Flight Model Development of the AGU Remote Innovative CubeSat Alert system - ARICA

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Abstract

We present the flight model development of the 1U CubeSat, AGU Remote Innovative CubeSat Alert system (ARICA), which is scheduled to be launched in the Japanese fiscal year 2021 as the JAXA Innovative Satellite Technology Demonstration-2 project. The main goal of ARICA is to demonstrate the real-time alert system of the transient astronomical sources using commercial satellite network devices. The development of the flight components has been finished in April 2021. The thermal vacuum test was conducted at the end of April 2021. The vibration and shock tests were performed in May 2021. We are currently in the final stage of the development of ARICA to be ready for launch.

Background

Gamma-ray bursts (GRBs)

- The prompt gamma-ray emission: a few milliseconds to a few minutes
- The afterglow emission: a day to a week
- GRBs are not possible to predict when and where they occur
  - The observations of GRBs require a quick alert to the ground for the follow-up observations of afterglows by various telescopes to understand the nature of GRBs

Current GRB alert system

- NASA's data relay satellite system
  - Requiring a contribution from NASA to be able to use
- An installation of a large number of ground stations throughout the orbit
  - Requiring a large number of efforts to prepare many ground stations
  - We will develop a new GRB alert system using a commercial satellite communication service and demonstrate its capability using the CubeSat.

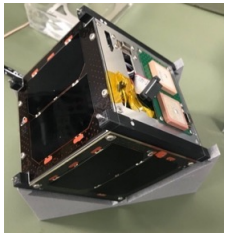
Features of ARICA

2 types of commercial satellite network devices

- Short Burst Data (SBD) using the Iridium satellite
- Eyestar-S3 (Eyestar) using the Globalstar satellite
  - Unclear whether they can be used as real-time communication capabilities as a new GRB alert system between ground and space

Component

- Mission component - Our development
- The flight satellite bus components - Purchasing from AAC-Clyde Space
  - Shorten the development period



ARICA

Mission Goals

①Alert the burst information to the ground within a minute.

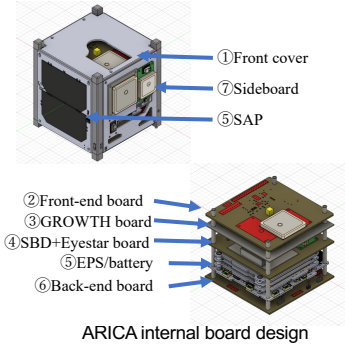
②Receive the housekeeping data regularly for more than 70% of the operation time.

③Measure the tolerance to the radiation of the gamma-ray detector (GAGG+MPPC) for 6 months and make sure there is no significant degradation in its performance.

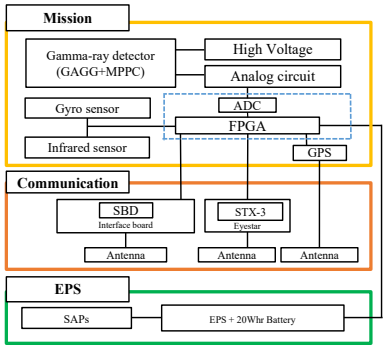
④A command uplink to the satellite within 10 minutes anywhere in the orbit.

Satellite Design

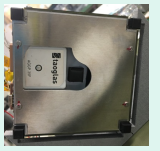
Size: 1U (10 cm x 10 cm x 10 cm)



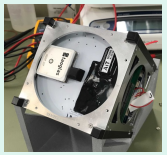
ARICA internal board design



System diagram of ARICA



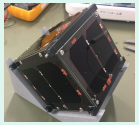
① Front cover plate
- 1.6 mm thick aluminum plate



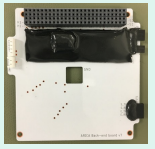
②Front-end board
- Equipped with a GPS module, an antenna and a gamma-ray detector
- 1.5 mm think lead tiles on the back

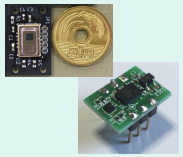
③GROWTH board
- To control the system
- Originally developed for thundercloud gamma-ray detection
- FPGA: Artix-7

④SBD+Eyestar board
- Two communication devices



⑤EPS/battery, SAPs
- The EPS/ 20Whr battery and 4 SAPs





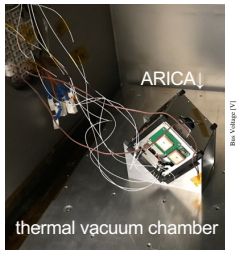
⑥Back-end board
- Equipped with a gyro sensor and a connector of the infrared sensor
- External connection ports so that we can connect to a battery charging port, RBF, or communication devices

⑦Sideboard plate
- Equipped with an infrared sensor and each antenna
- Aluminum with 0.9 mm thickness

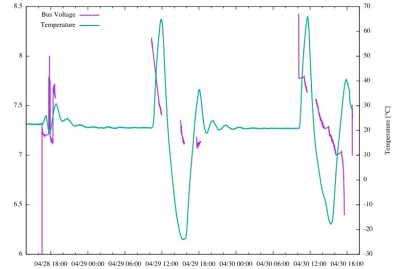
Test

Thermal vacuum test

April 27th ~ 30th @the Institute of Space and Astronautical Science
Purpose: To see if ARICA can operate in an environment close to outer space
Monitoring: Temperatures (ARICA and the chamber),
The HK data from the spacecraft
Process: vacuum state→HK data (the room temperature)→ 50°C→ HK data → -30 °C→ HK data → 50°C→ HK data → -30 °C→ HK data → the room temperature
Through this test, we were able to confirm that the satellite functions normally even under temperature changes and a vacuum environment.



ARICA inside the thermal vacuum chamber

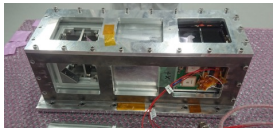


Temporal variations of the bus voltage (purple) and the temperature inside the chamber (green) during the thermal vacuum test

Vibration and Shock test

May 24th ~ 26th @Kyushu Institute of Technology
Purpose: To make sure that the satellite can withstand the vibrations that occur when the rocket launches without any failure.
Container: Kyushu Institute of Technology and JAXA

After these tests, the attached screws were not loosed or broken. and there was no problem in the basic function of the satellite before and after the tests.



ARICA inside the container of Kyushu Institute of Technology

Conclusion and Future work

We are constructing 1U CubeSat ARICA to demonstrate a real-time alert system for transient astronomical sources such as GRBs using commercial satellite networks. As part of JAXA Innovative Technology Demonstration-2, we will proceed with final preparations for launch in the Japanese fiscal year 2021.

Contact Information

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For more details, please refer to the paper.

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