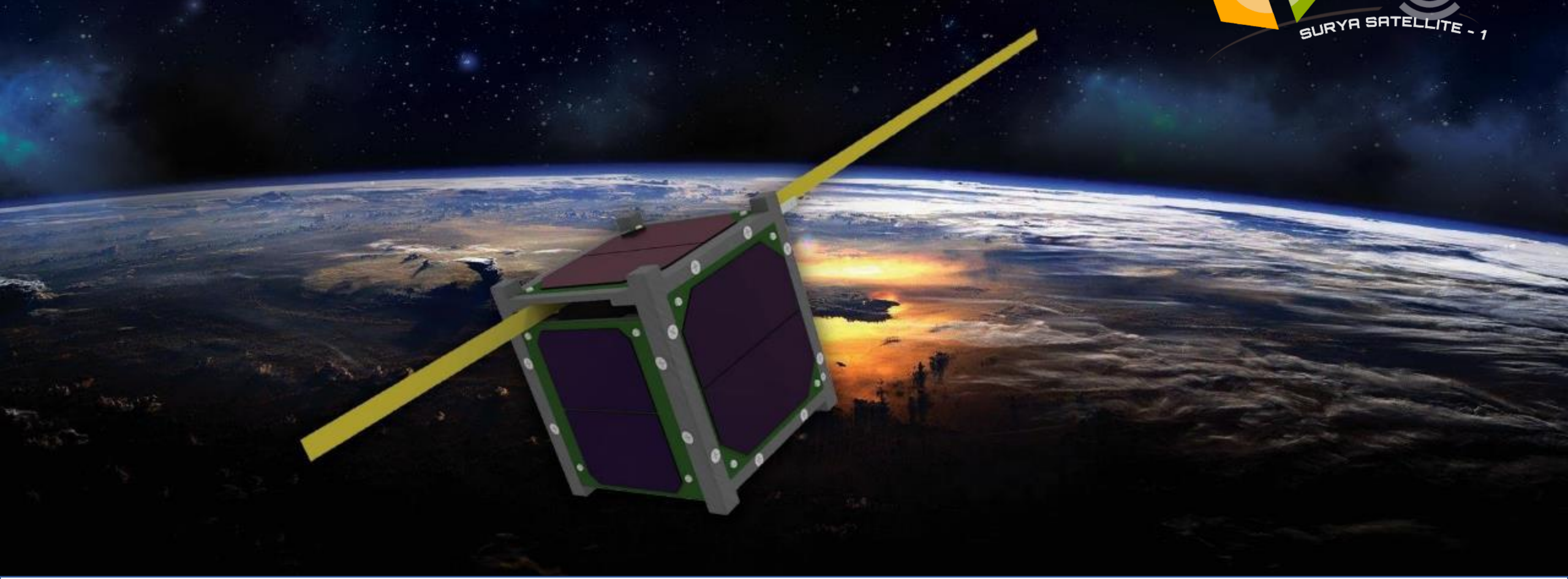
FINAL REPORT

December 2023



Contents

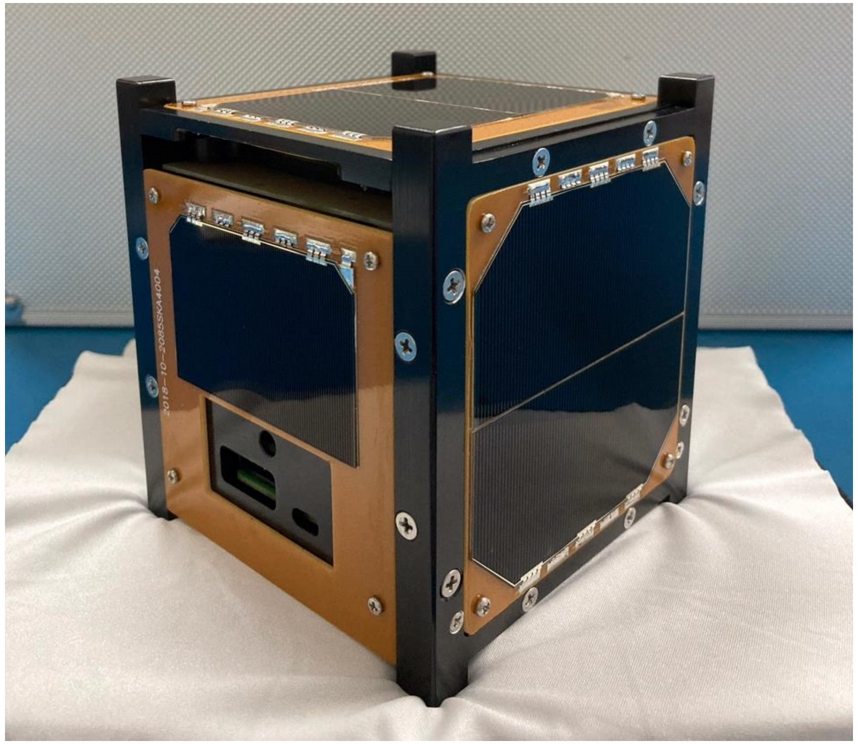
PROJECT BACKGROUND



Background

- SS-1 is an initiative to build the first Indonesia Nano Satellite by Students in Surya University
- The project aim to develop satellite technology and give long-range communication service from space
- To disseminate space utilization awareness to public commercial and academics in Indonesia

Surya Satellite 1



Mission

Surya Satellite is the first nanosatellite developed by Surya University students. It aims to demonstrate a two-way text message communication payload for amateur radio enthusiasts.

Objectives

Objective	Nature	Priority
Satellite able to beacon APRS data	Technical, Scientific	minimum/primary
Satellite able to digital repeating	Technical	half/primary
Apply satellite for remote communication and scientific data collection from remote stations or disaster mitigation	Technical	full/secondary
Improve education on satellite development in Indonesia, especially nanosatellite technology	Social	full/primary

Stakeholders

SURYA UNIVERSITY

BRIN
BADAN RISET DAN INOVASI NASIONAL

INASA
INDONESIAN SPACE AGENCY

PSN

AMSAT-ID

KOMINFO

ORARI
Organisasi Amatir Radio Indonesia
Indonesia Amateur Radio Organization

PS PUDAK SCIENTIFIC

Stakeholders – Regulatory

ORARI
Organisasi Amatir Radio Indonesia
Indonesia Amateur Radio Organization

- Indonesia Amateur Radio Organization (ORARI) is the administrator of IARU registration and frequency coordination

KOMINFO

- The Ministry of Communication and Information Technology (KOMINFO) is the administrator of ITU registration and frequency coordination

INASA
INDONESIAN SPACE AGENCY

- The Indonesian Space Agency (INASA) is the administrator of the Space Object Registration in Indonesia

Stakeholders – Technical Assistance

- The National Research and Innovation Agency (BRIN) helped SS-1 with its expertise in small satellite engineering and Assembly, Integration, and Tests (AIT) equipment and facilities.

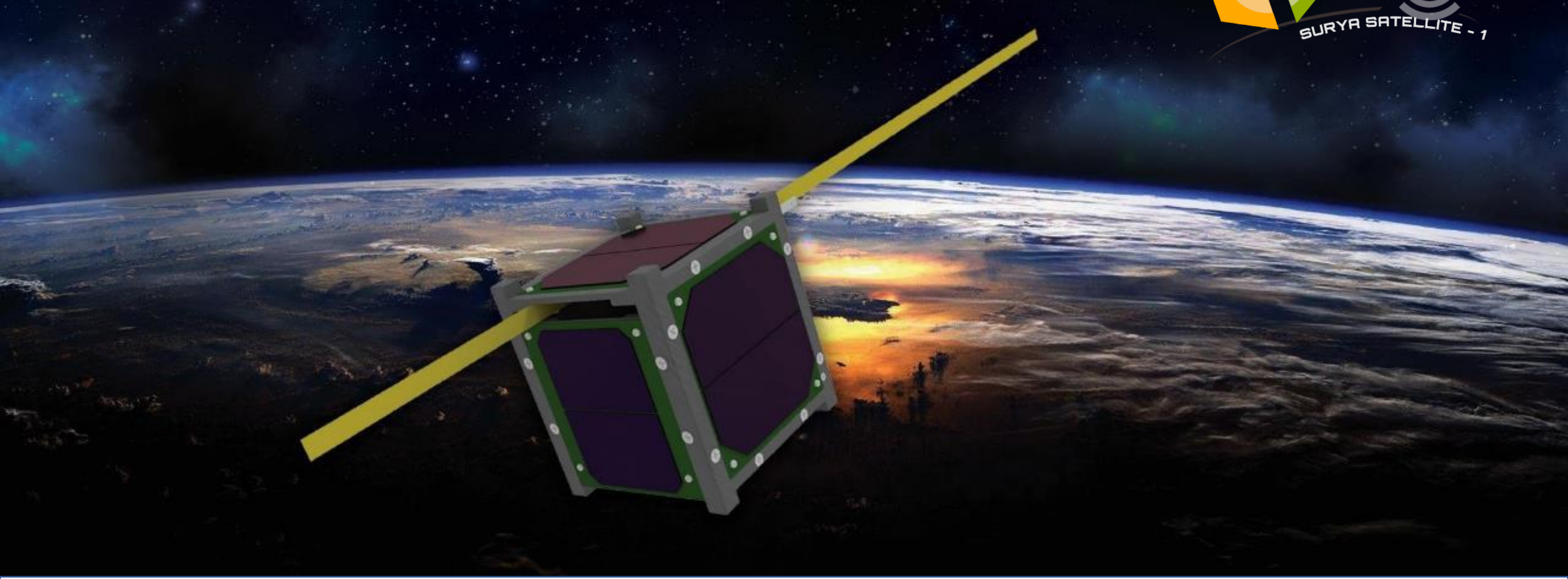
- The Indonesia Amateur Satellite Community (AMSAT-ID) under ORARI helped SS-1 with ground system engineering and tracking the satellite after its deployment.

Stakeholders – Private Sponsor

- PT. Pasifik Satelit Nusantara (PSN) is the first and the biggest private satellite operator in Indonesia. PSN sponsored SS-1 solar panel and ground station. PSN manpower is also crucial in the ground station procurement and construction. Moreover, they also contributed to the shipment, handover, and the publication of SS-1.

- PT Pudak Scientific is a precision manufacturer of various laboratory equipment and industrial parts. They sponsored the manufacturing of SS-1's structure, which is essential in its development.

MAJOR MILESTONES



SS-1 MAJOR MILESTONES

2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023


Workshop with ORARI, Tangerang


Mock-up Model

Project Initiation

Project was initiated after a Workshop with Indonesian Amateur Radio Organization (ORARI) held in one of Surya University's research center. The workshop is hands-on to build an in-house Ground Station to communicate with Amateur Radio satellites. After a successful in-house Ground Station, ORARI then challenged the students to build an in-house satellite. The initial members who joined the initiative were 14 students from the Department of Physics Engineering and the Department of Computer Science.

First Mockup Model

The first mockup model was built in the Center for Robotics and Intelligent Machine (CRIM) at Surya University. The design did not follow any launchers ICD.

ORARI Organisasi Amatir Radio Indonesia Indonesia Amateur Radio Organization

SURYA UNIVERSITY

SS-1 MAJOR MILESTONES

2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023

APRSAF 2016, Manila

BRIN Facility, Bogor

Indonesia's Ministry of Communication and Information, Jakarta

Initial Step: Networking

The team explored networking in the space industry to fine-tune the initial step for starting a nano-satellite project.

APRSAF 23rd

The SS-1 team had a chance to present at APRSAF 23rd 2016, Manila, and deliver the project's initiation. From there, they received the first information about the KiboCube program.

BRIN - Satellite Technology Center

Visit BRIN's (formerly known as LAPAN) Research Center for Satellite Technology as the first entity to build an in-house satellite from Indonesia. The team received the support of experts and testing facilities.

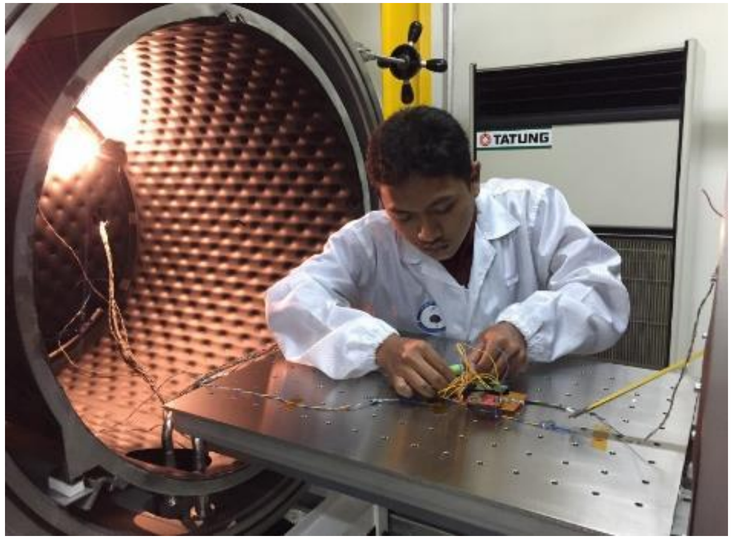
MoCIT of The Republic of Indonesia

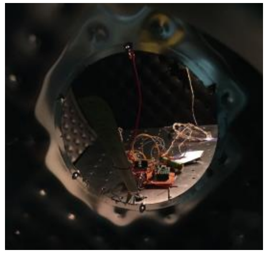
The team had an audience with the Minister of Communication and Information—Indonesia to seek regulatory support. Since it was the first satellite built by a non-commercial entity, a relaxation in the regulation or even a new regulation is needed.

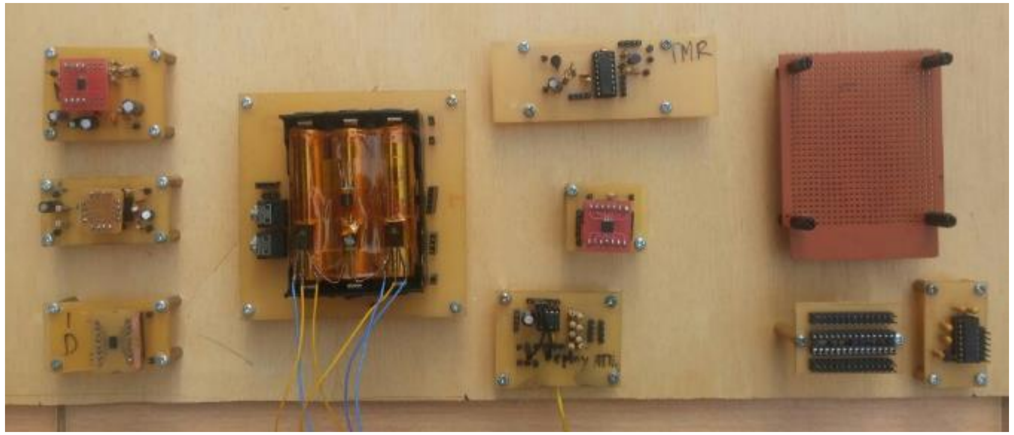
KOMINFO INASA INDONESIAN SPACE AGENCY BRIN BADAN RISET DAN INOVASI NASIONAL

SS-1 MAJOR MILESTONES

2016 | **2017** | 2018 | 2019 | 2020 | 2021 | 2022 | 2023







Satellite Sub-System Development, – BRIN Facility Bogor (2017)

Pre-EM Structure

This year, the team started building the satellite by developing the first structure pre-engineering model and simulating the CAD model using Computational Solid Mechanics software guided by BRIN's expert.

Structure Manufacturing

Finding a manufacturer with the capability to mill the tiniest feature of SS-1 is challenging. The team chose the best CNC milling workshop in the city. The result of the SS-1 model could represent the big feature, but the finishing and detail did not satisfy our requirements. Later, we approached PT Pudak Scientific, an industrial-scale manufacturer in Bandung, for the next model.

COTS-based Subsystem

Along with the mechanical aspect, the team also developed the subsystems starting from bread board and PCB model. SS-1 used COTS components in the development, which do not have any space qualification. Consequently, the team tested some of the subsystem in the Thermal Vacuum Chamber (TVAC) to verify the endurance of the components in space environment.

SS-1 MAJOR MILESTONES

2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023

MOU with PT.PSN

LISAT 2017, Bogor

Solar Panel Sponsorship

In 2017, Surya University and PT. PSN signed a Memorandum of Understanding about supporting LEO satellite development and operation. Starting from this point, PT. PSN sponsored the procurement of SS-1 solar panels from a China satellite manufacturer. In addition, the cooperation also included the enrichment of Indonesian youth capability in satellite engineering.

First Scientific Publication

As the progression of the SS-1 PCB model, the members also wrote three publications and presented them in the International Symposium on LAPAN-IPB Satellite 2017 (LISAT 2017) at Bogor. The topics published are the overall system engineering, structure requirements and design, and the Electronic Power Subsystem of the SS-1.

SS-1 MAJOR MILESTONES

2016 | 2017 | **2018** | 2019 | 2020 | 2021 | 2022 | 2023

Cooperation Agreement with BRIN

The International Amateur Radio Union

Since 1925, the Federation of National Amateur Radio Societies
Representing the Interests of Two-Way Amateur Radio Communication

Hans P. Blondeel Timmerman, PB2T
Satellite Advisor
Nieuwe weg 21, 4031 MN Ingen, Netherlands
Email: satcoord@iaru.org

Date: 10 September 2019

To Suhandinata YD1XBG

Dear Suhandinata,

In response to your request dated 1 August 2019 the IARU Satellite frequency coordination panel coordinated the following frequencies for **Nusantara-SS1-A (aka Surya Satellite-1)**.

- for APRS digipeater up- and downlink 145.825 MHz with emission designator 16K0F2D, EIRP 31.3 dBm
- for TT&C up- and downlink 435.825 MHz with emission designator 16K0F2D, EIRP 31.3 dBm

Filing Notification

BRIN Cooperation Agreement

The Cooperation Agreement between Surya University and BRIN – Pusristeksat (Research Centre for Satellite Technology) had finally signed in early 2018. The agreement allows the expertise advisory from BRIN to SS-1, the manufacturing and testing facility usage for CubeSat development and joint scientific publication.

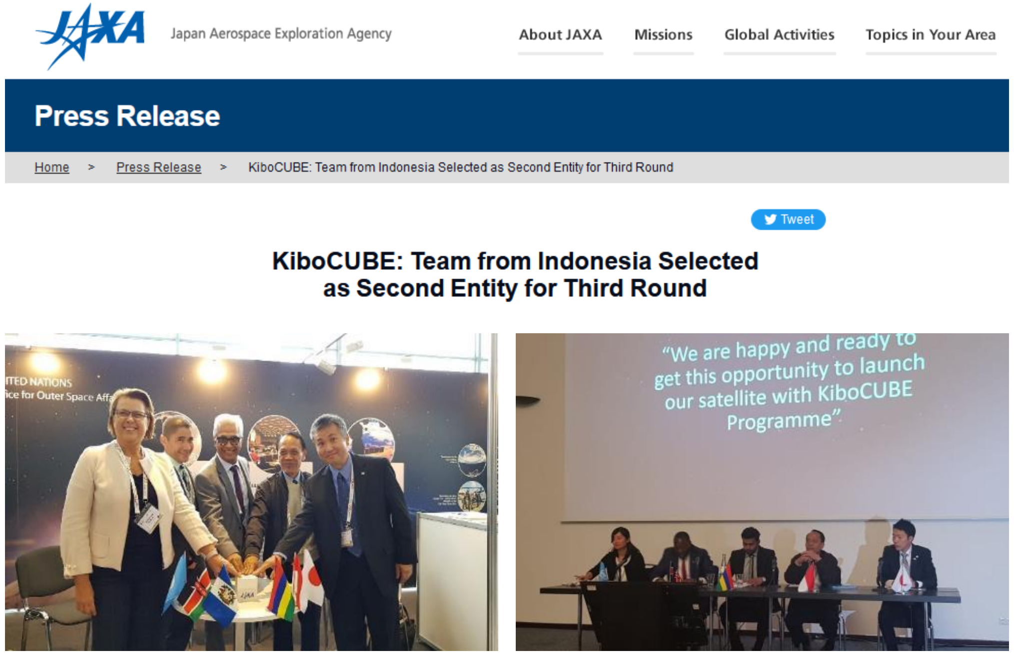
Regulatory Filing

The SS-1 satellite filing had been published in the ITU (API-A) under the name Nusantara-SS-1-A. The team then started the regulatory coordination with support from IARU. Completing the filing was also a challenging part of this project. As engineering students, we found International Radio Regulation to be a new exploration area. The filing could have been difficult without much back-and-forth support and intense communication with KOMINFO and ORARI.

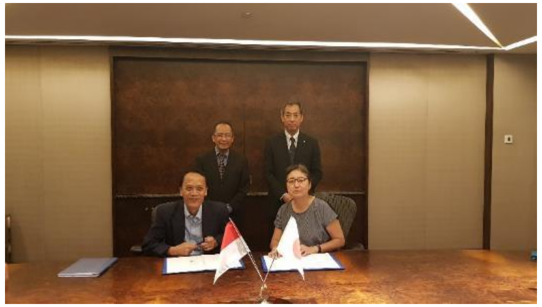
ORARI Organisasi Amatir Radio Indonesia
Indonesia Amateur Radio Organization
KOMINFO
INASA INDONESIAN SPACE AGENCY
BRIN BADAN RISET DAN INOVASI NASIONAL

SS-1 MAJOR MILESTONES

2016 | 2017 | **2018** | 2019 | 2020 | 2021 | 2022 | 2023



KiboCube Award at IAC 2018, Bremen



APRSAF 2018, Singapura

Proposal Submission

In early 2018, SS-1 submitted a mission proposal for Administration for the KiboCube Competition. Before submission, the proposal had been peer-reviewed with local partners such as BRIN and PSN.

KiboCube Announcement

In September, UNOOSA and JAXA announced that SS-1 was selected as the awardee as the second entity of the 3rd round of the KiboCube program.

Awarding Event

The awardee gathered in the IAC 2018, Bremen, Germany, for the official event for the Satellite Launch slot award

Agreement Signed

The MoU between Surya University and JAXA was finally signed at APRSAF 2018, Singapore

SS-1 MAJOR MILESTONES

2016 | 2017 | 2018 | **2019 | 2020** | 2021 | 2022 | 2023

Meeting with JAXA – BRIN Facility Bogor (2019)

Technical Meeting with JAXA

- In March 2019, the first technical meeting was held between the SS-1 team and the JAXA contractor in the BRIN Satellite Technology Center. It was the first time when JAXA introduce about the work that the SS-1 team need to be done during the program and that they will assist the team to achieve every requirements.

- The meeting was to assess and guide the design of the satellite to meet JSSOD's requirements. SS-1 presented the initial design of the satellite on paper and the early physical prototype, while JAXA asked questions and collected detailed information.

- A list of launch documents was presented, and the first template was provided for SS-1 to complete the drafts. After that, the completion of the documents was monitored remotely by electronic means and regular meetings.

SS-1 MAJOR MILESTONES

2016 | 2017 | 2018 | **2019 | 2020 |** 2021 | 2022 | 2023

PUDAK Scientific, Bandung

Structure Manufacturing Agreement

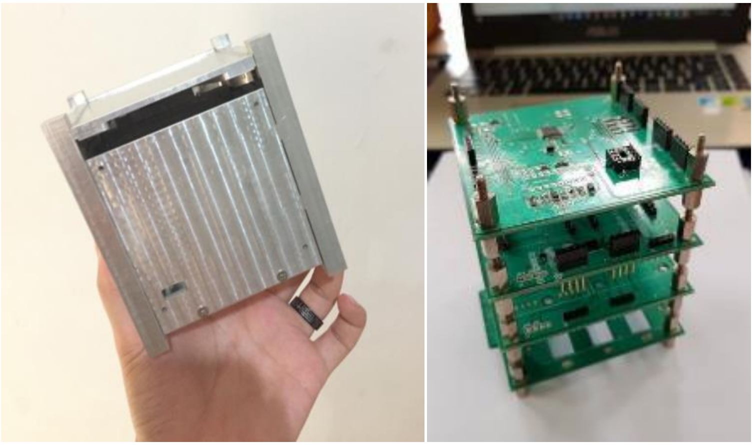
- SS-1 signed an agreement with PT. Pudak Scientific, a precision manufacturing company that is certified for aerospace use, has become a sponsorship agreement.

- SS-1 also sent a plate of aluminum series 7075 to their workshop for the manufacturing of SS-1 structure for the Engineering Model and Flight Model

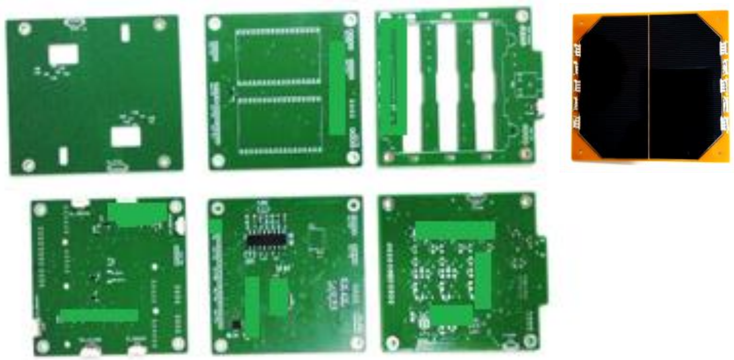
- The manufacturing consists of six pieces of structure, a couple of mechanical parts of the antenna deployer, and an anodized coating of the structure.

SS-1 MAJOR MILESTONES

2016 | 2017 | 2018 | **2019 | 2020** | 2021 | 2022 | 2023



SS-1 Engineering Model



Flight Model PCB and Solar Panel

2019 – PoC of Subsystem and Solar Panel

- After the proof of concept at the subsystem level, the procurement then started for the PCB Engineering Model and Flight Model PCB
- Meanwhile, the Solar Panels were handed over from PSN to SS-1. The system consists of six GaAs triple junction solar panels. Each panel is equipped with two parallel cells and a safety diode.

2020 – Launch Document and Start Assembly

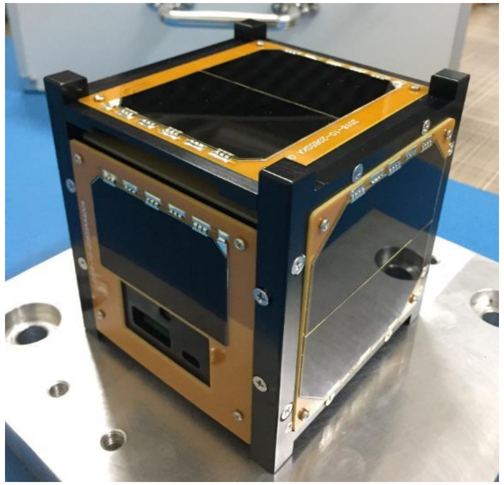
- SS-1 has completed the Launch Documents of Phase 012 and submitted to JAXA
- Once the satellite subsystems of Engineering and Flight models are completed, then the satellite assembly is initiated

PSN PUDAK SCIENTIFIC

SS-1 MAJOR MILESTONES

2016 | 2017 | 2018 | 2019 | 2020 | **2021** | 2022 | 2023

BRIN Facility Bogor (2021)



Subsystem Testing

In this year, most of the time was spent by working on the AIT of SS-1 alongside the JAXA's phase 3 documents. The team tested some of essential subsystem, such as the solar panel, battery, heater, antenna deployer, APRS payload, and the electrical inhibit.

Assembly and Integration

In parallel with those tests, the SS-1 Flight Model (FM) manufacturing was also progressing. After the team received the structure from PT Pudak assembled it for the first time in the BRIN facility to check whether the structure panels perfectly fit each other. After ensuring the fit, the structure was processed again at PT Pudak for anodized surface finishing.

Launch Documents Phase 3 Completion

Completing the phase 3 documents from JAXA was another challenge. The team was juggling their time between works and finishing the satellite tests and writing the report. They were fully work in BRIN's facility during this period. In addition, they keep a close contact with JAXA during this phase to ensure they can fulfill the expectation of JAXA documents.

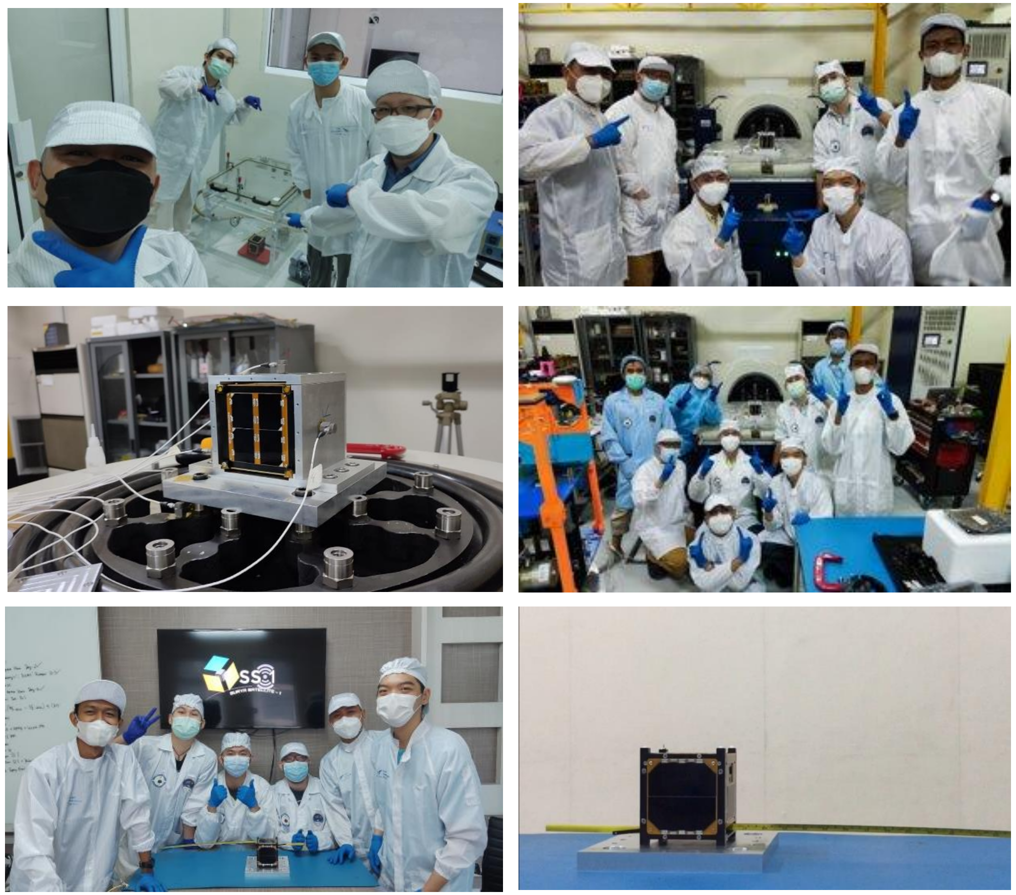
Final Assembly

After a long campaign to finish the subsystem tests, the team completed the Flight Model of SS-1. The final assembly can be seen in the picture at the bottom right.

BRIN
BADAN RISET
DAN INOVASI NASIONAL

SS-1 MAJOR MILESTONES

2016 | 2017 | 2018 | 2019 | 2020 | **2021** | 2022 | 2023



BRIN Facility Bogor (2021)

Satellite Assembly, Integration & Test

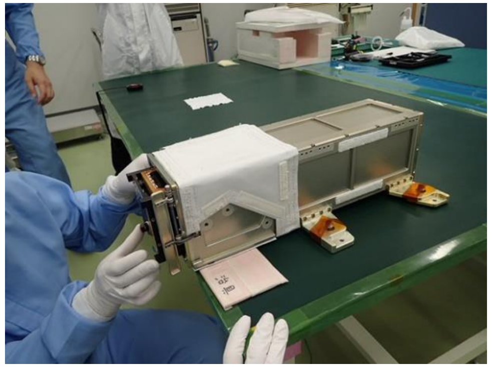
- The space environment is unfriendly. To ensure the survivability and functionality of the SS-1 in space, the team did an environmental tests campaign, which consisted of the vacuum chamber, thermal chamber, and vibration tests.

- The thermal chamber and vibration tests were the most challenging. Creating the procedure and test setup required tedious work and is the most important part of the test. Once the tests are running, there is always a risk that they can damage the satellite. Therefore, creating a good procedure and setup is the way to minimize the risk of damaging the satellite and ensure the test data we collected is valid.

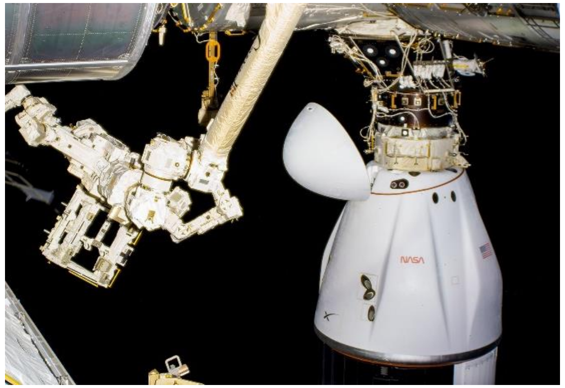
- After weeks of the test campaign, the team concluded that the satellite could survive the environment and function well.

SS-1 MAJOR MILESTONE

2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023

Tsukuba Space Centre, Japan

SpaceX CRS-26

Handover to JAXA

The SS-1 handover to Tsukuba Space Center, Japan, lasted from June 29, 2022, to July 8, 2022. During this critical phase of the mission, the team meticulously ensured the proper transfer and integration of the satellite with the facilities and procedures at the Tsukuba Space Center. This process included thorough checks, testing, and coordination with the experts from JAXA to meet the stringent requirements for the upcoming launch. The dedication and expertise of the team members were instrumental in guaranteeing a successful handover and preparing SS-1 for its journey to space.

Launch to ISS

SS-1 was successfully launched as part of the cargo on board the SpaceX Falcon 9 CRS-26 into the International Space Station on November 26, 2022, at 19:20 hours (UTC). The launch marked a significant milestone for Indonesia's space exploration program. The Falcon 9 rocket delivered a range of payloads, including SS-1, to the designated orbit, further showcasing the versatility and reliability of the launch vehicle. This achievement contributed to expanding the presence of nanosatellites in space and fostered international recognition of Indonesia's capabilities in space technology and research.

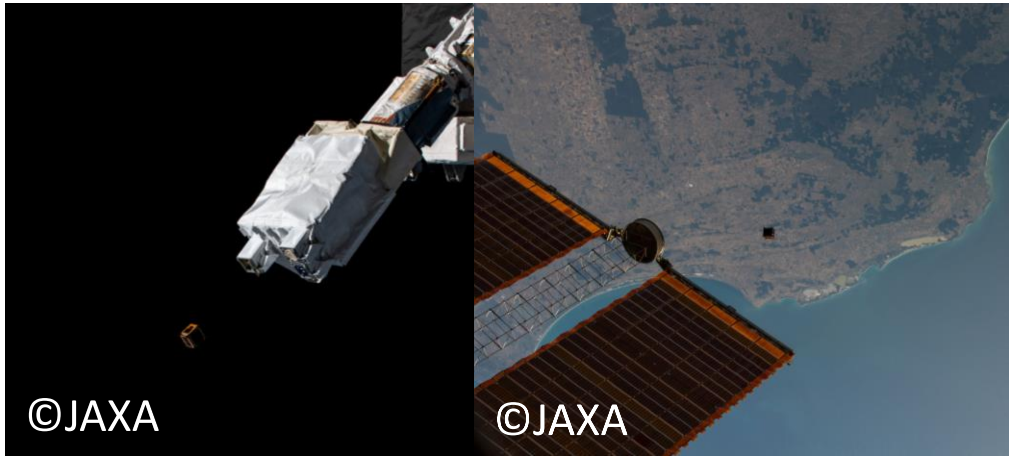
SS-1 MAJOR MILESTONE

2016 | 2017 | 2018 | 2019 | 2020 | 2021 | **2022 | 2023**

SS-1 Ground Station

2022 Ground Station Preparation

To ensure SS-1 first signal acquisition a network ground station established with a total of 33 ground stations all over Indonesia. Each GS have been tested to at least 5 satellites operating in VHF or UHF frequency (LAPAN-A2, ISS, Athenoxat-1, Galassia, CAS 4A/B).

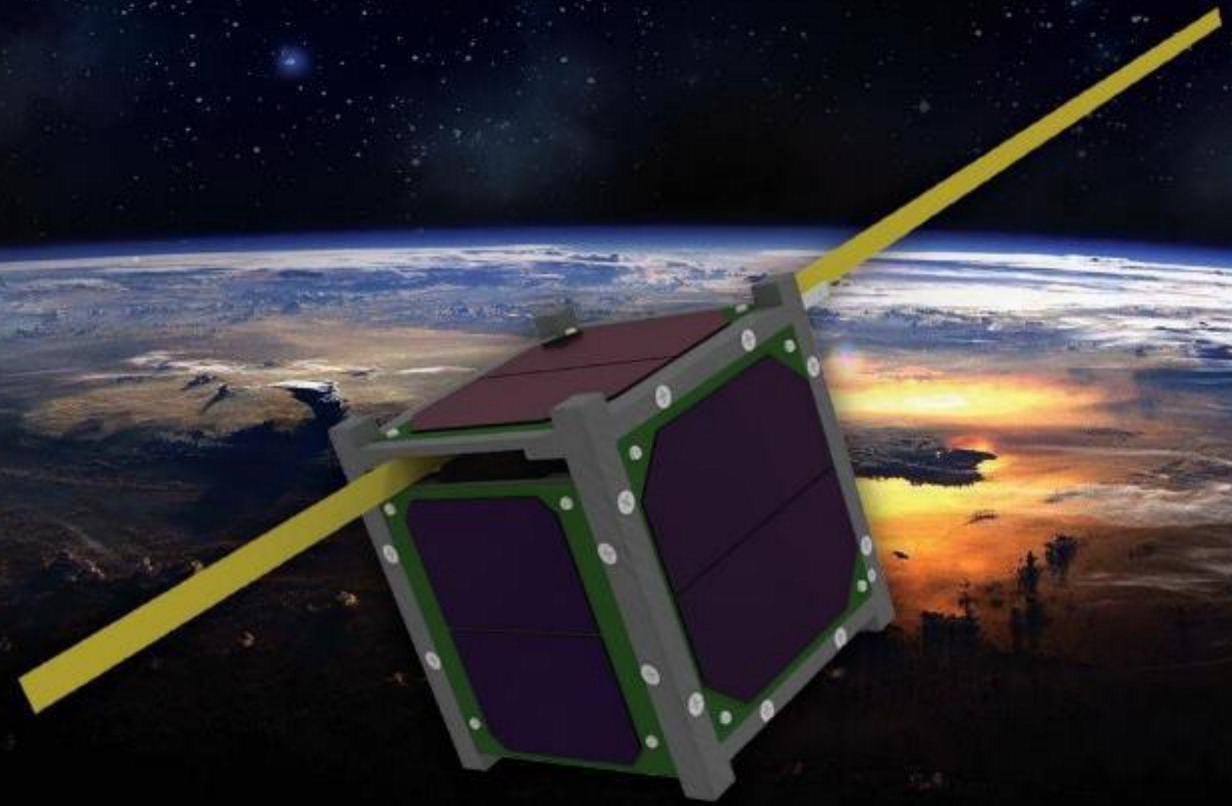


SS-1 Deployment from International Space Station

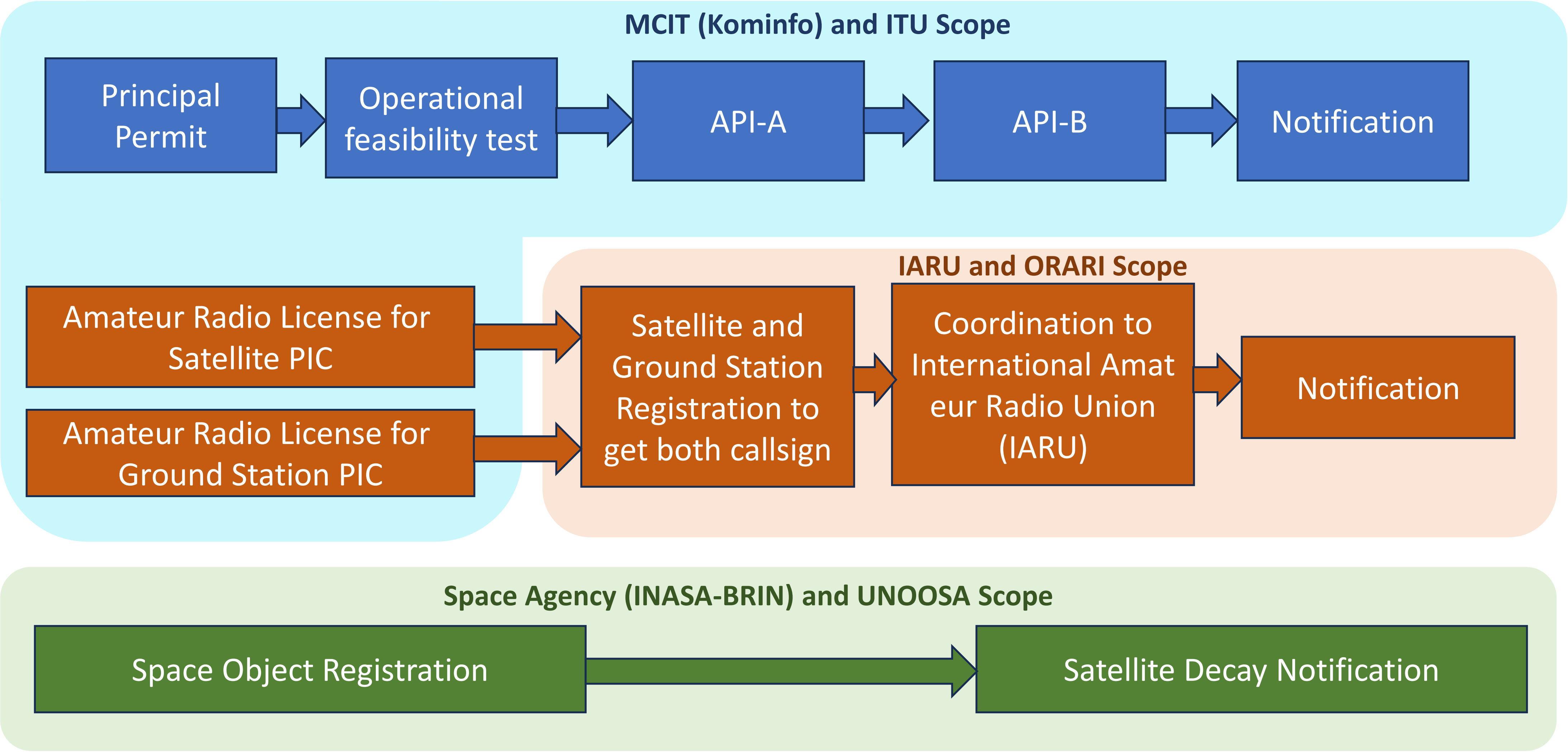
Deployment from the ISS on 6 Jan 2023

The next crucial phase of SS-1 was the deployment from ISS. The J-SSOD released SS-1 in a backward direction and 45o downward from the ISS. This ensured the satellite would not be conjunct with the ISS within the next orbit. As the J-SSOD executed the deployment successfully, the tracking activities of SS-1 were begun.

REGULATORY AND COMPLIANCE



Regulatory Flow



Regulation Compliance Challenge

- The SS-1 case is the first time the Indonesian government has proceeded with filing submissions from the university body. Moreover, it is in an amateur band.
- On the other hand, the SS-1 Team is the first timer to submit a filing application and all those regulation processes. Both regulatory bodies and the SS-1 team should re-figure the regulation path to be taken.
- Again, since it’s the first time, no one was to be asked in university, no amateur radio license, unstable university organization (such as changes of address, and others)
- some of the requirement documents are unsynchronized. We should be proactive in seeking out solutions.

Regulation Compliance Process

Collaboration with Regulatory Bodies in advance: Actively establish communication channel with the relevant regulatory authorities such as Ministry of Communication and Informatics (Kominfo), IARU Region 3, Local Amateur Radio Organization (ORARI), Space Agency (BRIN-INASA). This could provide direct insights into the compliance requirements and offer a platform for addressing queries or concerns.

Kominfo assists us with the submission and coordination of the filing process internationally. Members of ORARI and IARU Region 3 contribute to our understanding of regulatory compliance within the amateur band. Case studies provided by BRIN-INASA offer us valuable guidance.

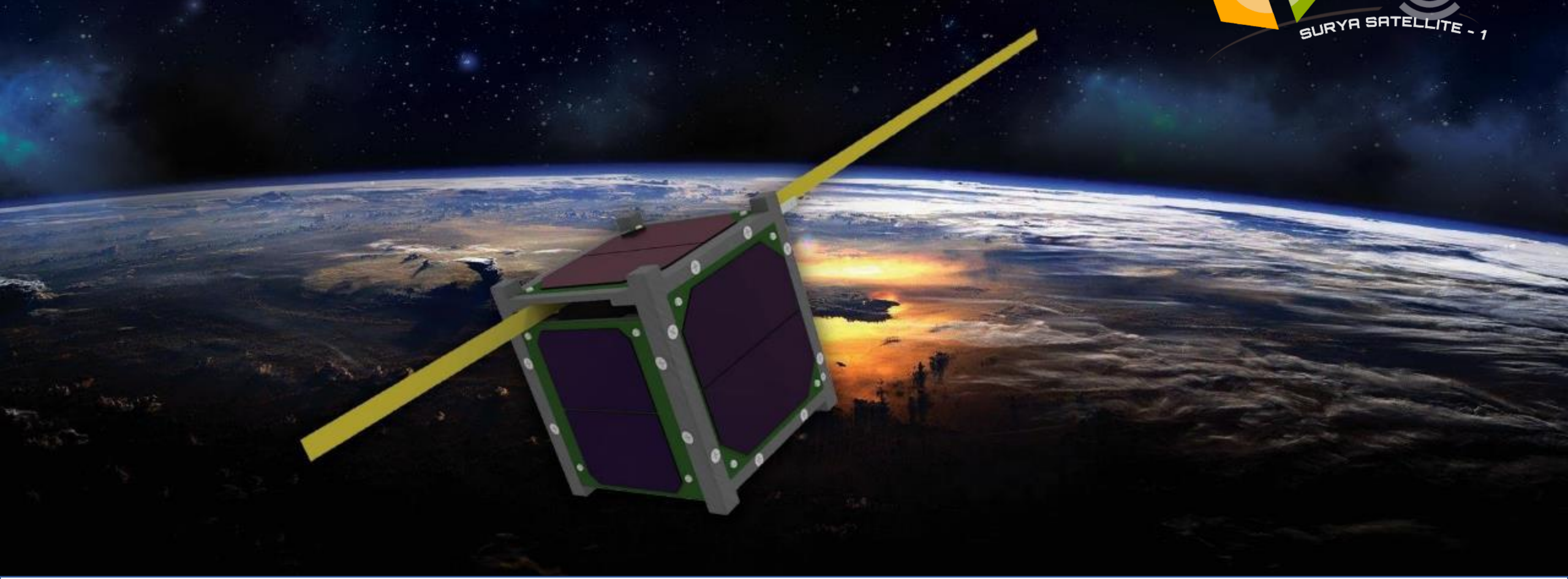
Regular Peer Review and Audits: Implement a system of peer reviews or internal audits to check compliance at various stages of the satellite project. This promotes a culture of accountability and continuous learning.

Case Studies: Highlight examples of successful satellite projects such as LAPAN A2 that have met regulatory compliance. These stories can serve as inspiration and provide practical insights into the process.

Coordination meeting with MCIT

ARCHITECTURE AND DESIGN

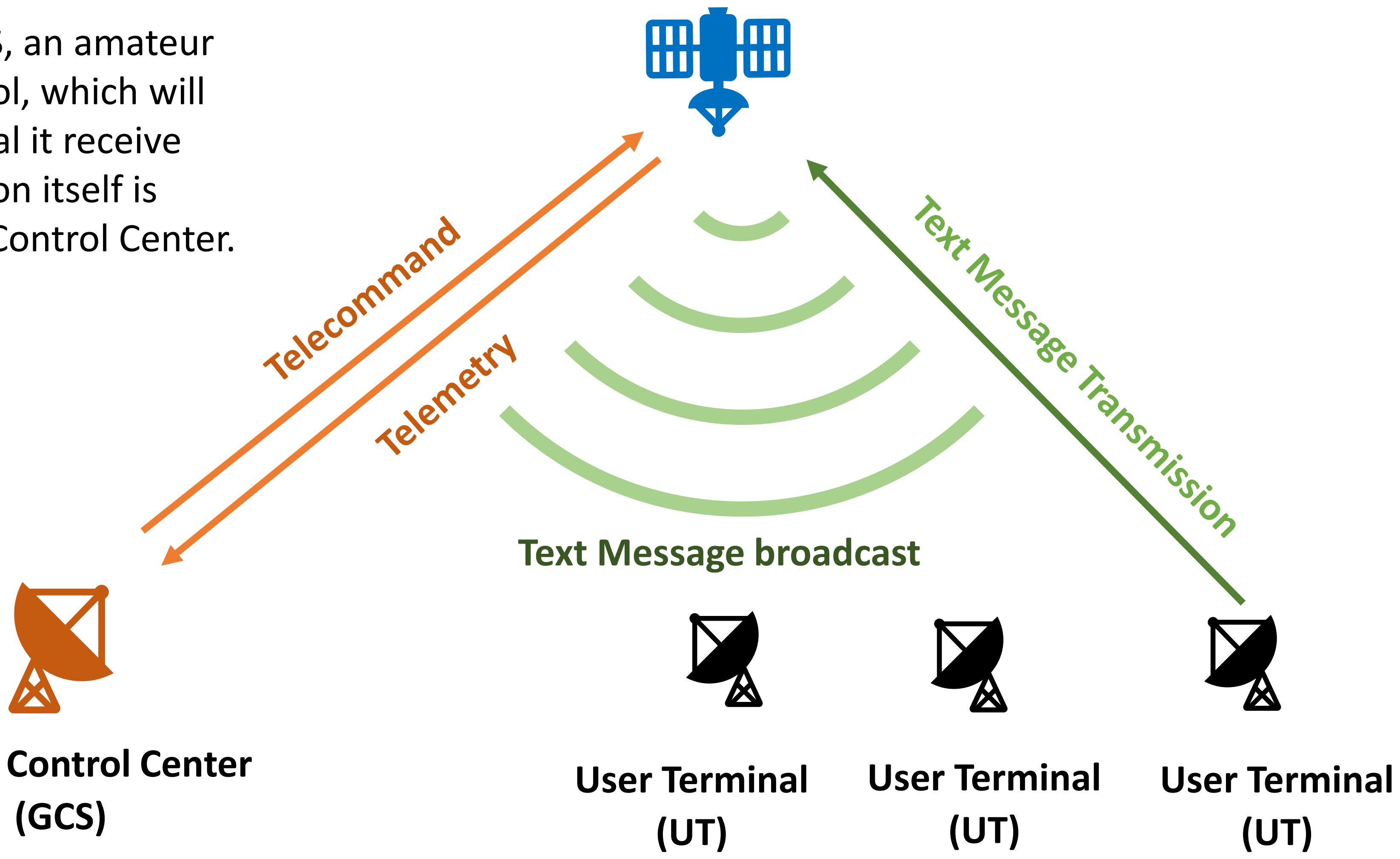
SS-1 SURYA SATELLITE - 1



SURYA UNIVERSITY · PSN · ORARI Organisasi Amatir Radio Indonesia · PUDAK SCIENTIFIC · INASA INDONESIAN SPACE AGENCY · BRIN · KOMINFO · AMSAT-ID

Surya Satellite Architecture

SS-1 is designed to host APRS, an amateur radio communication protocol, which will digipeat any other APRS signal it receive directly. The satellite operation itself is controlled from the Ground Control Center.



SS-1 Subsystem

Electrical Power System

- Source : Six solar panels
- Method : MPPT Charge Controller
- Storage : Li-ion Battery
- Protector : Current limiter, battery protector, voltage protector

Communication Module (Payload)

- Frequency : VHF & UHF
- Function : Beacon and re-broadcast signal from and to earth
- Protocol : APRS

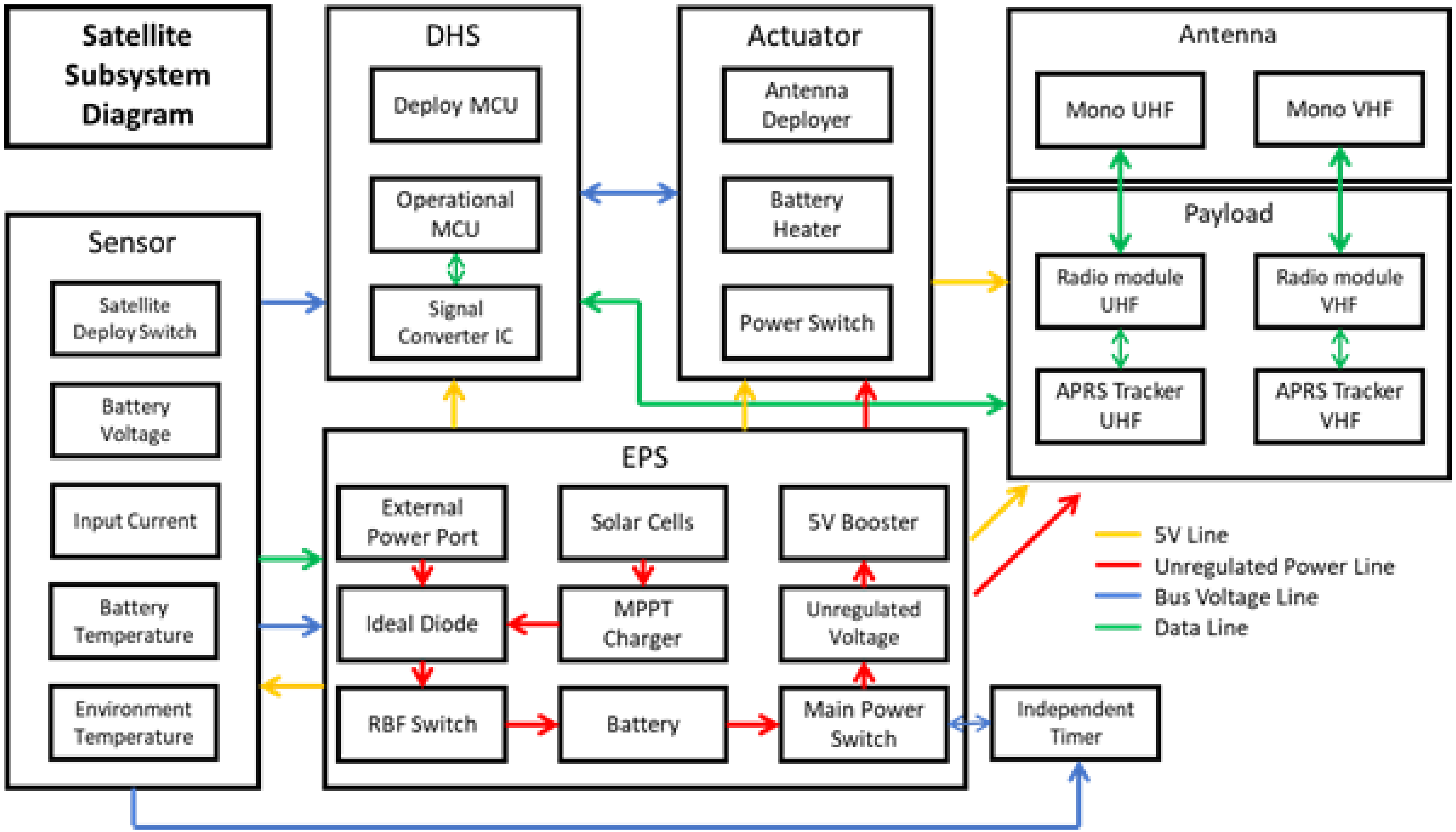
Data Handling System

- Satellite M&C system
- On-board processor installed
- Programmed to be autonomous
- Command receiver
- Developed in-house

Structure

- Aluminum Series 7 Case
- Designed based on JAXA Interface Control Document (ICD)
- Made in Indonesia

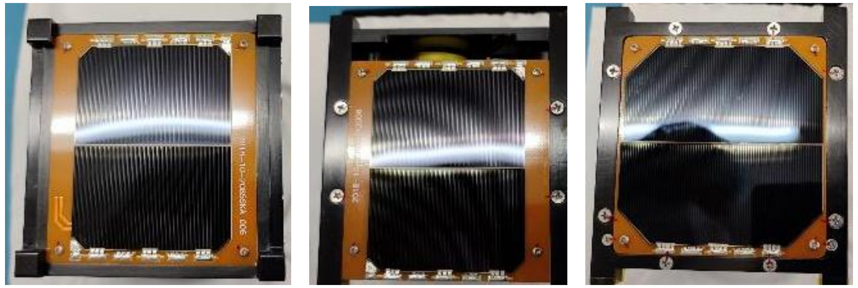
SS-1 Subsystem



SS-1 Subsystem

Electrical Power System

- Source : Six solar panels
- Method : MPPT Charge Controller
- Storage : Li-ion Battery
- Protector : Current limiter, battery protector, voltage protector



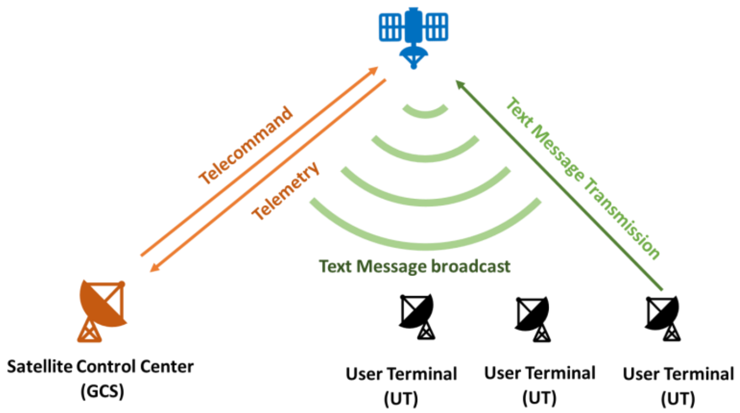
SS-1 solar panels

The EPS objective is to generate, store and distribute power for the satellite's operation. The power generation comes from solar panels installed at each of the six satellite sides and will be conditioned with Maximum Power Point Tracking (MPPT) and Charge Controller (CC) before being stored. The power is stored in a Li-ion Battery with 10,000 mAh of total capacity. For the distribution, EPS needs to supply 5V regulated electricity and unregulated electricity for high current loads. EPS is completed with a power-inhibit system that will keep the satellite powered off until before deployment. This inhibit system is achieved by making good use of a pin header that is installed in the satellite rail as a trigger to power the satellite

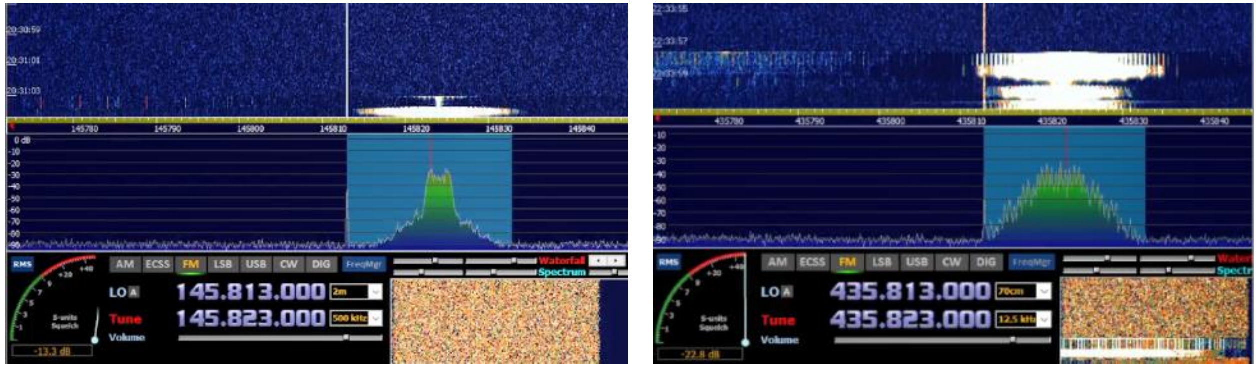
SS-1 Subsystem

Communication Module (Payload)
- Frequency : VHF & UHF
- Function : Beacon and re-broadcast signal from and to earth
- Protocol : APRS

THE SS-1 APRS communication module was co-engineered by the SS-1 and ORARI teams. APRS is a digital communication system that implements the AX.25 protocol, which is used primarily in amateur radio frequency for the real-time exchange of digital information between various communication devices. The APRS serves multiple functions, primarily centered around real-time digital communication, tracking, and emergency information dissemination.



SS-1 communication diagram

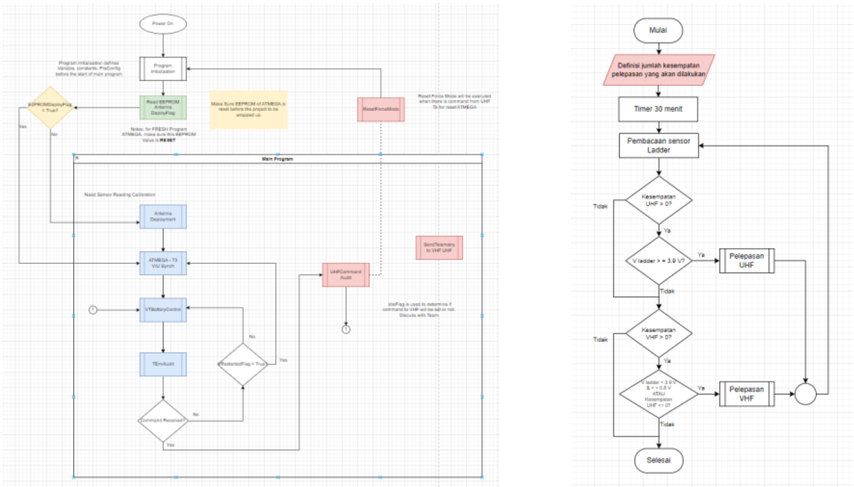


SS-1 signal signature

SS-1 Subsystem

Data Handling System

- Satellite M&C system
- On-board processor installed
- Programmed to be autonomous
- Command receiver
- Developed in-house



SS-1 DHS workflow

The DHS's objective is to monitor and control the entire satellite operation. The DHS was developed in-house by the SS-1 team and consists of the following features:

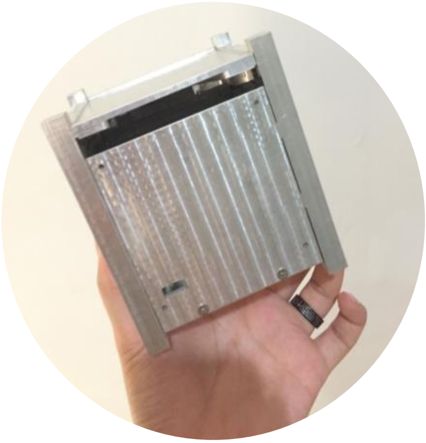
- Satellite Deployment monitoring and control
- Heater monitoring and control
- Telemetry and Telecommand management
- Mode of operation management
- Payload control management
- EPS monitoring

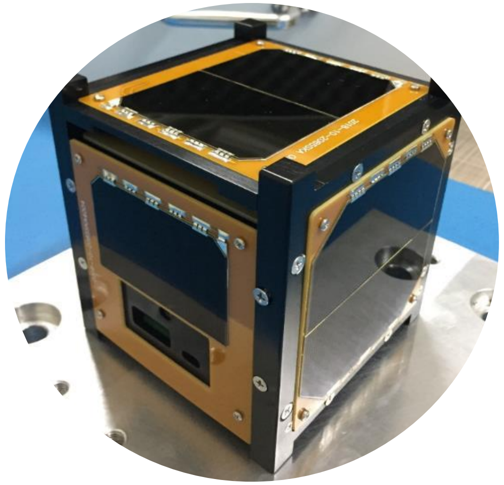
It is well noted that the DHS is developed in-house by SS-1 team, thus modification along the development can be accommodated.

SS-1 Subsystem

Structure

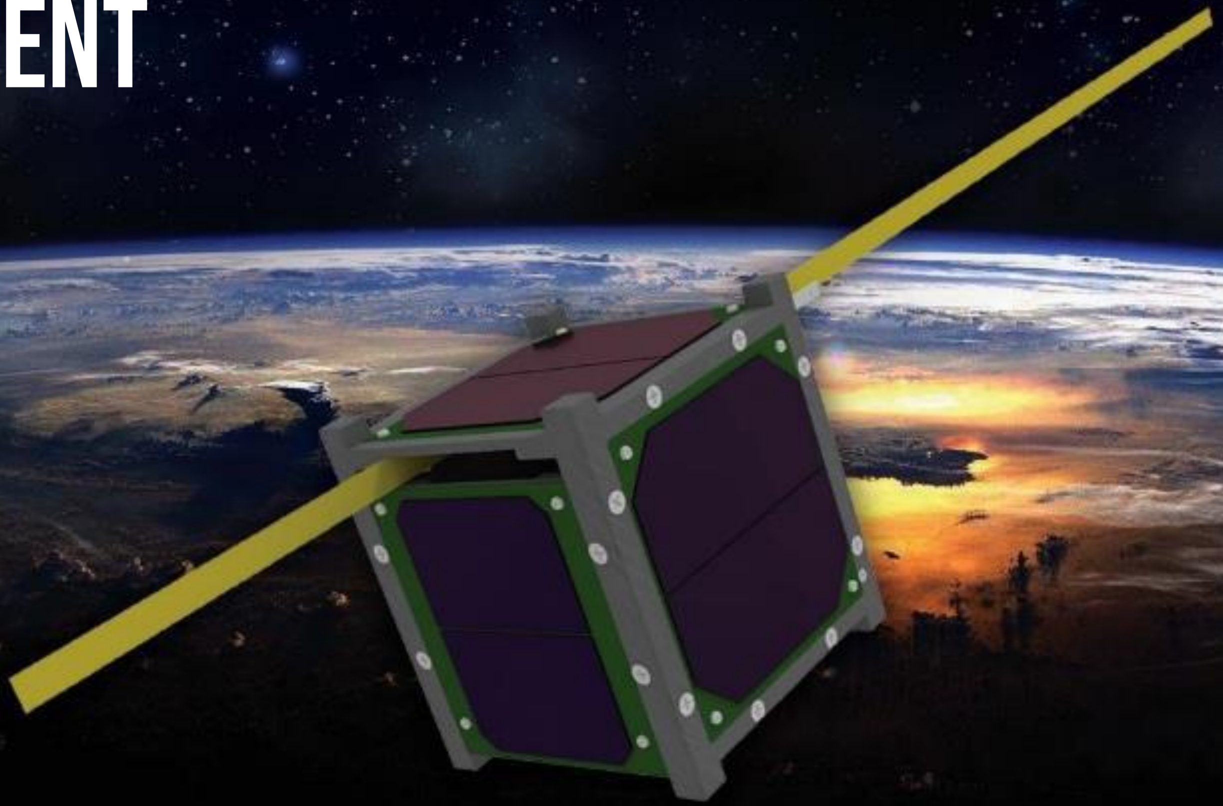
- Aluminum Series 7 Case
- Designed based on JAXA Interface Control Document (ICD)
- Made in Indonesia





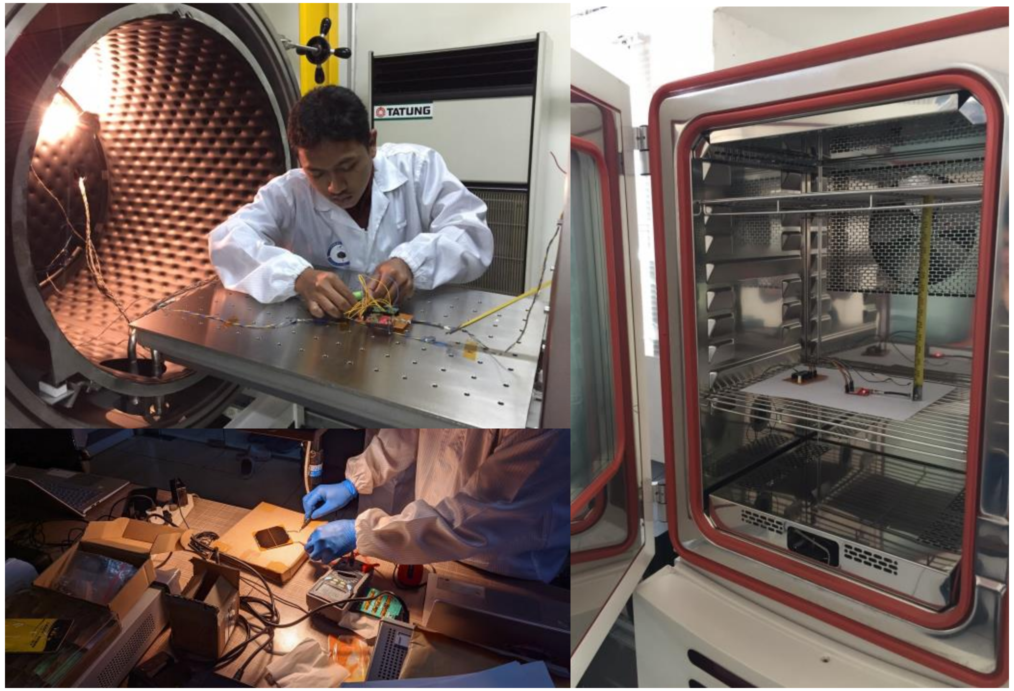
SS-1 Structure provides the rigidity and integrity needed to survive in launch environments. 7075-T365 aluminum alloy with proven heritage in space makes the satellite resistant to vacuum and shock and thermally stable in the space environment. The structure is also a rigid housing for the solar panel of SS-1. Based on computational analysis, SS-1 structural integrity is highly safe, with a highest yield strength margin of safety of 11.9 and an ultimate margin of safety of 10 with the worst yield strength margin of safety on the PCB board of 1.69. Moreover, the first natural frequency of the structure by analysis was 532.32 Hz.

AIT, HANDOVER, LAUNCH AND DEPLOYMENT



SS-1 AIT

SUB-SYSTEM FUNCTIONAL TEST | BATTERY TEST | MASS & DIMENSION TEST



Sub-System Functional Test - BRIN Facility Bogor (2021)

Description

- The objective of the functional test is to ensure that all the components of the satellite work properly at subsystem and system levels. The team conducted the test at the Research Center for Satellite Technology – BRIN. The appropriate procedure was constructed and reviewed before the test began.

Activity

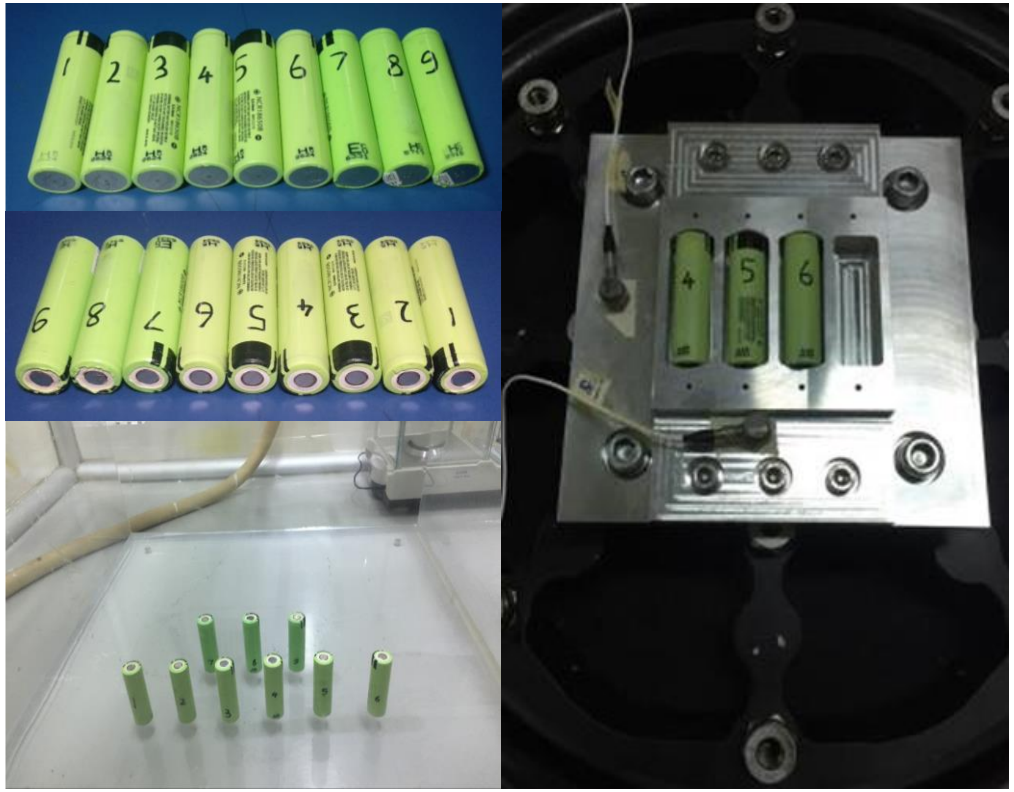
- Due to the non-space-qualified nature of the subsystem, the team decided to qualify the subsystem by conducting functional tests in the thermal vacuum chamber.

Result

- Since the subsystems, such as the low-cost radio module and the APRS modem, showed good functionality during the test, the team concluded using these subsystems.

SS-1 AIT

SUB-SYSTEM FUNCTIONAL TEST | BATTERY TEST | MASS & DIMENSION TEST



Battery Test, Mass and Dimension Test - BRIN Facility Bogor (2021)

Description

- The objective of this activity is to verify that the battery to be used in the satellite is healthy, well-manufactured, and functioning
- The procedure has been designed and agreed before the test activity
- The test is conducted on nine cells of the battery

Activity

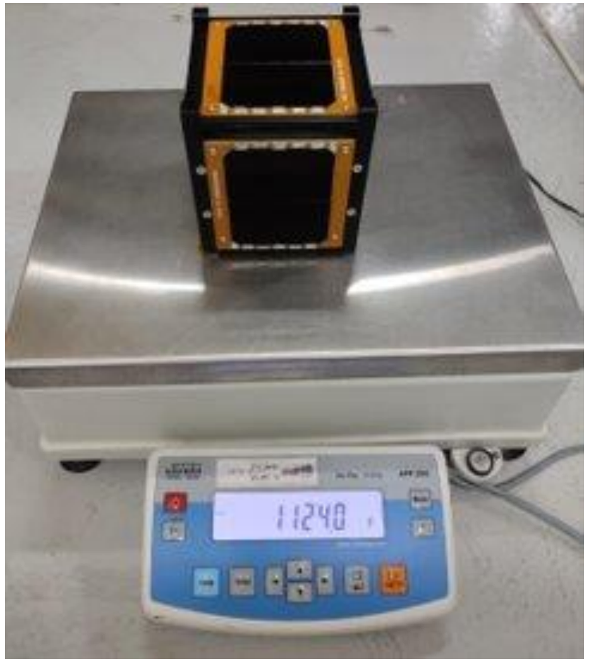
- The first phase is the lot *Sampling Test,* which consists of visual check, mass measurement test, open-circuit voltage measurement, and battery charge-discharge test
- The second phase is the *Acceptance Test, which* consists of a battery random vibration test, battery vacuum test, and battery function test

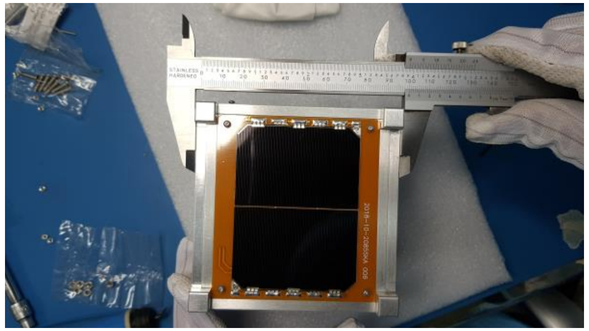
Result

- All tests have been conducted successfully
- 6 out of 9 batteries have been deemed flight worthy

SS-1 AIT

SUB-SYSTEM FUNCTIONAL TEST | BATTERY TEST | MASS & DIMENSION TEST





Mass and Dimension Test - BRIN Facility Bogor (2021)

Description

- The mass and dimension test objective is to verify compliance with JAXA's interface requirements.

Activity

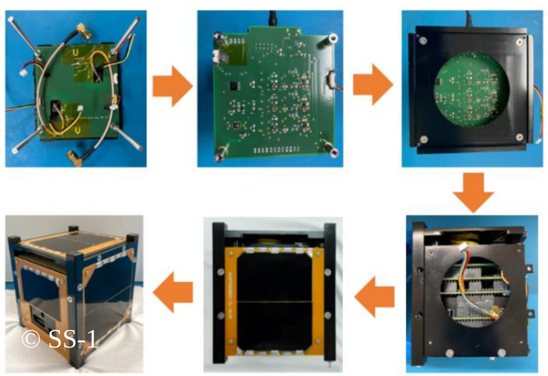
- To measure the satellite mass, the team used a scientific digital scale with a surface-level indicator. When the team measured the mass, the surface had to be perfectly horizontal to the earth.
- To measure the satellite dimension, the team used two different tools, a Vernier Caliper and a Coordinate-Measuring Machine (CMM). The team used the Vernier Caliper as a coarse verification during assembly. The final dimension measurement for JAXA's review used the CMM to ensure accurate and precise measurement data.

Result

- The final satellite mass is 1.124 kg, which is within the range of JAXA's requirement (0.13 – 1.33 kg/1U CubeSat). The dimension of the satellite has also complied with JAXA's 1U dimension requirements.

SS-1 AIT

ASSEMBLY & INTEGRATION



Sub-System Thermal Test - BRIN Facility Bogor (2021)

Description

All subsystems that have been fully developed shall be integrated into the satellite. The flight model (FM) philosophy applied in the development of SS-1 was testing the satellite at the system level to ensure its resilience in the challenging space environment. The assembly of the SS-1 flight model took place in a cleanroom located within the Research Center for Satellite Technology – BRIN Laboratory.

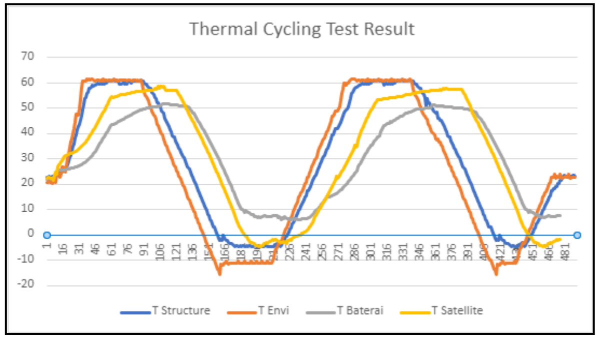
Activity

FM assembly process, which underwent testing and rehearsal during the assembly phase. This phase spanned from September to October 2021, during which careful preparations and assessments were conducted to ensure the successful assembly of the flight model of SS-1. Throughout the assembly process, a series of mandatory inspections and checks were conducted at critical junctures by a team composed of SS-1 and BRIN personnel who were designated as quality inspectors. These mandatory inspection includes Visual Inspection, Connectivity Test and Mechanical Measurements.

SS-1 AIT

THERMAL TEST | VACUUM TEST | VIBRATION TEST

Sub-System Thermal Test
- BRIN Facility Bogor (2021)



Parameters	Condition
Start Cycle	Hot
Ambient Temperature	25°C
Vacuum Pressure	Less than 0.1 psia (6 hours)
No. of Cycle	2
Dwell time	1-hour cold plateau 1-hour hot plateau
Temperature Ramp	1°C/Min
Range	-10°C to + 60°C

Thermal Cycle Test Parameters

Description

A thermal Test was conducted to test the functionality of the satellite in a space temperature environment

Activity

In thermal cycling testing, two temperature sensors were mounted to the satellite's top cover and side panel to monitor its surface temperature. Additionally, two environmental temperature sensors acted as a reference point.

Throughout the hot and cold soak phases, a total of four functional checks were carried out, as well as functional assessments of Antenna Deployment and RF functionality. Both the functional checks performed during these phases similar with those conducted during the vibration test, ensuring a consistent and thorough evaluation of the satellite's performance.

The secondary objective to be conducted is also to simulate the satellite’s 30-minute antenna deployment sequence after deployment, and it was run successfully.

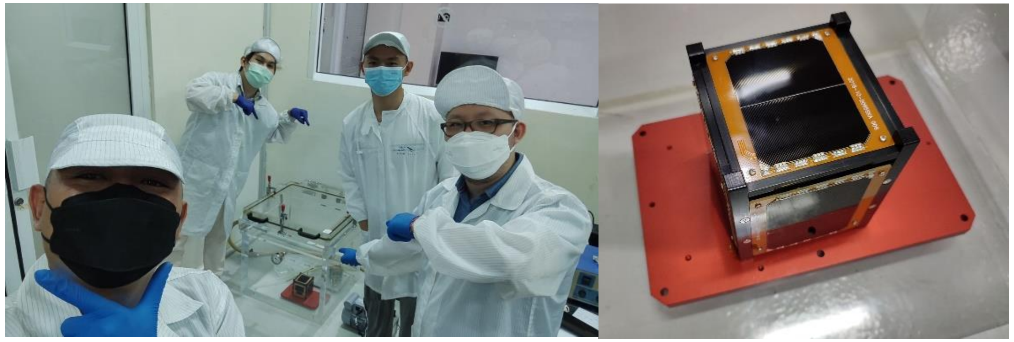
Result

The test demonstrated that all satellite functionality works in high and low temperatures.

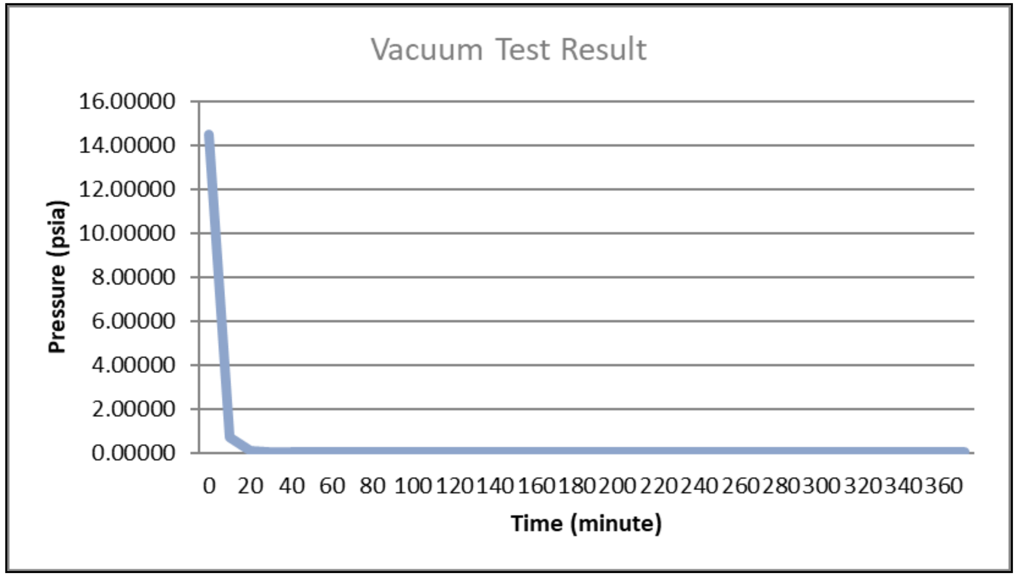
The thermal Cycling result graph illustrates the thermal profile of the satellite concerning external temperature in a space-like environment.

SS-1 AIT

THERMAL TEST | VACUUM TEST | VIBRATION TEST



Sub-System Vaccuum Test - BRIN Facility Bogor (2021)



Description

The objective of conducting a vacuum test is to assess the functionality of SS-1 in a realistic simulation of the space vacuum environment on the ground.

Furthermore, the key test points such as to confirm the proper operation of the antenna satellite deployment subsystem and battery heater subsystem under worst-case conditions.

Activity

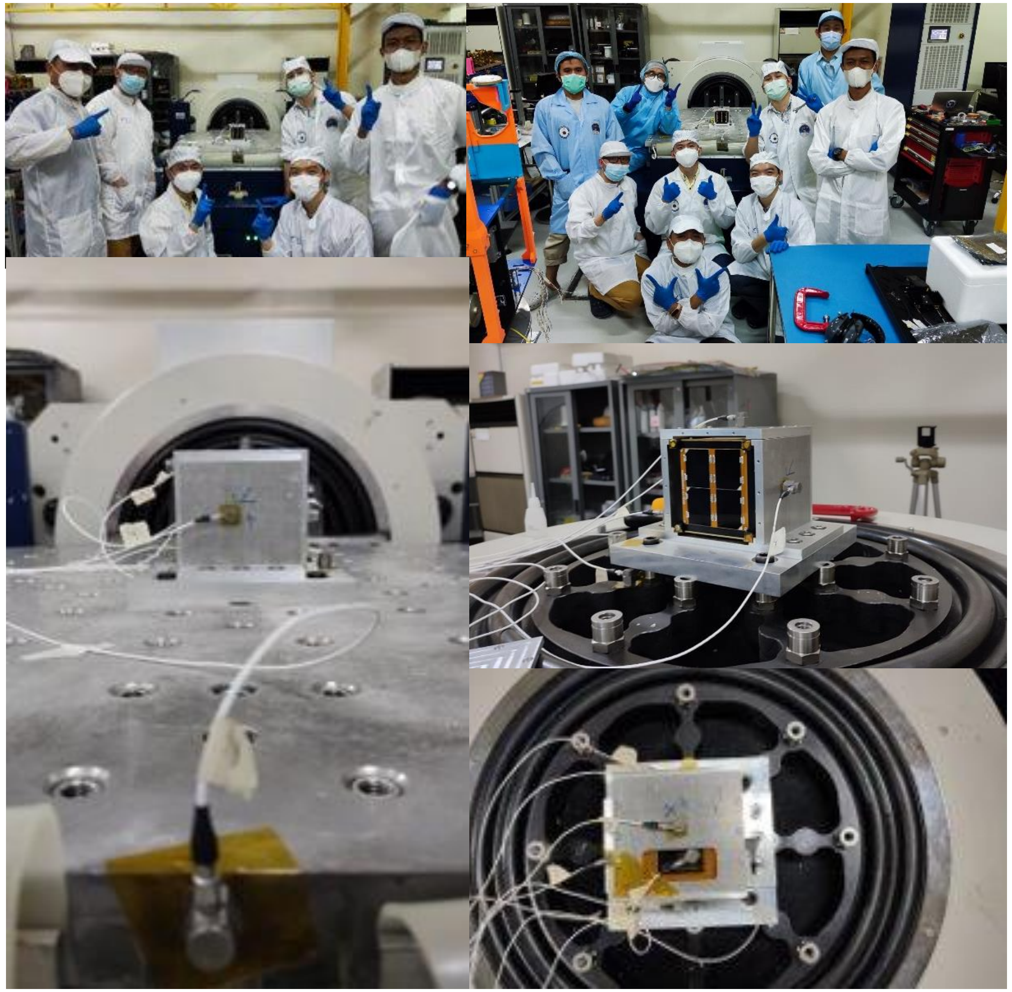
Vacuum testing was conducted under standards of less than 0.1 psia, lasting for a duration of 6 hours, as illustrated in Vacuum Test Result chart.

Result

The results from this vacuum test reveal that there was no noticeable change in mass before and after the test, indicating the satellite's stability under these conditions.

SS-1 AIT

THERMAL TEST | VACUUM TEST | VIBRATION TEST



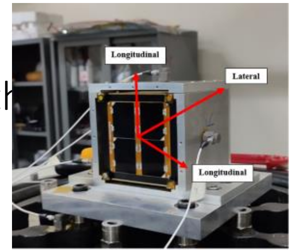
Vibration Test – BRIN Facility Bogor (December 2021)

Description

- Vibration test is a compulsory test to be conducted on the satellite to make sure the satellite is able to sustain the mechanical stress imposed during launch.
- The vibration test is designed to be compliant with HTV-X, SpaceX Dragon, and Orbital Cygnus.

Specification of test

- The image on the right side shows th definition of satellite longitudinal (X & Y-Axis) and lateral (Z-Axis)



- While table below shows low level sine Test profile

	Frequency [Hz]	Amplitude [g]	Sweep rate [Oct/min]	Sweep direction
Each axis	20 ~ 2000	0.5	2	Sweep up/Once

- The graph below shows the profile of the random vibration test envelope

SS-1 AIT

THERMAL TEST | VACUUM TEST | VIBRATION TEST

Test phase	Test sequence
Pre-vibration	Visual Inspection of Satellite
X-axis test	Random Vibration Test (without satellite)
	Satellite Setup
	Sine Sweep
	Random Vibration Test
	Sine Sweep
Z-axis test	Random Vibration Test (without satellite)
	Satellite Setup
	Sine Sweep
	Random Vibration Test
	Sine Sweep
Y-axis test	Random Vibration Test (without satellite)
	Satellite Setup
	Sine Sweep
	Random Vibration Test
	Sine Sweep
Post-vibration	Visual Inspection of Satellite
	Functional Test of Satellite

Natural Frequency Result	X-axis	Z-axis	Y-axis
Natural Frequency (> 100 Hz)	492 Hz	1455 Hz	1219 Hz

Activity

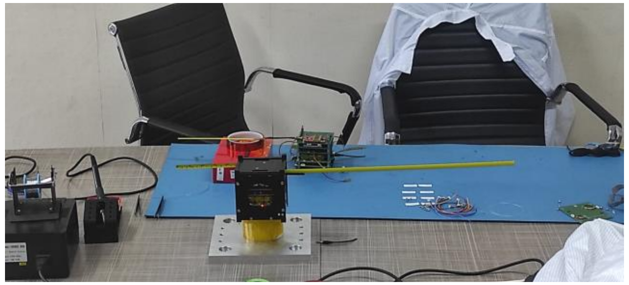
- The vibration test to be conducted are Random Vibration test (mounting bracket), Sine Sweep test (Mounting bracket + Satellite) then Random Vibration Test (Mounting bracket + satellite). These test are to be conducted at all three axis.
- To ensure functionality of the satellite simple functional test is also conducted.

Result

- The low-level sinusoidal sweep & random vibration test conducted in both the lateral and longitudinal axes provides the following insights:
    - The first natural frequency of the SS-1 FM Assembly is observed on the X-Axis of the satellite, occurring at approximately 492 Hz.
    - At frequencies below 100 Hz, no discernible peaks are observed, indicating the absence of natural frequencies at any of the measured locations during this range.

SS-1 AIT

FINAL FUNCTIONAL TESTING (PAYLOAD TEST)



SS-1 Payload Test Result

Frequency	Rx Beacon and TM	Test Station Tx Power	Digipeat	Command Filtering
UHF	Success (65 dBc Rx)	High	Yes	Success
		Medium	Yes	
		Low	Yes	
VHF	Success (70 dBc Rx)	High	Yes	Success
		Medium	No	
		Low	No	

Description

The objective of the functional test is to ensure that all the components of the satellite work finely at subsystem and system levels. The team conducted the test in Research Center for Satellite Technology – BRIN. The appropriate procedure was constructed and reviewed before the test began. There are two functional tests that verify the satellite; payload test and deployment sequence & operational test.

Activity

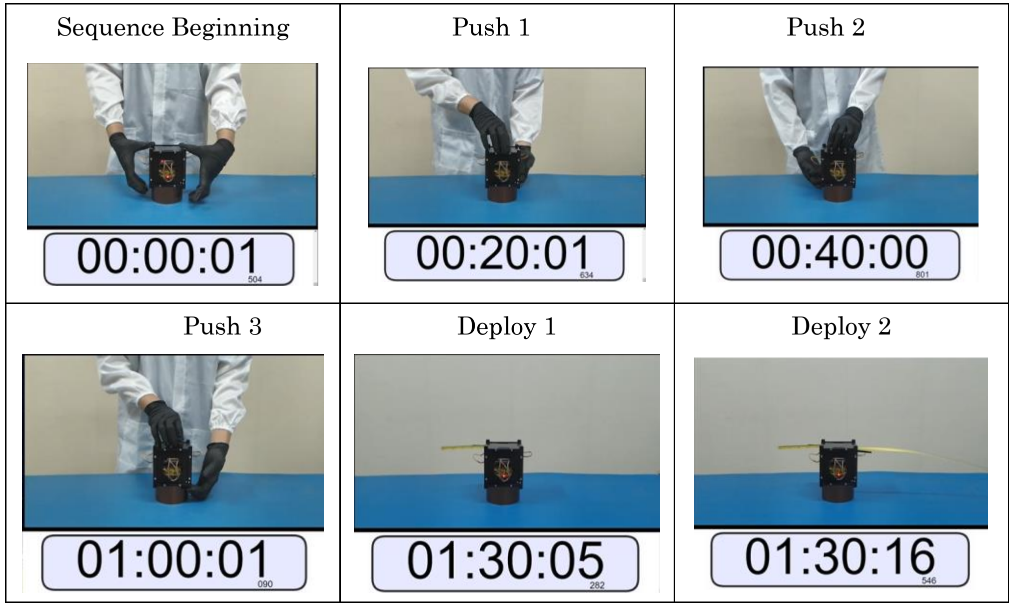
SS-1 Payload test is done with SS-1 left powered-up in a clean room, while another test ground station (TGS) was established in another building. The distance between the satellite and the TGS is approximately 60 meters with 8 obstacles in-between (mainly walls and trees). The TGS used an ALINCO DJ-500 radio with an SDR dongle connected to the computer. Three tests were conducted in this session:
1) received power of satellite beacon and telemetry;
2) satellite payload digital repeating (*digipeat*) sensitivity;
3) call-sign based command filtering.
For test number 2, the mobile station shall transmit in High, Medium, and Low power modes.

Result

The result shows that the UHF payload passed all three for the Payload test without anomaly. Meanwhile the VHF also passed all the payload test, however for VHF to trigger *digipeating* feature, the ground station will have to transmit higher power transmission compared to UHF.

SS-1 AIT

FINAL FUNCTIONAL TESTING (INHIBIT, ANTENNA DEPLOYMENT)



Stopwatch (hh.mm.ss)	Action	Result
00.00.01	Release all switches	Satellite turned on
00.20.01	Press Switch #1	No antenna deployed or RF emission
00.40.00	Press Switch #2	No antenna deployed or RF emission
01.00.01	Press Switch #3	No antenna deployed or RF emission
01.30.05		Antenna #1 deployed, RF #1 signal detected
01.30.16		Antenna #2 deployed, RF #2 signal detected

Satellite Inhibit and Antenna Deployment Test – BRIN Facility Bogor (January 2022)

Description

- The inhibit and antenna deployment test is a simulation to test whether the satellite's deployment sequence and inhibit system is functioning as required for ISS's safety until the operation phase begin. The satellite may only operate after 30 minutes of its deployment from the JSSOD on the ISS.
- The design is implemented with three deployment switches which are at the bottom of the three of four satellite railings. The switches act as power inhibition that prevents the timer program from running the deployment sequence. Only if all three switches are released, then the deployment sequence will run, and the sequence will restart even if one of them is pressed.

Activity

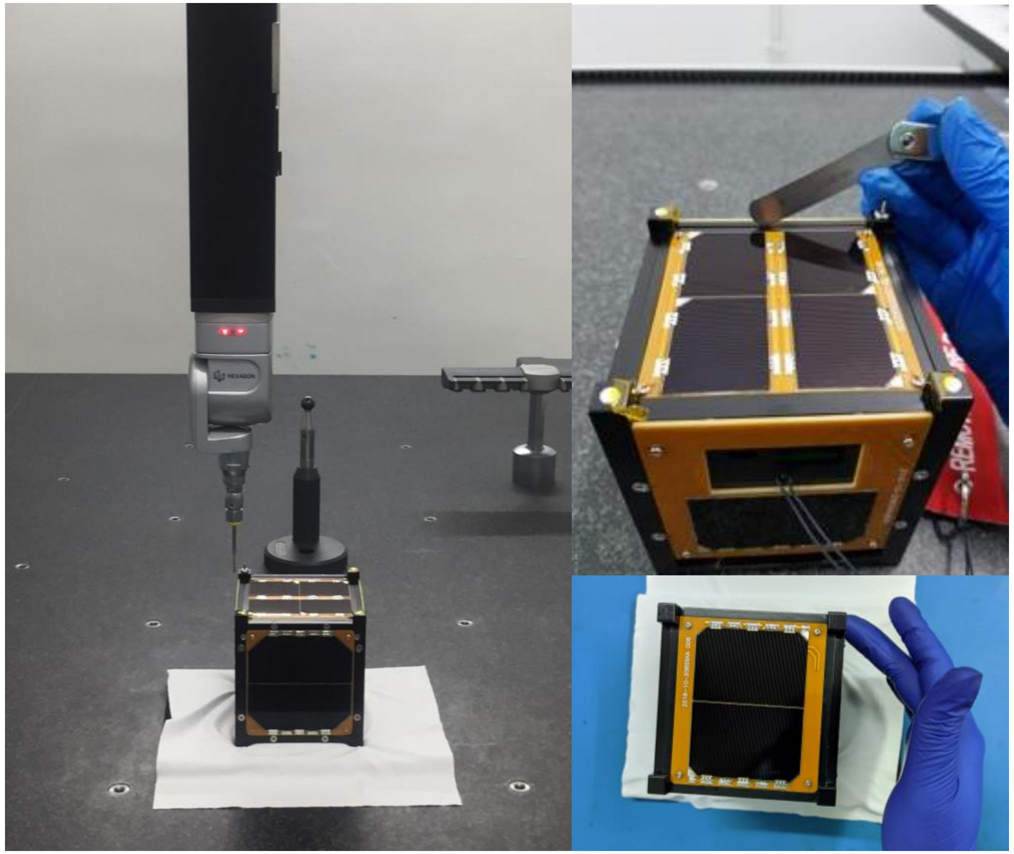
- The test is conducted by releasing all deployment switches. Every 20 minutes, a deployment switch is pressed, and this is done once for each deployment switch. The activity was recorded and showed the time when each action was taken.

Result

- The test demonstrated a successful inhibit function check, and the antenna deployment sequence is in compliance with ISS safety requirements.

SS-1 AIT

FINAL FUNCTIONAL TESTING (ROUGHNESS TEST, SHARP EDGE TEST)



Final Functional Test – BRIN Facility Bogor (January 2022)

Description

- The objective of this activity is to verify that the dimensions meet the requirements; no rough surface nor sharp edge is found on the body of the satellite
- The procedure has been designed and agreed upon before the test activity
- The tests are conducted to ensure that the satellite is ready for shipment

Activity

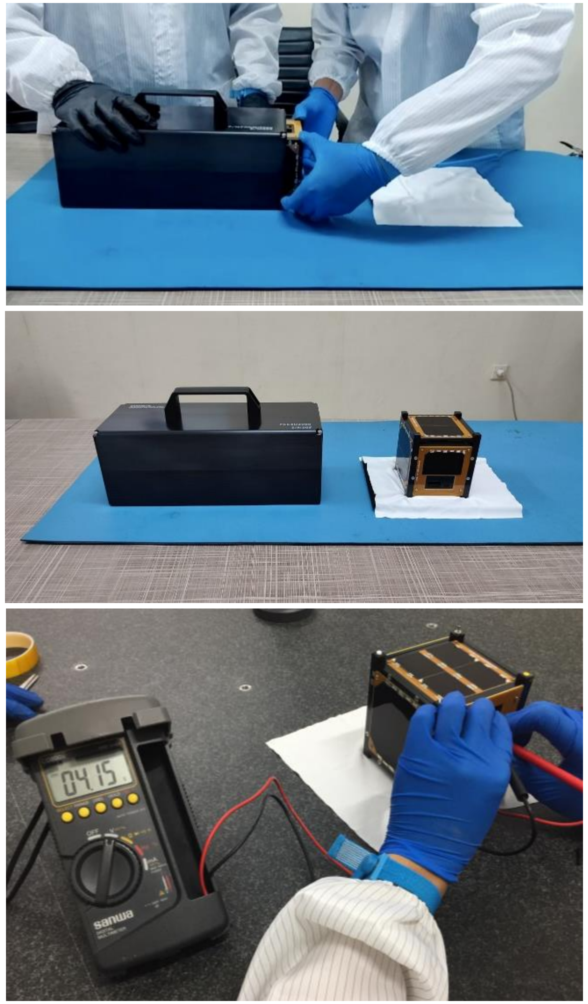
- The first phase is to assess with touch and visual check at the edges of the satellite outer structure whether there was no sharp edge
- The second phase checks the roughness with precise measurement using CMM and checks the gap within structure assemblies.

Result

- All tests have been conducted successfully
- All the requirements are met

SS-1 AIT

FINAL FUNCTIONAL TESTING (FITCHECK)



Final Functional Test – BRIN Facility Bogor (January 2022)

Description

- The objective of the fit check test is to verify if the satellite is fit with the J-SSOD and can run through smoothly
- The objective of the battery checkout test is to verify if there is no self-discharge level that does not meet requirements during the storage period
- The procedure followed the instructions and checklist provided

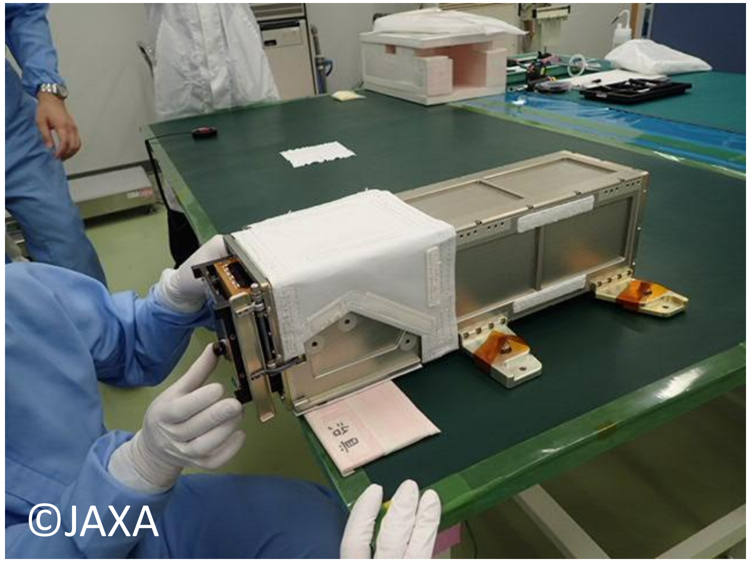
Activity

- The fit check test is to put the satellite into the deployer, push it from the end to end of the deployer, and then verify if it runs smoothly and leaves no scratch inside the deployer
- The battery checkout test is done by measuring the open voltage of the battery from an access window, which was done regularly within the week of the test period

Result

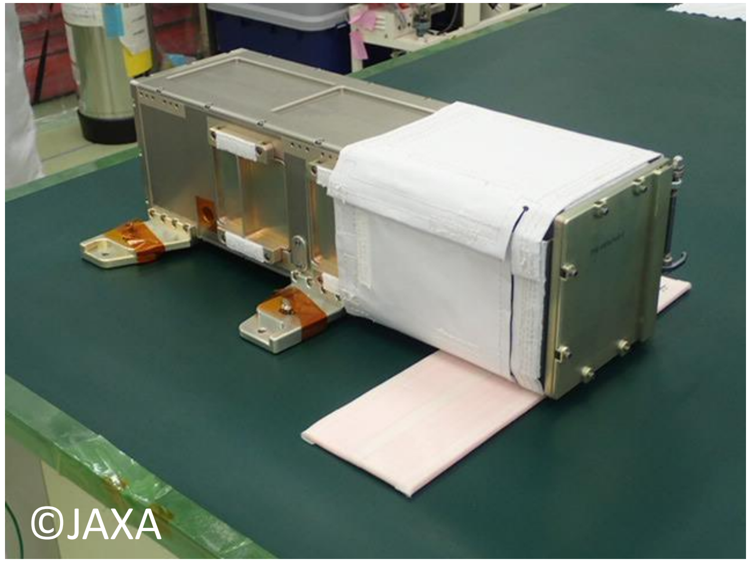
- All tests have been conducted successfully
- All the requirements are meet

Handover



- SS-1 was planned to be handed over at the end of June 2022. However, an unexpected incident happened when SS-1 and JAXA teams tried to insert the satellite into the final fit check case. The satellite could not enter the fit check case smoothly but could enter the flight case due to the higher dimension tolerance.
- The cause of the insertion stuck was the existence of burrs on the structure bolts that were placed on the CubeSat rail. The burrs also scratched the solid lubricant in the flight case where the rail contact was there. This problem could create a deployment stuck risk even though SS-1 could enter the flight case. SS-1 and the JAXA team held an ad hoc meeting to discuss the best solution in the tight time constraint.
- After the meeting was concluded, The SS-1 team needed to stay and remove the burr with a procedure agreed by the SS-1 team and JAXA. Then, the team, accompanied by JAXA’s personnel, bought the tools needed (on the top photo) to remove the burrs. The method agreed was using a small hand grinder to scrape the burr. The team worked on the burr removal at the JAXA facility for three days. Thanks to the warm cooperation and the dedication of the JAXA team, who also accompanied the team to work until late in the clean room.

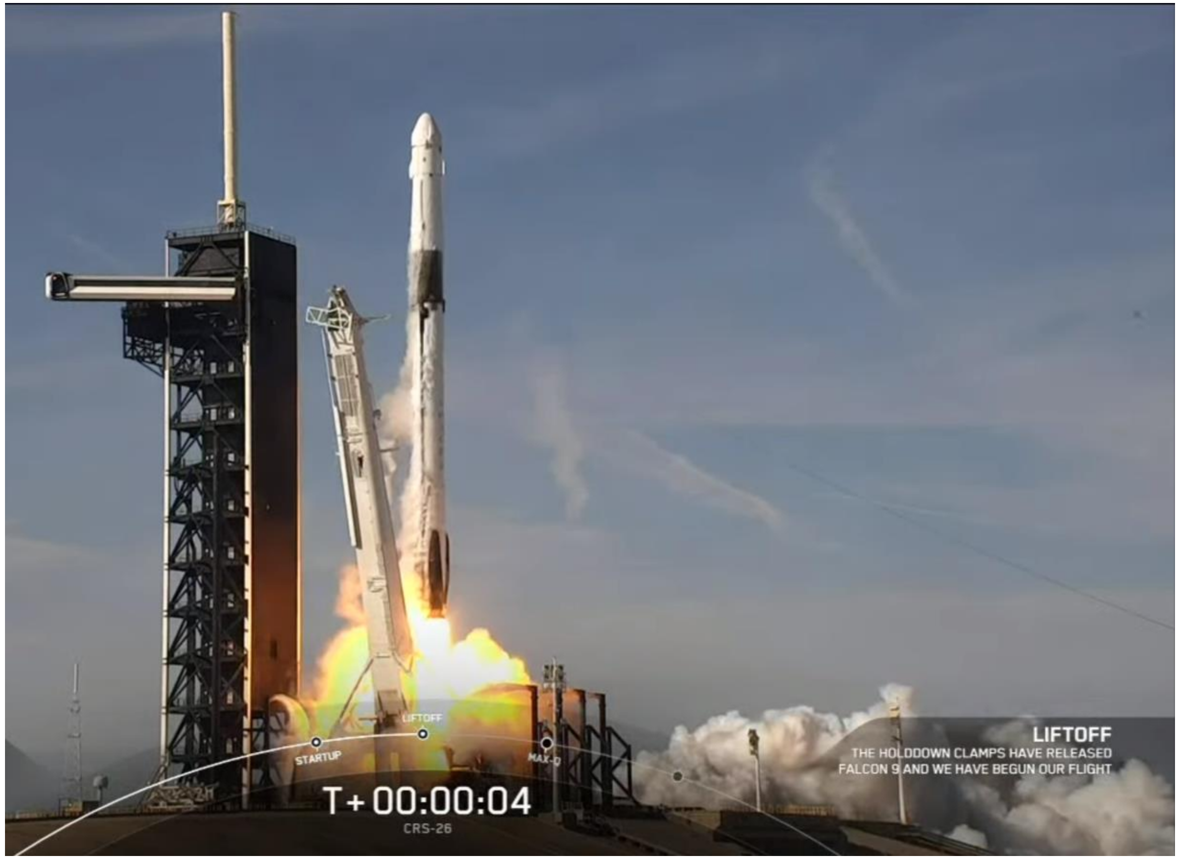
Handover



- Working directly with the JAXA team in the JAXA’s cleanroom was a priceless and memorable experience. However, it was an unfavorable incident, and the team learned how to prevent it. The lessons learned from the non-conformance are listed below.
  - To avoid bolts on the CubeSat rails, the rails have to be smooth. If the structure design has already been implemented bolts on the rails, ensure the bolts' surface is below the rails' surface.
  - To ensure the bolts were not over-torqued to eliminate the risk of burr existence.
- After the burr removal was completed, the JAXA team tried to insert SS-1 into the flight case again. When no scratch was observed, all concurred that JAXA could accept SS-1. The team handed over SS-1 to JAXA on 8 July 2022. The installation into the J-SSOD followed afterward

Launch

- SpaceX Commercial Resupply Service 26 (CRS-26) launched on 26 November 2022 (UTC) to the International Space Station (ISS) with SS-1 as one of the payloads.

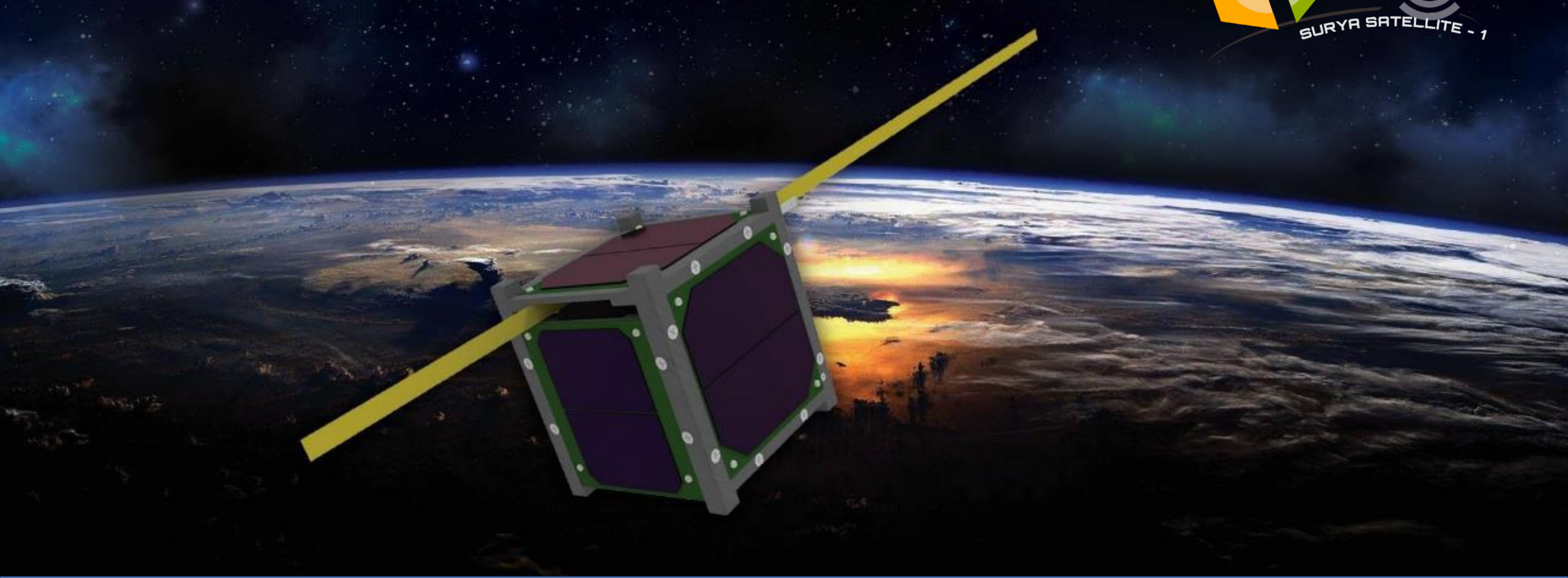


SS-1 Deployment

- Deployment Event sucessfully held on 6 Jan 2023

EARLY OPERATION PHASE

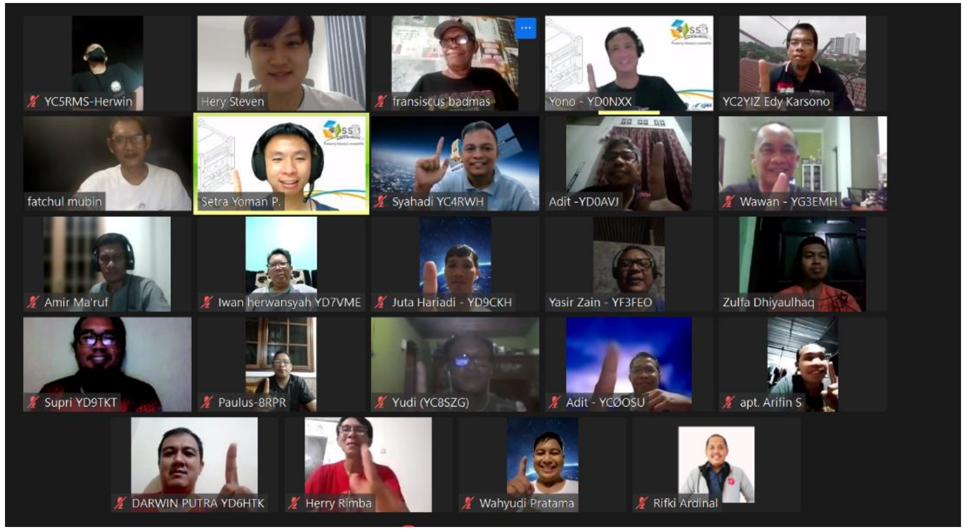
SS1 SURYA SATELLITE - 1



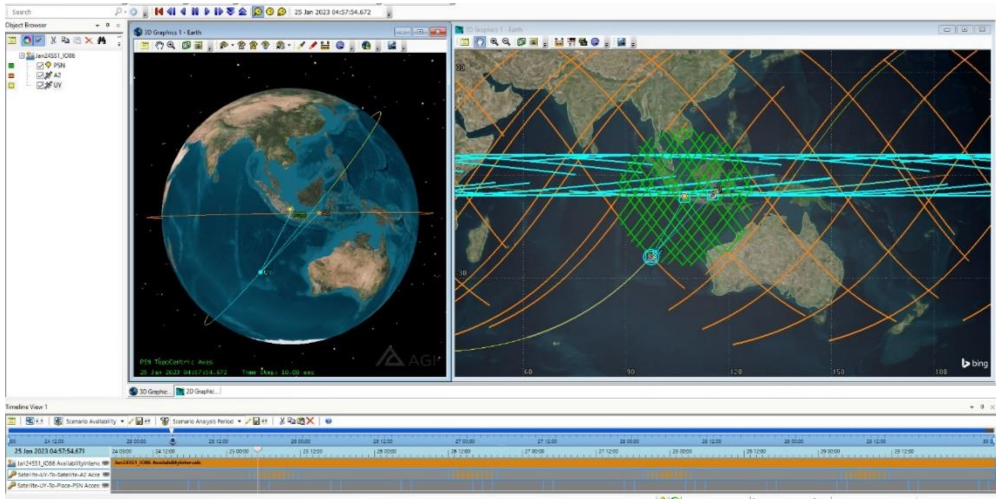
SURYA UNIVERSITY | PSN | ORARI Organisasi Amatir Radio Indonesia Indonesia Amateur Radio Organization | PUDAK SCIENTIFIC | INASA INDONESIAN SPACE AGENCY | BRIN | KOMINFO | AMSAT-ID

Early Operation Phase Preparation

- To ensure SS-1 first signal acquisition a network ground station established
- Coordination with BRIN, ORARI and AMSAT-ID started since 6 October 2022
- A total of 33 ground station join the effort for SS-1 EOP



SS-1 & AMSAT-ID EOP



SS-1 Tracker Scheduling

EOP Preparation

- Total **33 ground** station participate in signal receiver

	Event	Date
L-21	GS Hardware / Software Readiness Check	16 Dec 2022
L-14	Ground Station Operation Readiness Check	23 Dec 2022
L-3	EOP final briefing	3 Jan 2023
L-0	Deployment from ISS	6 Jan 2023

EOP Status

- Several source of satellite signal are used:

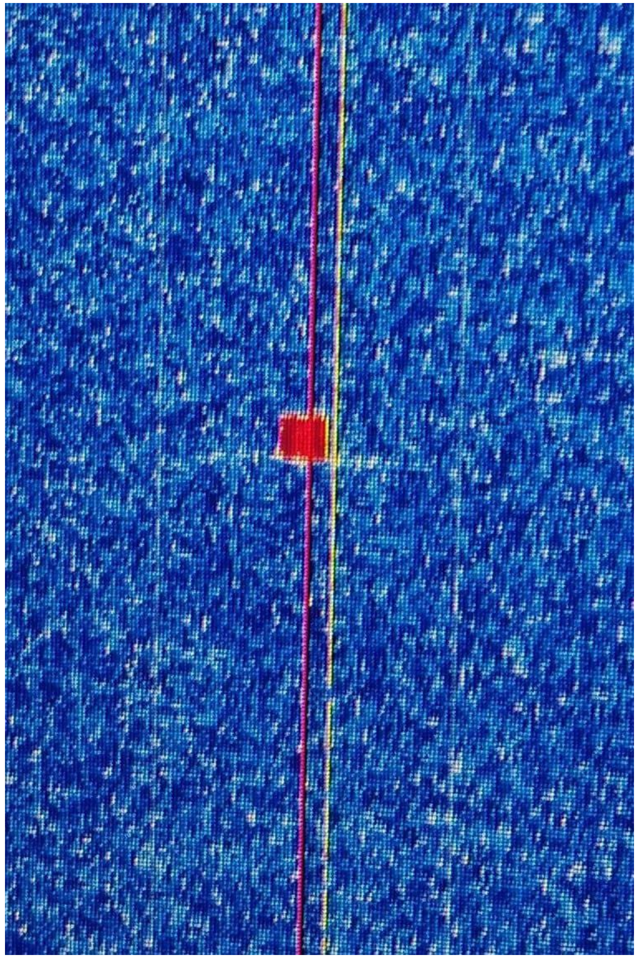
No	Source	Decoded	Not decoded
1	SS-1 tracker team (ORARI + AMSAT-ID)	11	+3 (reported)
2	aprs.fi	29	0
3	Satnogs	7	+5
4	Others (social media / email / etc)	3	0

- VHF has 45 recorded data
- UHF has 4 recorded data

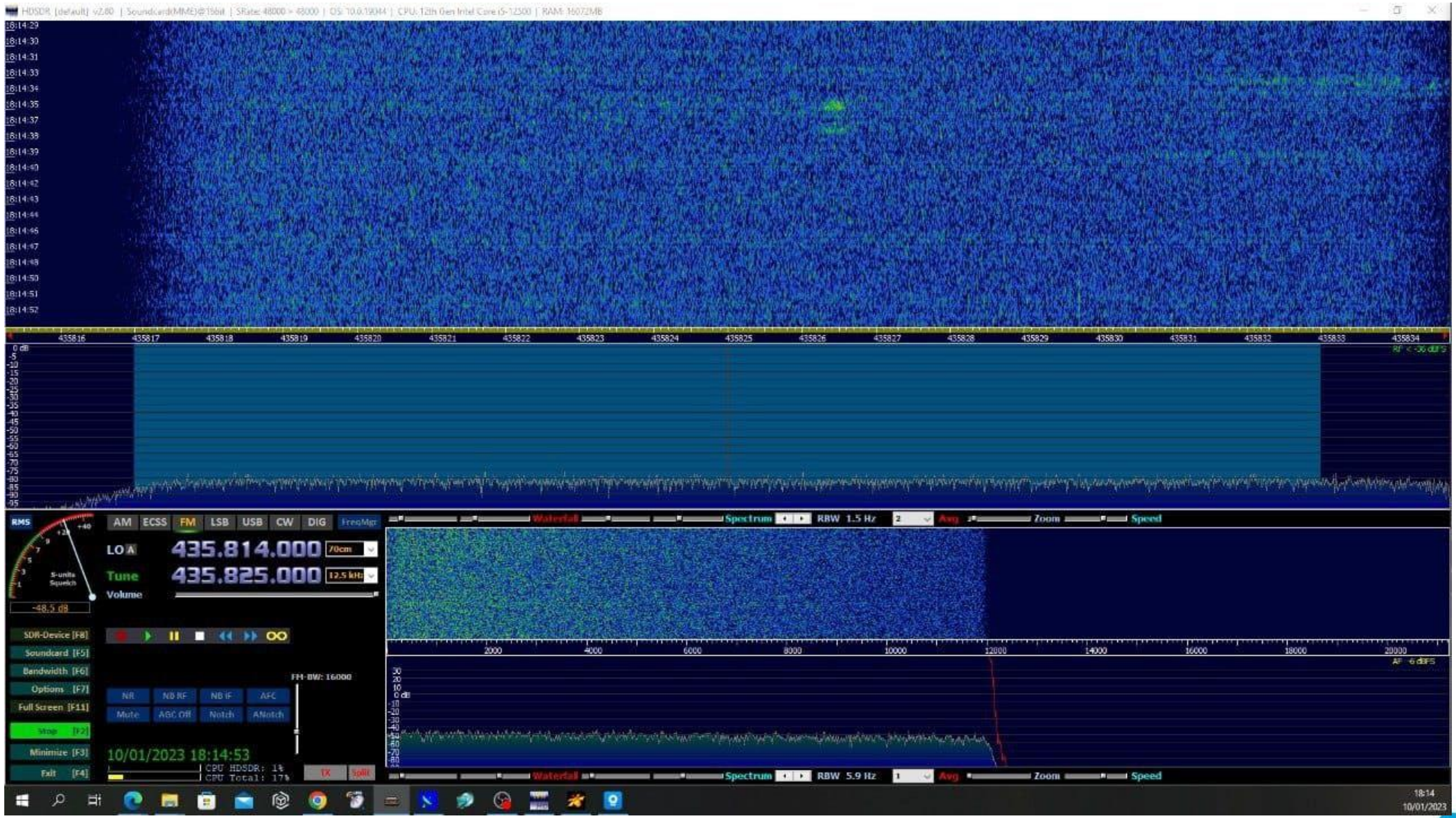
EOP Status

Location in which SS-1 beacon are received and recorded

EOP Status

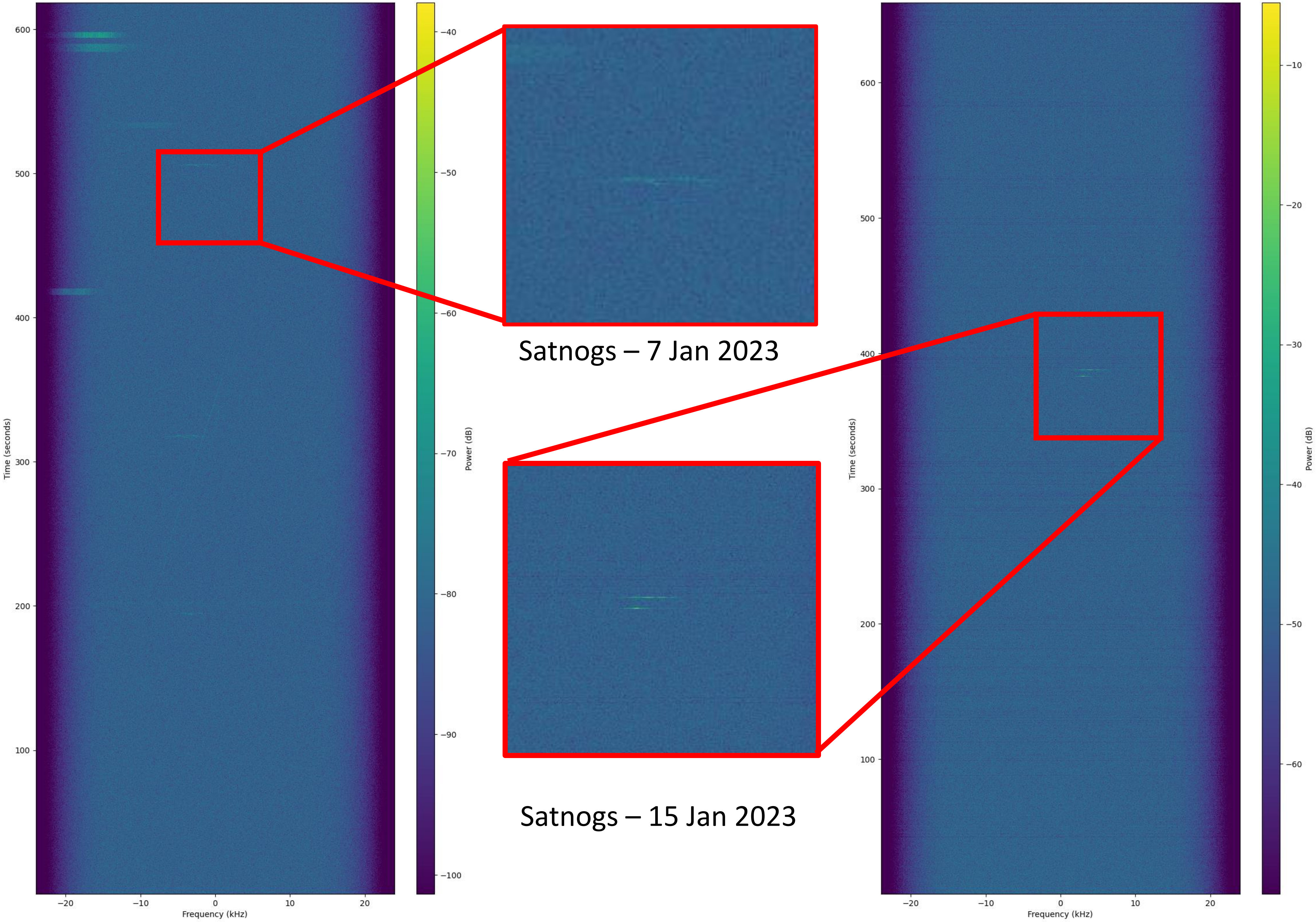


ORARI receive from Bekasi
9 Jan 2023



Nanosat team receive from Cikarang
12 Jan 2023

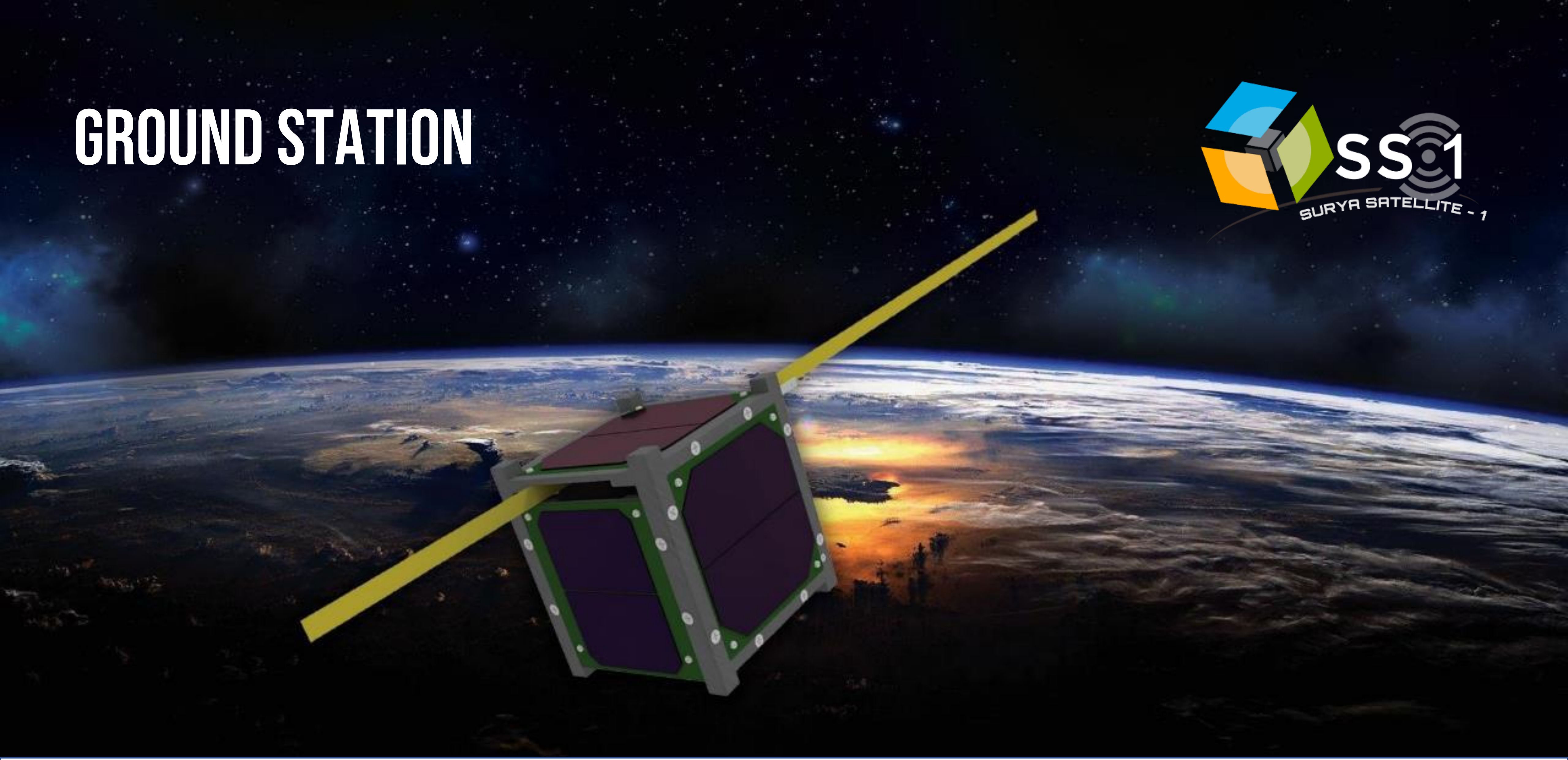
EOP Status



Satnogs – 7 Jan 2023

Satnogs – 15 Jan 2023

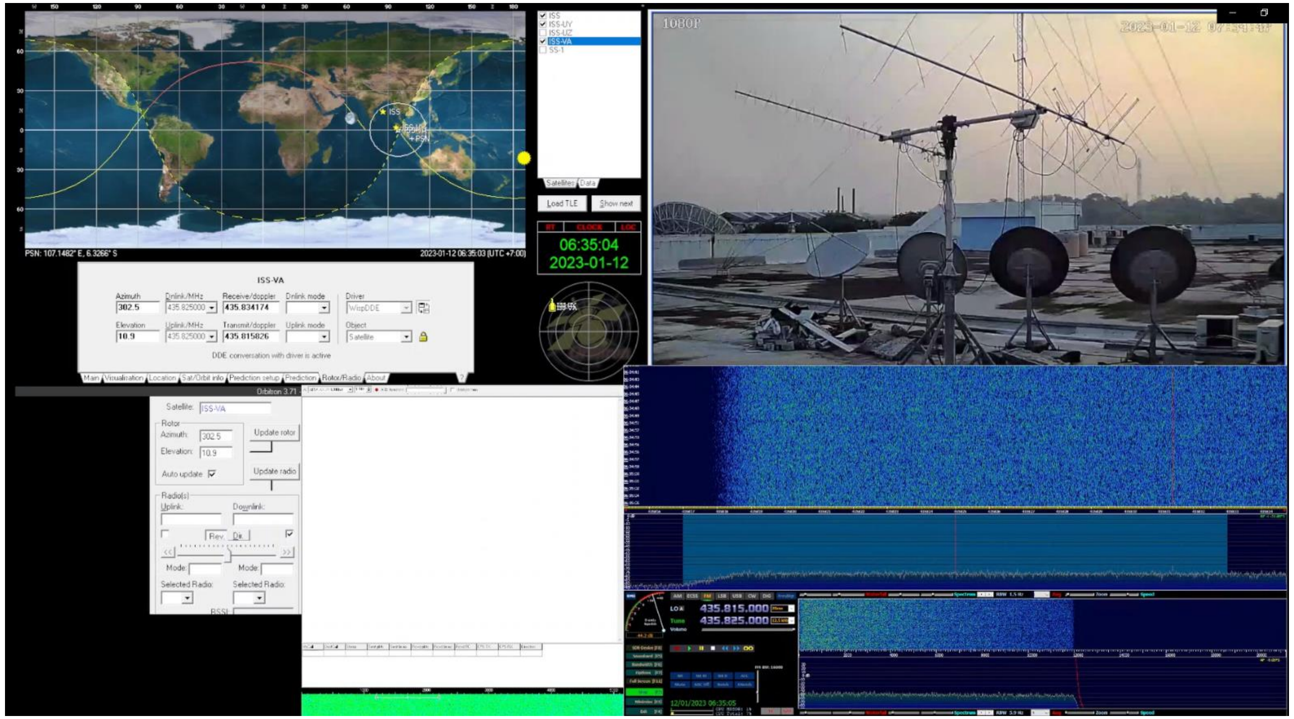
GROUND STATION



Ground Station

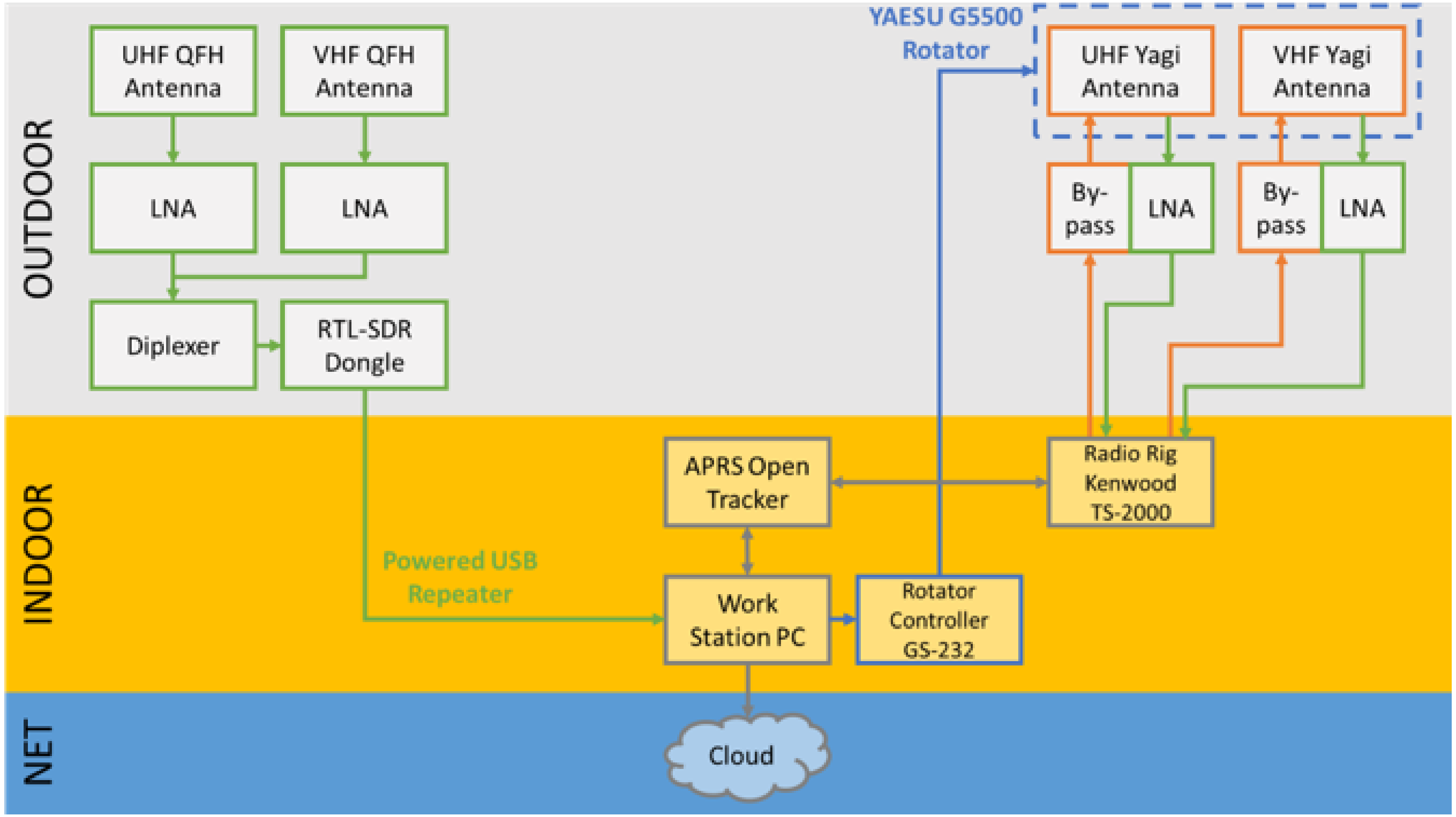
Status Update

- Ground Station is operational
- Nanosat pass Cikarang 3-4 times a day
- Satellite has been registered for space object tracking
- GS operation SOP has been created



Nanosat Workstation setup

Ground Station Block Diagram



Ground Station Block Diagram

Ground Station Construction

SWR Measurement – 30 August 2022

Antenna Construction – 5 September 2022

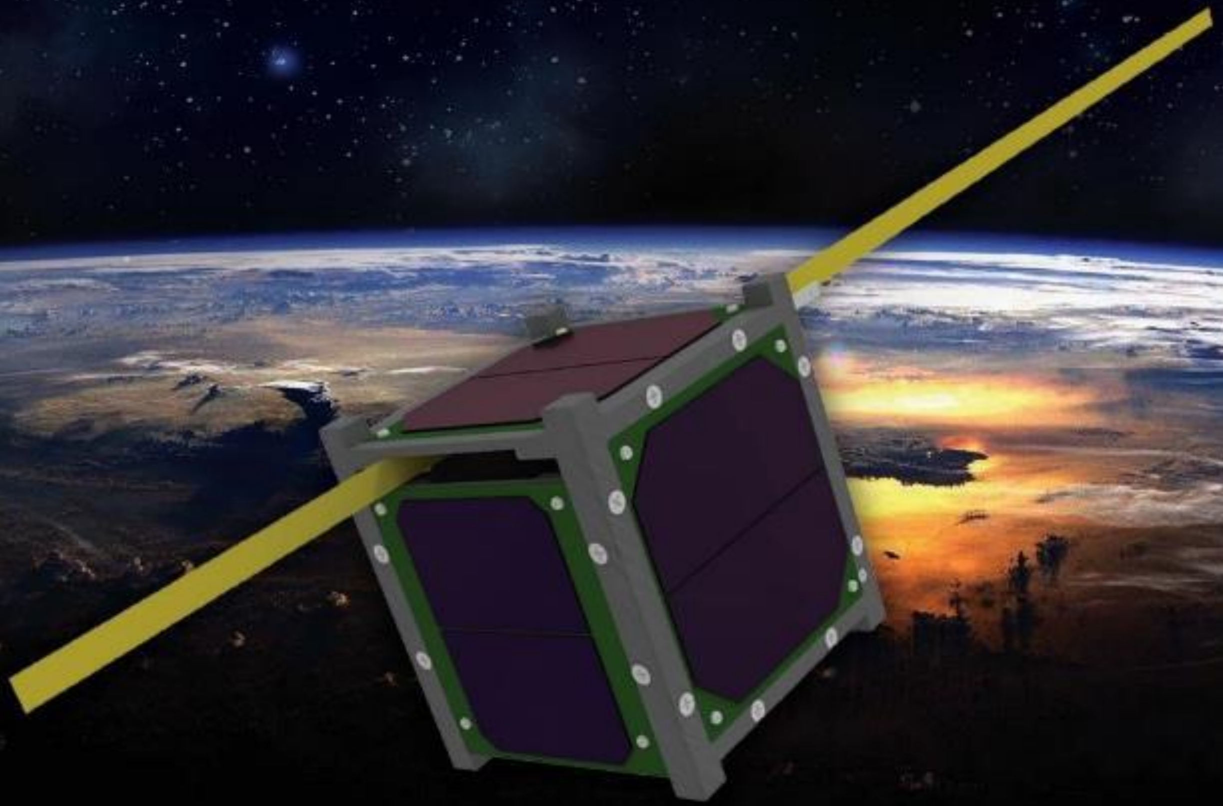
Antenna Installed – 13 September 2022

Ground Station Operation

Satellite Tracking

AMSAT-ID visit

RESULTS AND CONCLUSIONS



Satellite Operation – things that work

- Antenna deployment : **OK**
  - First signal received at 6 Jan 2023 @ 15:32:52 WIB → exactly 30 minute after deployment which is ideal case
- EPS : **OK**
  - Satellite is powered on → can transmit signal
  - Satellite is functional after >32 hour power on → power charging operational
- DHS : **OK**
  - Several telemetry shows satellite's internal flag works according to program
- Communication payload : **OK**
  - Several beacon & telemetry can be decoded
- Structure : **OK**
  - Passed launcher environment and successfully deployed from ISS

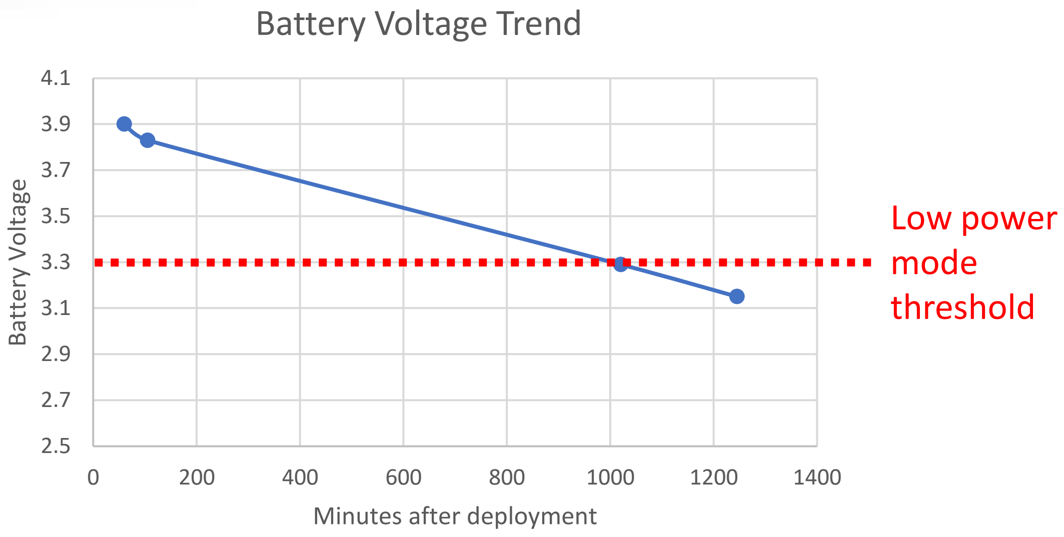
Operational – Received Telemetry

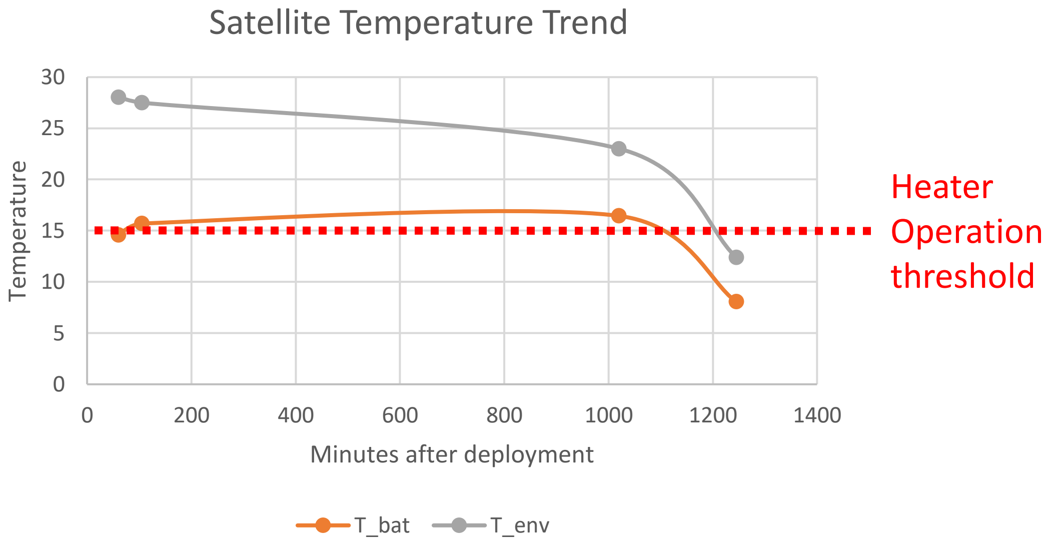
No.	Date	Time (GMT+7)	Call Sign	Via	Data Package	Est. Location
1	1/6/2023	15:32:52	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	California, US
2	1/6/2023	15:33:53	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	California, US
3	1/6/2023	15:35:54	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	Iowa, US
4	1/6/2023	15:36:54	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	California, US
5	1/6/2023	16:31:27	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	Perth, Australia
6	1/6/2023	16:33:29	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	Perth, Australia
7	1/6/2023	16:39:33	YH1SSS-2	RS0ISS*	T#022,205,000,000,118,113,00000000	Adelaide, Australia
8	1/6/2023	16:37:30 - 16:46:55	YH1SSS-2		T#023,205,000,000,119,113,00000000	East Australia, Brisbane
9	1/6/2023	17:09:51	YH1SSS-2	RS0ISS*	T#032,205,000,000,117,113,00000000	California, US
10	1/6/2023	17:12:53	YH1SSS-2	RS0ISS*	T#033,205,000,000,116,114,00000000	California, US
11	1/6/2023	17:14:54	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	California, US
12	1/6/2023	17:15:56	YH1SSS-2	RS0ISS*	T#034,207,000,000,116,113,00000000	Iowa, US
13	1/6/2023	17:16:07	YH1SSS-2	RS0ISS*	T#023,205,000,000,119,113,00000000	Manado, Indonesia
14	1/6/2023	17:17:08	YH1SSS-2	RS0ISS*	T#023,205,000,000,119,113,00000000	Manado, Indonesia
15	1/6/2023	17:37:06	YH1SSS-2	RS0ISS*	T#041,205,000,000,113,114,00000000	Fortaleza, Brazil
16	1/6/2023	18:11:00 - 18:15:04	YH1SSS-2		T#053,205,000,000,118,113,00000000	West Autralia
17	1/6/2023	18:11:00 - 18:15:04	YH1SSS-2		0011111000010010;3.83;15.70;27.48;0.20;0.00	West Autralia
18	1/6/2023	18:13:28	YH1SSS-2	RS0ISS*	T#053,205,000,000,118,113,00000000	Denpasar, Indonesia
19	1/6/2023	18:13:28	YH1SSS-2	RS0ISS*	T#053,205,000,000,118,113,00000000	Bali, Indonesia
20	1/6/2023	18:14:43	YH1SSS-2	RS0ISS*	0011111000010010;3.83;15.70;27.48;0.20;0.00	Yogyakarta, Indonesia
21	1/6/2023	18:14:44	YH1SSS-2	RS0ISS*	0011111000010010;3.83;15.70;27.48;0.20;0.00	Bali, Indonesia
22	1/6/2023	18:14:44	YH1SSS-2	RS0ISS*	0011111000010010;3.83;15.70;27.48;0.20;0.00	Yogyakarta, Indonesia
23	1/6/2023	18:16:49	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	Trenggalek, East Java, I
24	1/6/2023	18:17:30	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	Manado, Indonesia
25	1/6/2023	18:17:30	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	Manado, Indonesia
26	1/6/2023	18:17:30	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	Bali, Indonesia
27	1/6/2023	18:17:30	YH1SSS-2	RS0ISS*	SuryaSat-1 in Commissioning phase	Ambon, Indonesia
28	1/6/2023	18:22:33	YH1SSS-2	RS0ISS*	T#056,205,000,000,119,114,00000000	Manado, Indonesia
29	1/6/2023	18:22:33	YH1SSS-2	RS0ISS*	T#056,205,000,000,119,114,00000000	Manado, Indonesia
30	1/6/2023	18:22:33	YH1SSS-2	RS0ISS*	T#056,205,000,000,119,114,00000000	Halmahera, Indonesia
31	1/6/2023	18:46:47	YH1SSS-2	RS0ISS*	T#064,205,000,000,116,113,00000000	California, US
32	1/6/2023	18:53:51	YH1SSS-2	ARISS	SuryaSat-1 in Commissioning phase	Iowa, US
33	1/6/2023	19:04:58	YH1SSS-2	RS0ISS*	T#070,203,000,000,112,112,00000000	Medellin, Colombia
34	1/6/2023	19:11:02	YH1SSS-2	RS0ISS*	T#072,205,000,000,113,112,00000000	Fortaleza, Brazil
35	1/6/2023	19:50:25	YH1SSS-2	RS0ISS*	T#085,205,000,000,119,114,00000000	Bali, Indonesia
36	1/7/2023	6:47:44	YH1SSS-2	RS0ISS*	T#046,204,000,000,118,115,00000000	Trinidad & Tobago
37	1/7/2023	7:32:07	YH1SSS-2	ARISS	SuryaSat-1 in Commissioning phase	Bali, Indonesia
38	1/7/2023	08:35-24 - 08:46:40	YH1SSS-2		SuryaSat-1 in Commissioning phase	Germany
39	1/7/2023	08:35-24 - 08:46:40	YH1SSS-2		SuryaSat-1 in Commissioning phase	Germany
40	1/7/2023	8:39:44	YH1SSS-2	ARISS	SuryaSat-1 in Commissioning phase	Bruges, Belgium
41	1/7/2023	10:16:34	YH1SSS-2	ARISS	SuryaSat-1 in Commissioning phase	Bruges, Belgium
42	1/7/2023	11:37:00	YH1SSS-2		SuryaSat-1 in Commissioning Phase	Fayetteville, North US
43	1/7/2023	11:37:12	YH1SSS-2	ARISS	SuryaSat-1 in Commissioning phase	Iowa, US
44	1/7/2023	13:12:56	YH1SSS-2	ARISS	SuryaSat-1 in Commissioning phase	Iowa, US

No.	Date	Time (GMT+7)	Call Sign	Via	Data Package	Est. Location
1	1/6/2023	16:33:31 - 16:44:06	YH1SSS-1		0011111000010010;3.90;14.56;28.02;0.00;0.00	Adelaide, Australia
2	1/7/2023	06:58:35 - 07:06:24	YH1SSS-1	APOT30	SuryaSat-1 in Commissioning Phase	Ireland
3	1/7/2023	08:33:17 - 08:44:29	YH1SSS-1	APOT30	0011111010000010;3.29;16.45;22.99;0.0;0.0	Ireland
4	1/7/2023	12:13:49	YH1SSS-1	ARISS	0011111011000010;3.15;8.06;12.39;0.03;200.39E-6	Curepipe, Mauritius

Operational- Anomaly #1

- Anomaly observed in the satellite thermal system
- Heater seems to be working as designed (maintain battery temperature at above 15°C)
- But the usage of heater exceed initial expectation





Operational – Anomaly #1 Reason

- Heater to work if battery temperature reach ≤10°C, and heat the battery until 15°C
- Heater test on ground indicate heater can heat 0.3 °C/min
- Meaning 16 min of heater power should be sufficient
- Thus, initial duration of heating operation is only 25% of orbit time (in eclipse duration)
- The data received indicate the space is much colder thus heater work reaches 100% of orbit time
- This cause battery DoD to exceed the initial design

Operational – Anomaly #1 Solution

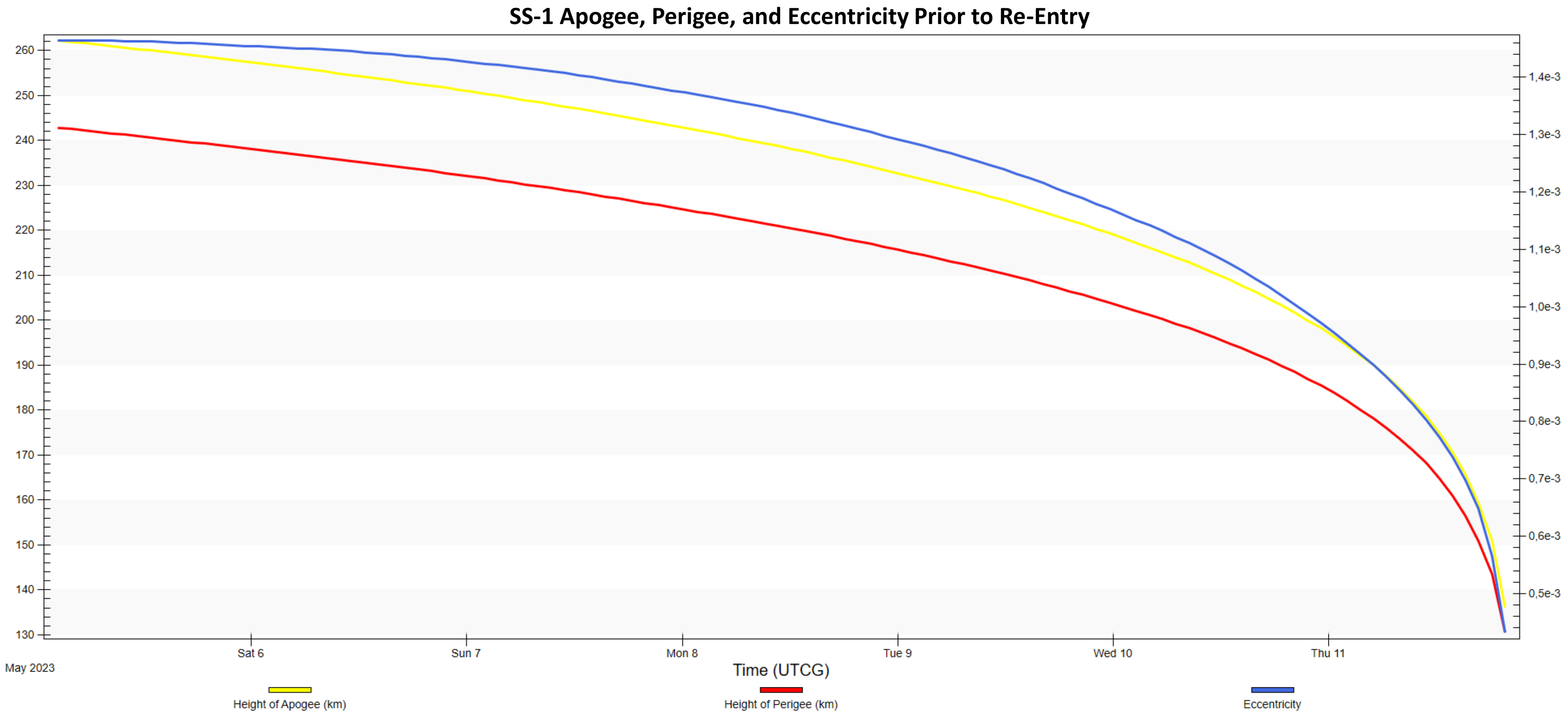
- Satellite has a soft limit, which will stop any heater activity if the battery is at 3.3V
- This function is confirmed to work at the latest telemetry data

No.	Date	Time (GMT+7)	Call Sign (SS-1)	Via	Call Sign (Amateur Radio)	Data Package	Est. Location
1	06/01/2023	16:33:31 - 16:44:06	YH1SSS-1		1382 - ITR UHF	0011111000010010;3.90;14.56;28.02;0.00;0.00	Adelaide, Australia
2	06/01/2023	18:11:00 - 18:15:04	YH1SSS-2	APOT30	2623 - vk2pet western Aust Discone	0011111000010010;3.83;15.70;27.48;0.20;0.00	West Autralia
3	06/01/2023	18:14:43	YH1SSS-2	RS0ISS*	YC2YIZ	0011111000010010;3.83;15.70;27.48;0.20;0.00	Yogyakarta, Indonesia
4	06/01/2023	18:14:44	YH1SSS-2	RS0ISS*	YD9CKH	0011111000010010;3.83;15.70;27.48;0.20;0.00	Bali, Indonesia
5	06/01/2023	18:14:44	YH1SSS-2	RS0ISS*	YC2YIZ-4	0011111000010010;3.83;15.70;27.48;0.20;0.00	Yogyakarta, Indonesia
6	07/01/2023	08:33:17 - 08:44:29	YH1SSS-1	APOT30	2271 - EIRSAT-1 GS - UCD Physics	0011111010000010;3.29;16.45;22.99;0.0;0.0	Ireland
7	07/01/2023	12:13:49	YH1SSS-1	ARISS	3B8DU	**0011111011000010**;3.15;8.06;12.39;0.03;200.39E-6	Curepipe, Mauritius

- The last telemetry indicates that the battery does need heating, but the heater is not turned on due to low battery voltage
- From the situation, increasing the transmit interval between the SS-1 beacon in VHF and UHF payload was the best way to optimize the power consumption. The team has set the transmit interval as long as possible.

End of Life

- Based on the prediction, SS-1 reached Karman Line on 11 May 2023 (UTC). The last TLE release was on 9 May 2023 (UTC)



Result and Outreach

Exposure and Media Engagement

Launch and Deployment Event from mainstream media

- >1,000,000 views
- >2300 comments

5 Publications:

- Development of Nanosatellite Technology with APRS Module for Disaster Mitigation – May 2018
- Requirements and design structure for Surya Satellite-1 – May 2018
- Design and Implementation of Effective Electrical Power System for Surya Satellite-1 – May 2018
- Design Structure, Dynamic Simulation, and Thermal Simulation of Surya Satellite-1 – April 2019
- The Development of Surya Satellite-1: Pioneering Indonesia Nanosatellite – soon to be released

18 Capacity Building Activities

Workshops, Seminars, Webinar, Podcast, Site Visit

Successful Objective Evaluation

Objective	Evaluation Method	Result
Satellite able to beacon APRS data	Any Ground Station could receive transmitted APRS data containing satellite conditions	Successful Data received right after the satellite deployment
Satellite able to digital repeating	APRS messages transmitted to the satellite are re-transmitted to other ground station	Cannot be verified Successfully done digital repeating in ground test, but during the operation the capability had not been activated due to safe operation mode
Apply satellite for remote communication and scientific data collection for disaster mitigation	Remote user messages or APRS messages from remote stations containing scientific data samples of disaster probability are re-transmitted by the satellite to any ground station.	Cannot be verified Disaster mitigation event had not occurred during the operation period and the digital repeating capability had not been activated.
Improve education on satellite development in Indonesia, especially in nanosatellite	More participation from student and communities in workshop and events held by SS-1	Successful More students and organization had visit to SS-1 and invite SS-1 members to share the expertise
	Another nanosatellite launched from Indonesia after the SS-1	Partially Successful Some nanosatellite projects have been initiated and under development but not yet launched
	More scientific publication in the field of small satellite design and utilization from Indonesia.	Successful More scientific publication from Indonesia has been released including from SS-1

Contribution on Sustainable Development Goals

- ✓ Created opportunities for the team members in pursuing higher education in Space sector
- ✓ Inspired high schools, universities, and communities in Space Education

- ✓ Fostering innovation in Space technology, which still a niche sector in the country
- ✓ Triggered industrialization in the small satellite business

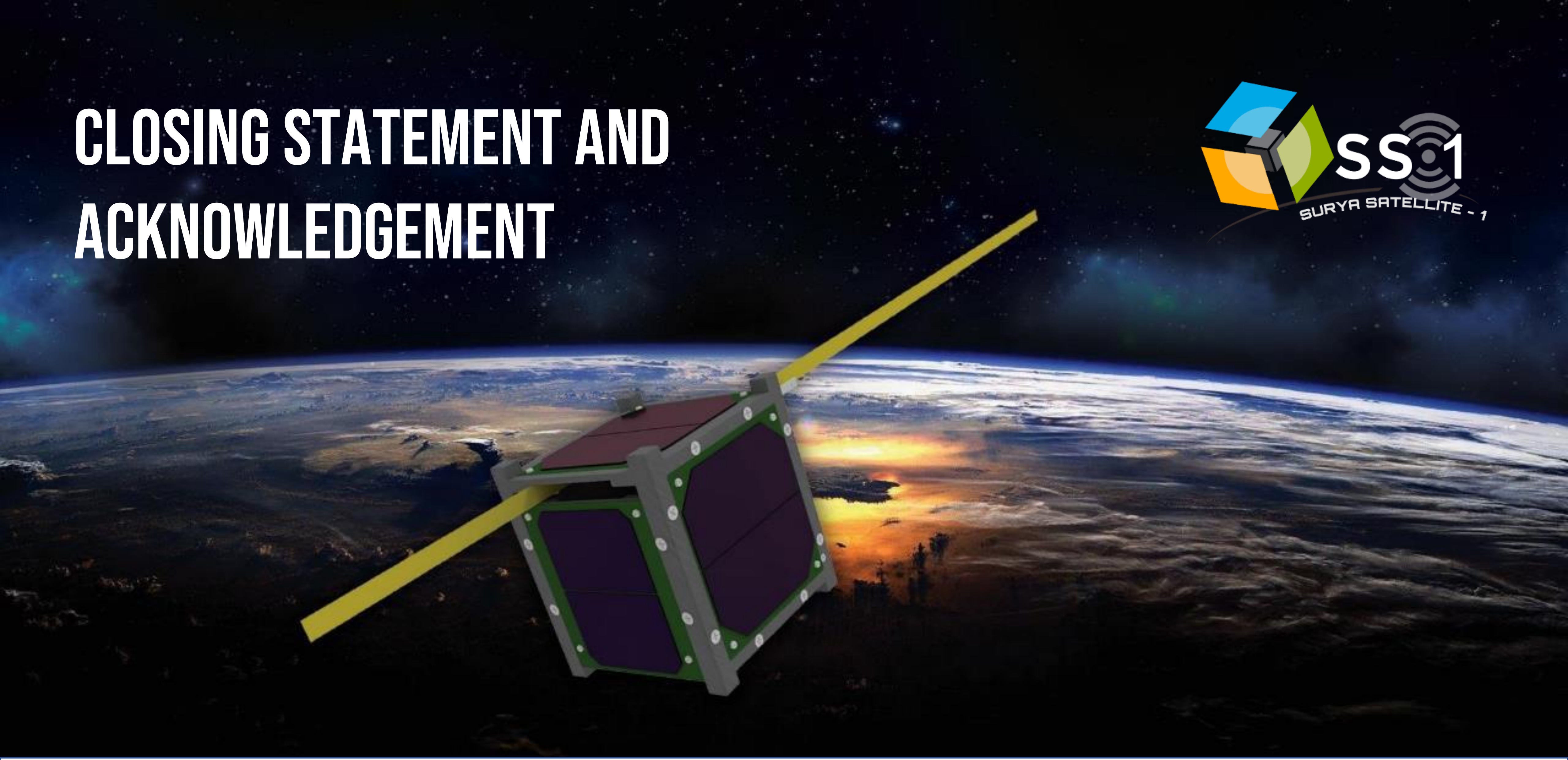
- ✓ Enable a first space entity coming from outside of big companies
- ✓ Proven that space is accessible for all especially a developing country

- ✓ Laid a foundation of local partnership ecosystem with capability in the space program
- ✓ International collaboration has enabled access to space

Conclusion Future Improvement

- **Power budgeting**
  - To consider colder environment
  - To do TVAC test harsher environment
  - To increase power inputs / decrese power output
- **Electrical Power System**
  - To add robust deep discharge protection system
- **Software Development**
  - To design more robust architecture which can monitor and control all part of satellite
  - To implement OTA
- **To add ADCS (Attitude Determination and Control System)**

CLOSING STATEMENT AND ACKNOWLEDGEMENT



Closing Statement

Despite reaching its end-of-life, SS-1 has left a lasting positive impact on our team. It has been an invaluable life experience, and we humbly acknowledge that there is still much to learn. **The pioneering spirit of SS-1 continues to inspire us, igniting our eagerness to seize future opportunities** and actively contribute to the advancement of Indonesia's Space Program.

As we bring our SS-1 project to a close, we sincerely thank all those who have been a part of our journey. Your support and involvement have been instrumental, and we are excited for the adventures ahead.

Acknowledgement

We as SS-1 team would like to thank:

- BRIN especially Mr. Wahyudi Hasbi and his team for unwavering support to our team. Your experiences and feedbacks are valuable asset for us
- PT PSN especially Mr. Adi Rahman Adiwoso for being our true believer and for facilitating SS-1 operation activity
- ORARI especially Mr. Yono Adisoemarta for guiding us in ground station and payload side of SS-1
- UNOOSA and JAXA for all the support given since handover until satellite deployment
- And all stakeholders who have contributed to SS-1 project.

SURYA UNIVERSITY

PSN

ORARI
Organisasi Amatir Radio Indonesia
Indonesia Amateur Radio Organization

PUDAK SCIENTIFIC

INASA
INDONESIAN SPACE AGENCY

BRIN

KOMINFO

AMSAT-ID