VIETNAM ACADEMY OF SCIENCE AND TECHNOLOGY
VIETNAM NATIONAL SATELLITE CENTER

CUBESAT PICO DRAGON

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Introduction

The model of Vietnam Space Center in 2017

- Vietnam National Satellite Center (VNSC), which was established in 2011, is a research center under Vietnam Academy of Science and Technology (VAST).
- VNSC has the functions of research and development, technology applications, and development of high quality human resource in satellite technology; receive, manage and implement Vietnam Space Center Project.
- Deriving from the strategy: “Research and application of space technology” from 2007 to 2020 of Vietnamese government, Vietnam National Satellite Center deployed a Cubesat project in order to build the Flight Model (FM) of Pico Dragon and launch it into the orbit.

Introduction

08/2010 — 12/2012 — 8/2013 — 19/11/2013

- Manufacturing, integrating and testing the Flight Model of Pico Dragon
- Building and operating the Ground Station
- Ground testing of Pico Dragon
- Launching Pico Dragon to the International Space Station (ISS)
- Releasing Pico Dragon into the orbit

Timeline of Pico Dragon project

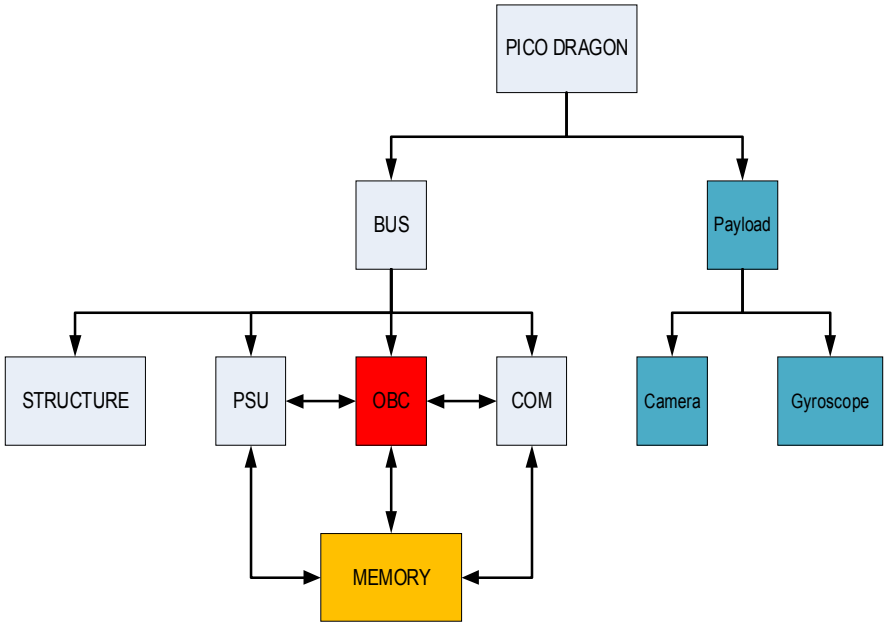
- Mass: ~ 1kg
- Dimensions: 10cm x 10cm x 11.35 cm
- Orbit from International Space Station (ISS)
  - ✓ Altitude: 398 km
  - ✓ Inclination: 51.6°
  - ✓ Period: 92.90 minutes
  - ✓ Orbit type: Circular

Introduction

- **Missions of Pico Dragon**
  - ✓ Taking pictures of the Earth.
  - ✓ Collecting the environment data by sensors which are equipped on the satellite.
  - ✓ Communicating and exchanging the data with the ground station.
- **Success Criteria**
  - ✓ Minimum success level
    - Flight model of Pico Dragon is completed and building a ground station which can communicate with satellites successfully via both uplink and downlink.
    - The launch of the satellite.
  - ✓ Full success level
    - Providing a reliable communication and data transfer between spacecraft and ground station in both directions.
    - Taking accepted quality pictures of the Earth.
    - All subsystems fully operational as designed.
  - ✓ Extra success level
    - Implementing four levels of camera design operation successfully.

System Design

- OBC: monitoring operation of the Pico Dragon, excuting the commands, transmitting and saving the information received from the Ground Station.
- COM: transmitting and receiving the radio frequency signals.
- PSU: monitoring and controlling the power of solar cells and batteries.
- Payload: doing missions of Pico Dragon.
- Structure: ensuring that Cubesat can endure the harsh conditions in launching and space environment.



Blocks Diagram of Pico Dragon

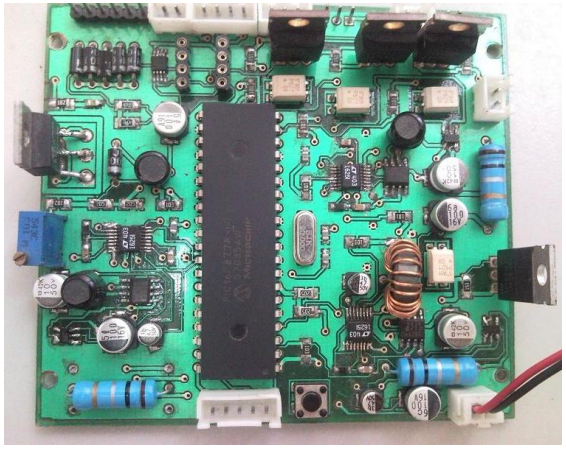
System Design

- **Onboard Computer (OBC)**
  - ✓ Main MCU: 8bit Microcontroller Unit PIC16F877A.
  - ✓ The 32Kb EEPROM as the main data storage.
  - ✓ Functions of the OBC subsystem of Pico Dragon are as follows:
    - Get sensors data and store them in onboard memory (24C256 – 32K EEPROM)
    - Take pictures from space (random pictures)
    - Generate the Continuous Wave (CW) signal
    - Receive commands from ground station and execute them
    - Form data packets for downlinks and output them to the communication subsystem via serial lines

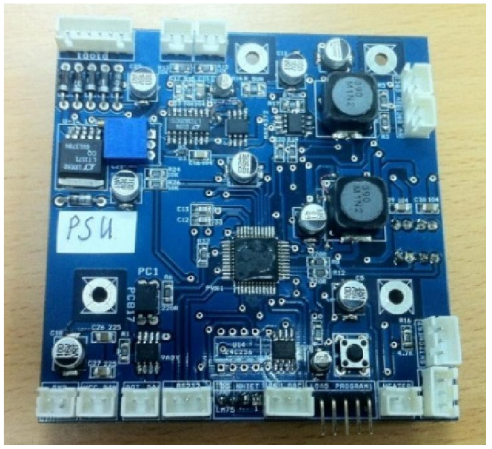
OBC Circuit Board

System Design

- **Power Supply Unit (PSU)**
  - ✓ Functions of PSU
    - Providing power for operation of other subsystems.
    - Collecting temporary voltage and current values to transfer to the ground station.
    - The backup for OBC.
    - Controlling the antenna deployment.
  - ✓ Including 3 components: solar cells, batteries and processing circuit board.



PSU Circuit Board of BBM Model

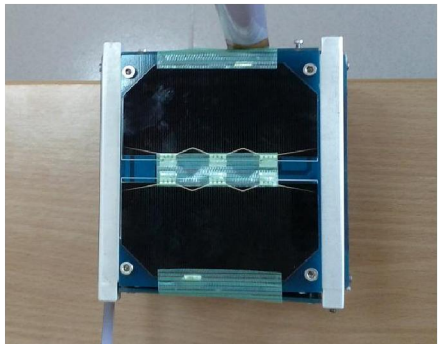


PSU Circuit Board of Flight Model

System Design

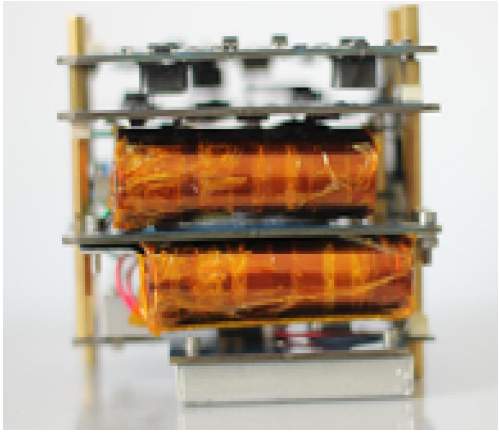
- ✓ Solar cells of Pico Dragon: Azurspace solar cell.

Dimension	40.15 x 80.15 mm
Average weight	≤ 116 mg/cm2
Thickness	380 ± 25 µm
Power	2.35 W (2 cells)



- ✓ Battery of Pico Dragon is chosen to satisfy some requirements such as: capacity, operation range temperature and capability of enduring harsh conditions in space environment.

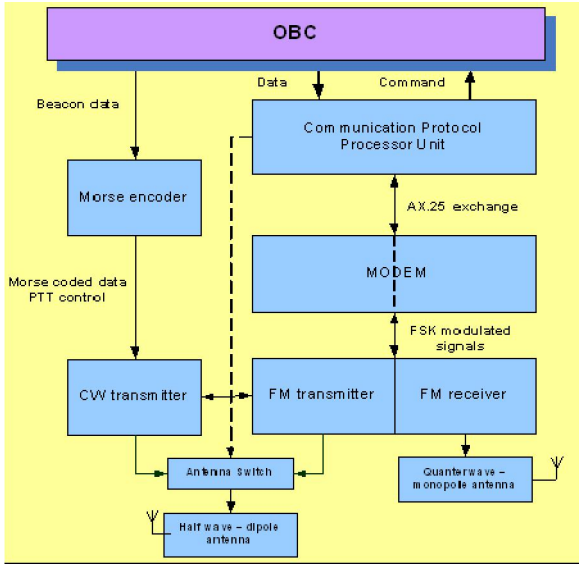
Battery Type	Li-ion
Diameter	18.3 mm
Height	65 mm
Nominal Voltage	3.7 V
Capacity	1450 mAh
Temperature	-5°C – 60°C



System Design

- **Communication (COM)**
  - ✓ Designing with two transmitters (430 MHz) and one receiver (144MHz).
  - ✓ A CW transmitter with low power (~100 mW). Another one is a FM transmitter with output power about 1W. Both of them use one sharing half-wave dipole antenna with an antenna switch provided.
  - ✓ One quarter-wave monopole antenna is used for the receiver.

Transceiver Nishimusen of Pico Dragon



Function Diagram of Communication Subsystem

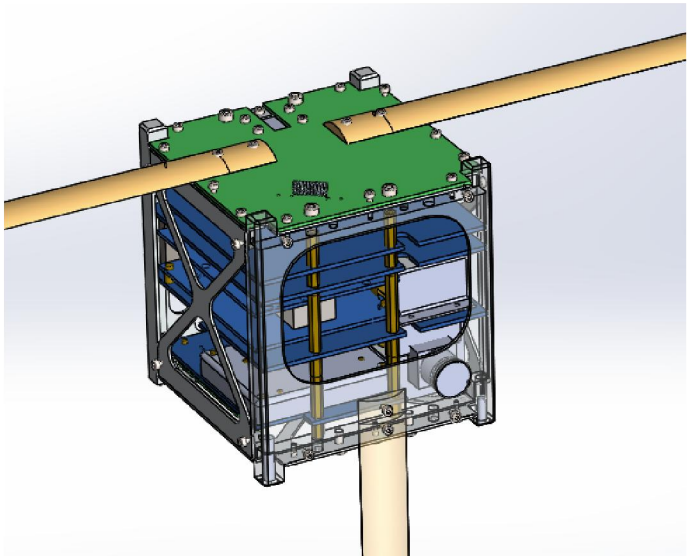
System Design

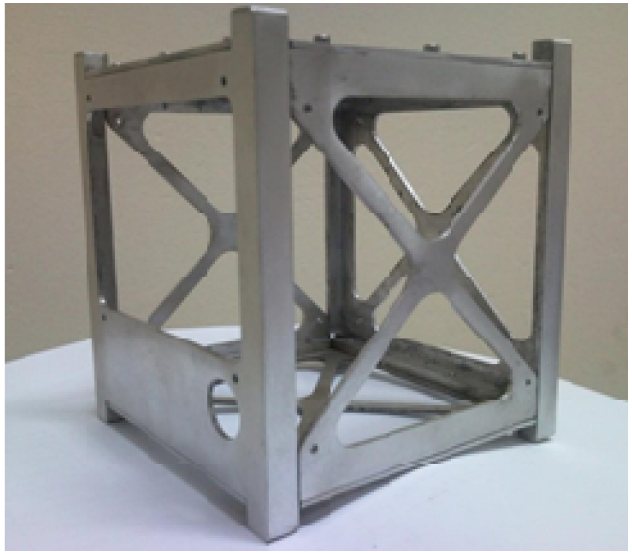
- ✓ In normal operation, Pico Dragon sends to the Earth continuously the message “PICO DRAGON VIET NAM” that is encoded in Morse code in every 30 seconds via CW transmitter.
- ✓ Pico Dragon will transmit the photos to the Earth when it receives commands from the Ground Station.

The default picture is stored in the memory of Pico Dragon

System Design

- **Structure**
  - ✓ Mass: 220g.
  - ✓ Material: Aluminum 6061-T6.
  - ✓ 2 main frames, top plate and bottom plate, two plates of either side. Some of them are integrated with solar panels.

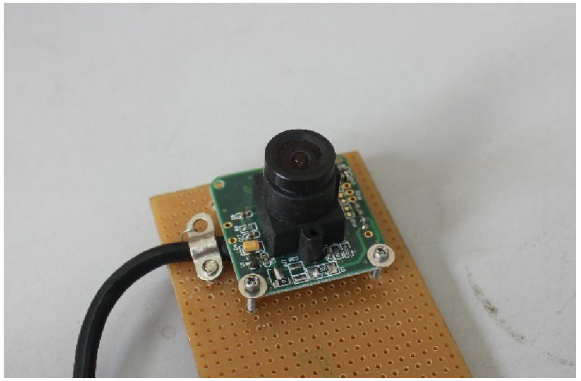


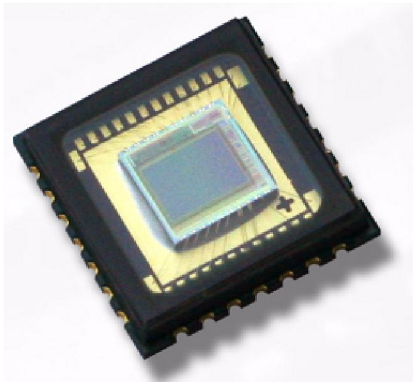


Structure of Pico Dragon

System Design

- **Payload**
  - ✓ The main payload of Pico Dragon is the camera that can compress images in JPEG format, using OmniVision CMOS VGA color sensor with low power consumption.
  - ✓ A 3- axis gyroscope equipped in Pico Dragon to measure angular velocity of 3 axes when the satellite moves on the orbit.
  - ✓ Some types of sensor to gather data of the temperature, voltage and current of satellite systems during its operation.





System Design

✓ The Ground Station

Control System

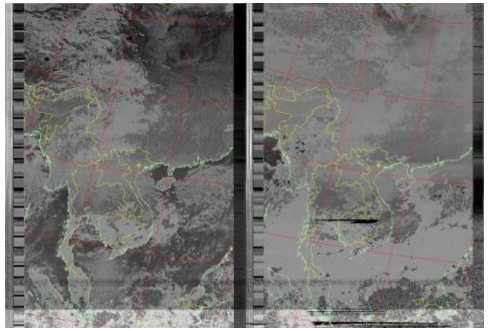
- Transceiver: TS-2000 (Kenwood)
- Terminal Node Controller: PicoPacket
- Rotator antenna controller: G-5500
- Tracking Interface: GS-232B

Antenna System

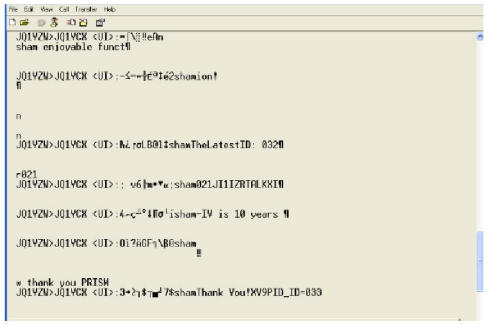
- Anten Yagi
  - Gain: 12 – 15 dB
  - Receiving antenna: 430 MHz
  - Transmit antenna: 144 MHz
- Low Noise Amplifier: SP7000 (Gain: 20 dB)

System Design

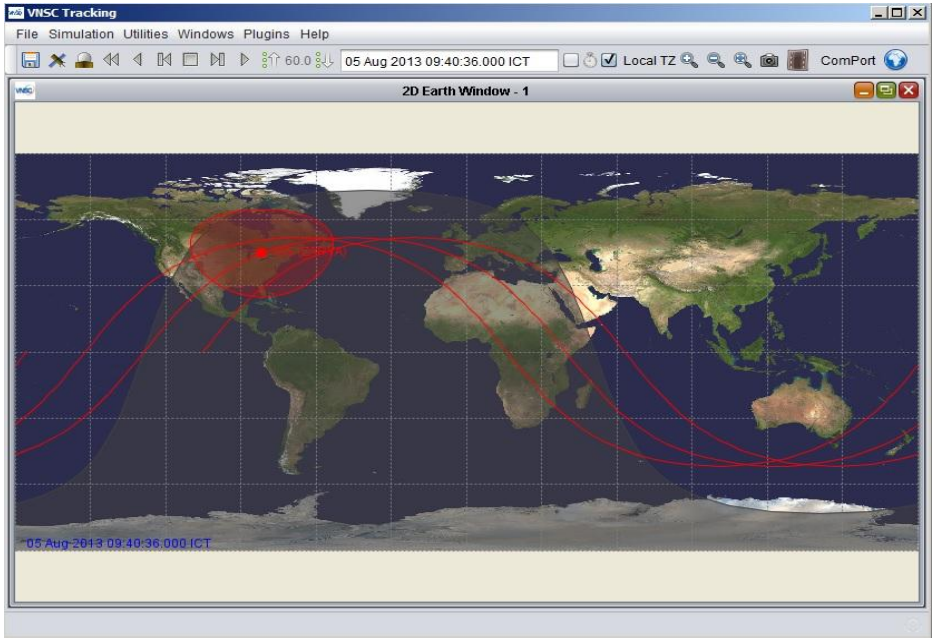
- ✓ Ground Station Software
  - Predicting and tracking software: VNSC Tracking, SatPC32, Wxtrack.
  - Software for controlling operation of Pico Dragon.
  - CW decoding software of Cubesats (PRISM, XI-IV, XI-V, Cute-1) and image decoding software of NOAA satellites: CwGet, Audacity and WxtoImg.



Picture of NOAA 19



PRISM FM message

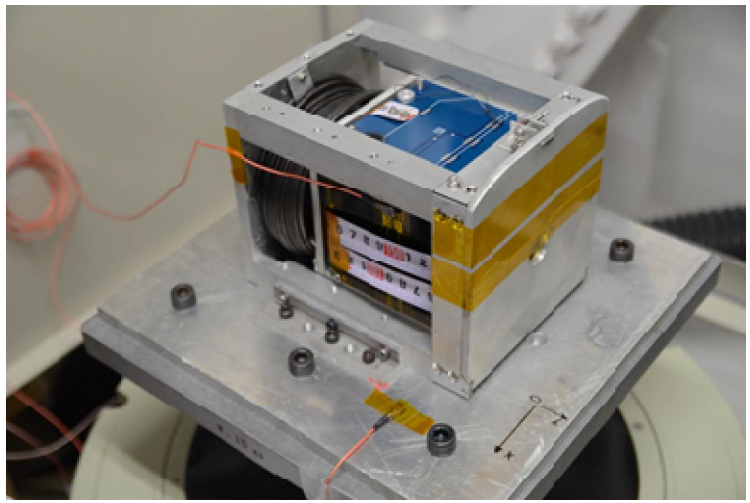


Tracking Software Interface

Environment Tests

- **Vibration test is conducted at Intelligent Space Systems Laboratory of the University of Tokyo**
  - ✓ The experiment is implemented with launching parameters of HTV-4 (flight value).

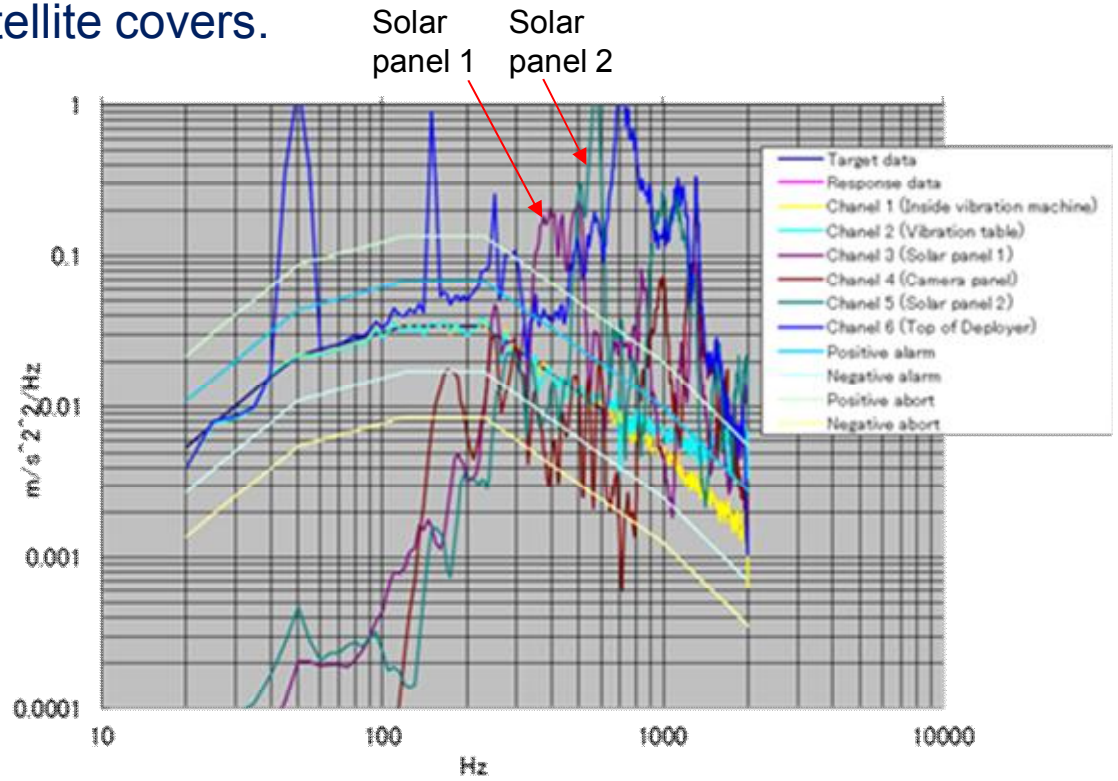
F (Hz)	Spectral Density (G^2/Hz)	
	Flight value	Acceptance Value
20	0.005	0.0055
50	0.02	0.0220
120	0.031	0.0341
230	0.031	0.0341
1000	0.0045	0.0050
2000	0.0013	0.0014



Vibration test setup

Environment Tests

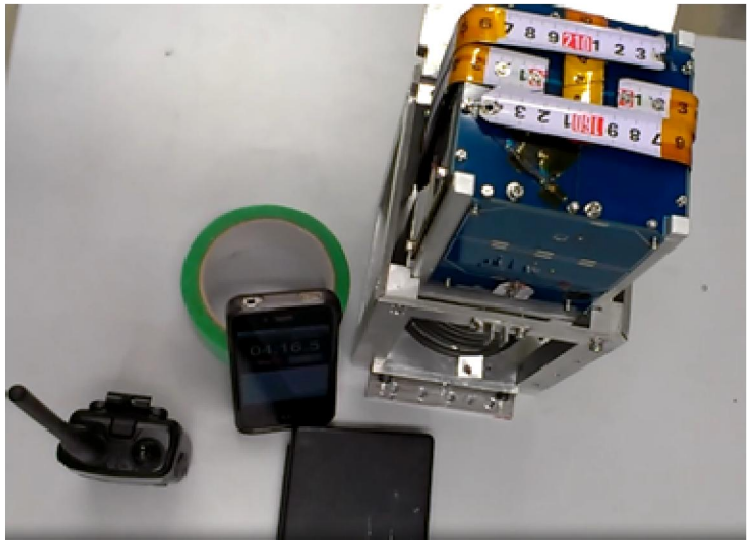
- ✓ The result of the test shows that the solar panel 1 (channel 3) and solar panel 2 (channel 5) had some of high magnitude of vibrations at about 400 to 800 Hz. The source could be the interaction between solar panels with satellite covers.

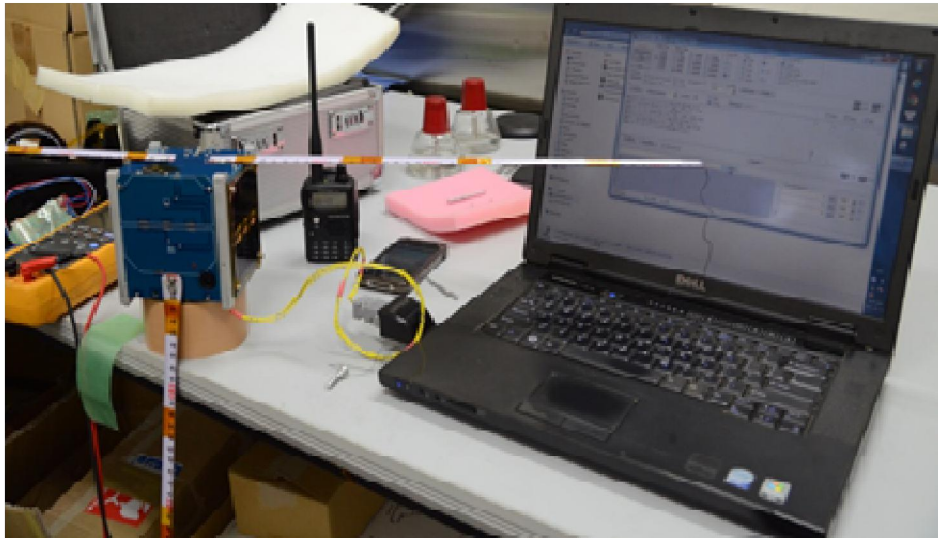


Result of random vibration test

Environment Tests

- ✓ Testing antenna deployment: Antenna is deployed successfully after 30 minutes as designed.
- ✓ Pico Dragon transmits CW signal nomarlly.
- ✓ Connectting Pico Dragon to PC to check data stored in the memory after vibration test. The data shows that operation of other subsystems are normal.

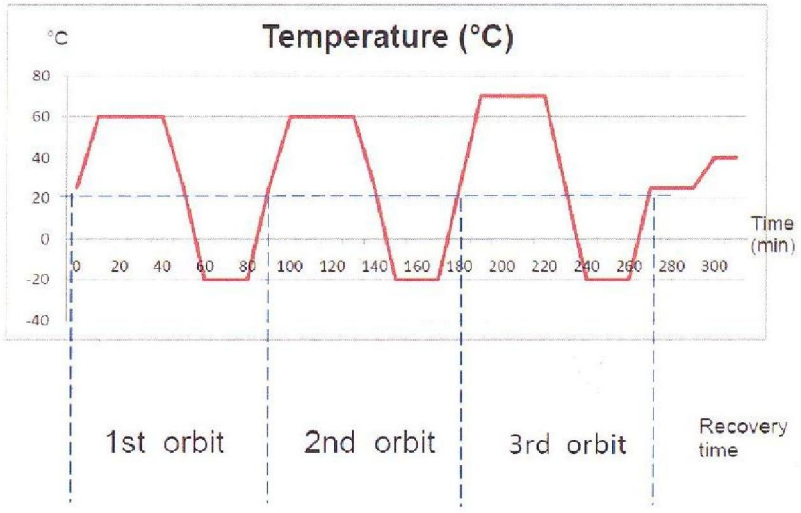




Environment Tests

- **Thermal test is implemented in PSL-2KP thermal bath, Intelligent Space Systems Laboratory**
  - ✓ The acceptance temperature range is from -20°C to 60°C.
  - ✓ Using transceiver TH-F7 to catch CW signals of Pico Dragon during the test.

Pico Dragon in the thermal bath

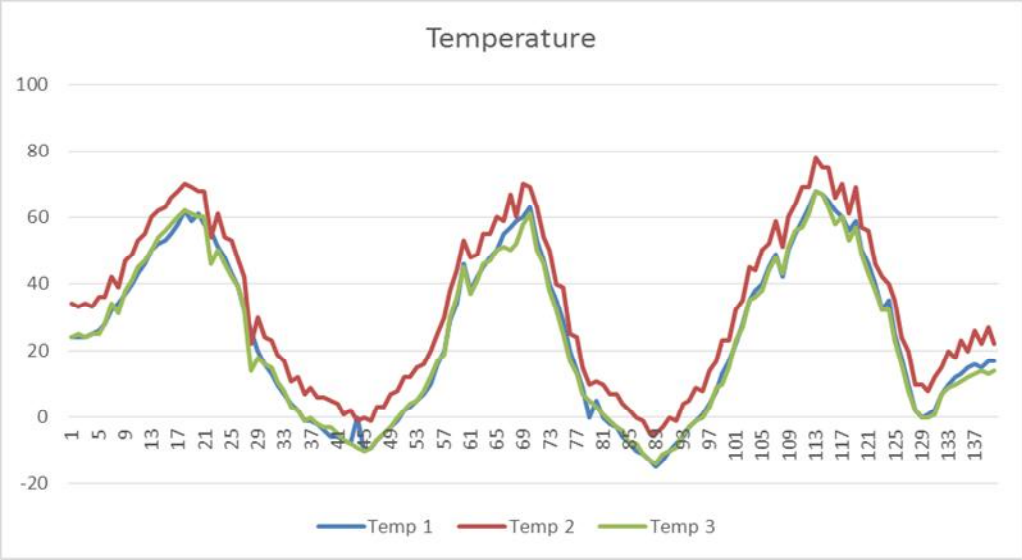


Thermal test cycle

Environment Tests

✓ *Result of the thermal test*

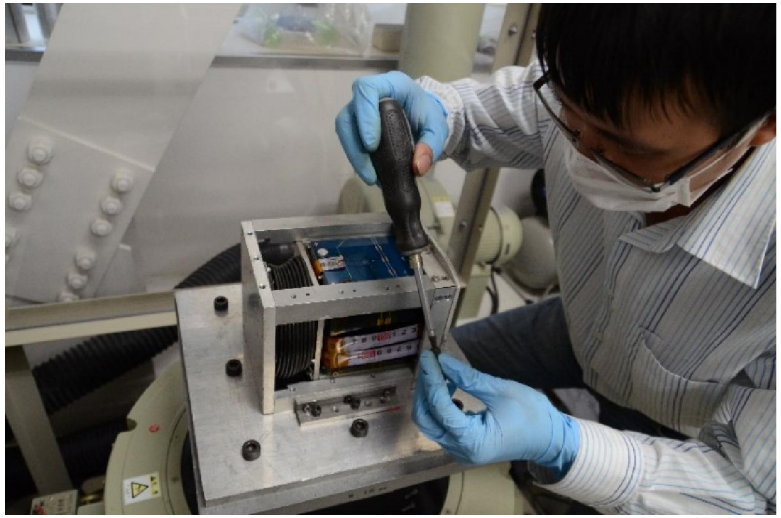
- CW operation is normal during the test.
- The mass of PDG is 989.0 grams and it doesn't change after finishing the vibration test.
- Operation functions is normal.



Temp 1: OBC board
Temp 2: Battery pack
Temp 3: PSU board

Launching Procedure

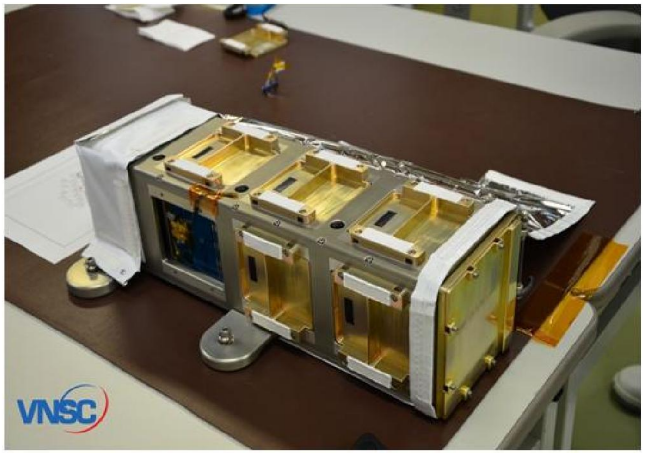
- ✓ **02/2013, sending request to JAXA for launching permission with the support of the University of Tokyo and IHI Aerospace.**
- ✓ **03-05/2013, submitting technical documents to JAXA for verification.**
- ✓ **14-22/5/2013, conducting environment tests for Pico Dragon at the University of Tokyo and Tsukuba Space Center.**



Launching Procedure

- ✓ **09/07/2013, Pico Dragon was transferred to JAXA in Tsukuba Space Center.**

- ✓ **22/07/2013, final test and putting Pico Dragon in the J-SSOD.**



Launching Procedure

- ✓ **04/08/2013: HTV-4 (Kounotori 4) cargo spacecraft was launched successfully, bringing Pico Dragon to the International Space Station (ISS).**
- ✓ **09/08/2013: HTV-4 arrived at the International Space Station - being captured by the Space Station's robotic arm.**

Launching of HII-B Rocket

HTV-4 was capturing by the robotic arm

Launching Procedure

- ✓ **19/11/2013: Pico Dragon was released from ISS in the evening following Japanese time.**
- ✓ **Early morning of 20/11/2013: Pico Dragon's beacon signals were captured by one member of the radio community in Japan.**

Pico Dragon Releasing

Pico Dragon Beacon

Beacon sound from Pico Dragon

Learning Lessons

- ✓ International cooperation with JAXA, the University of Tokyo and IHI Aerospace is very important to shorten the time for the project.
- ✓ We can learn from some mistakes during the development phase of Pico Dragon. Then, finally we can get the better design. This also helps us to develop other Cubesats (2U) in the future.
- ✓ Space engineering education: young researchers and engineers experienced all steps in the whole process of developing the satellite: from researching, designing, integrating, manufacturing, testing to launching.

THANK YOU FOR YOUR ATTENTION!