Development of Nano-Satellite "Cute-1.7+APD " and Its Current Status

Laboratory for Space Systems (LSS)
Tokyo Institute of Technology (Tokyo Tech)

Naoki Miyashita, Masafumi Iai, Kuniyuki Omagari, Katsutoshi Imai, Hideyuki Yabe, Kei Miyamoto, Thomas Iljic, Takeshi Usuda, Ken Fujiwara, Shinji Masumoto,Yasumi Konda, Saori Sugita, Tomio Yamanaka, Kazuya Konoue and Saburo Matunaga

Contents

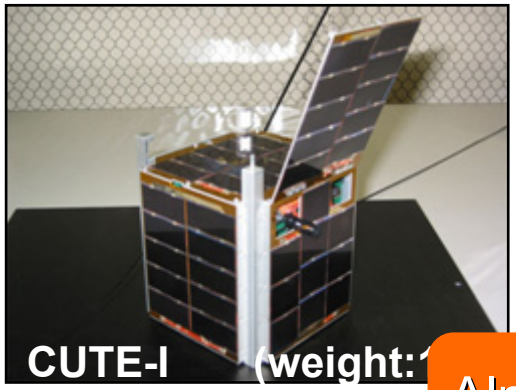
- Introduction (Success of CUTE-I)
- Objectives of Cute-1.7 + APD Project
- Mission Overview
- System Overview
- Operation Sequence
- Launch Rocket and Orbit
- Future Works
- Conclusions

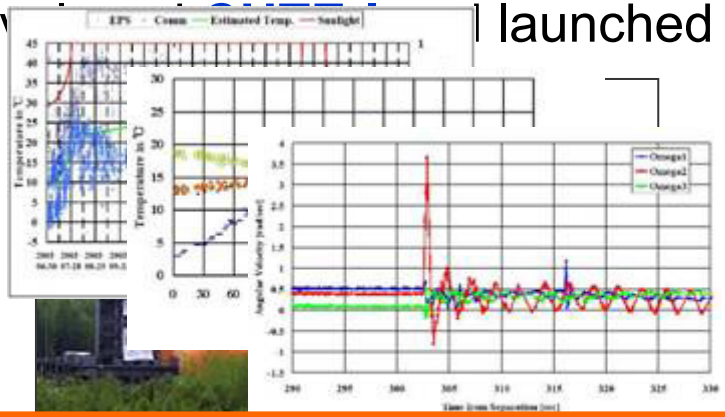
Introduction

CubeSat Project (10cm cubed pico-satellite)

2003.6

LSS at TokyoTech had dev launched it

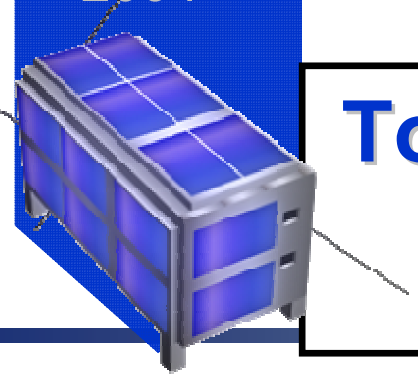




- Acquisition of satellite b
- Demonstration of stude

Almost all missions have been successed
2 years have passed !!

2004～



Tokyo Tech 2nd satellite
Cute-1.7
(20 x 10 x 10 cm, 3kg)

Objectives of Cute-1.7 Project

- To facilitate future nano-satellite development by demonstrating a new design methodology.

⇒ Use of Personal Digital Assinstance (PDA) and its peripheral devices.

- To demonstrate 3-axes attitude determination and control system for nano-satellite

⇒ Magnetic torquers attitude control

- To demonstrate newly developped observation equipment as a science mission

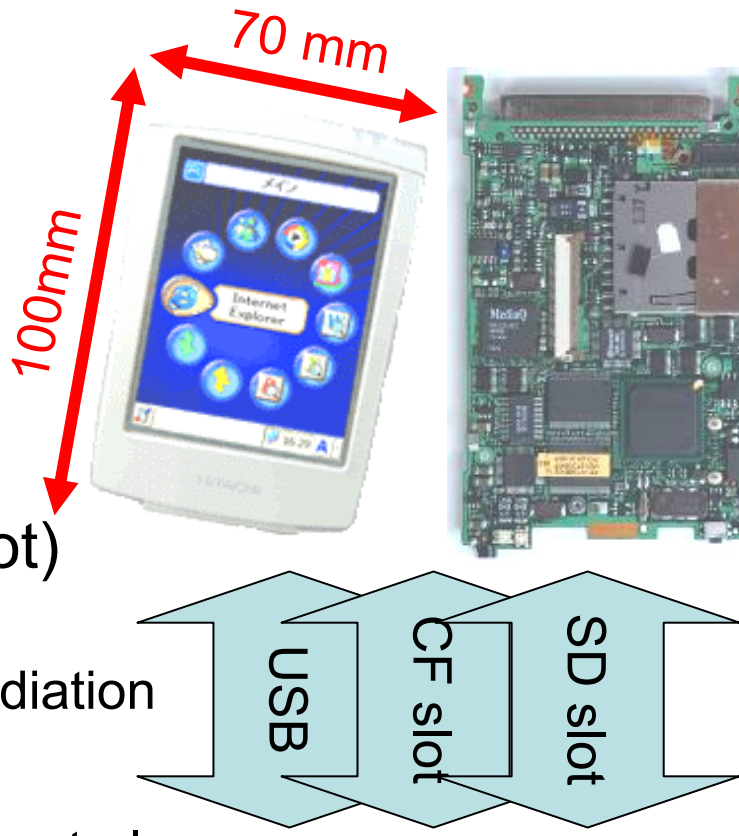
⇒ Demonstration of APD (Avalanched Photo Diode)

"Cute-1.7 **+ APD**"

(buss & technical mission unit) (science mission unit)

PDA-based OBC

- The main computer consists of two COTS-based PDAs (Personal Digital Assistance)
  - High performance
  - Easy software development
  - Many external interfaces (USB, CF card slot, SD card slot)

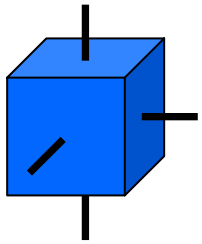


This PDA is good tolerant performance on radiation test at Osaka University In July 2004.

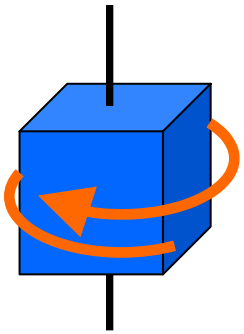
Moreover, Cute-1.7 + APD has redundancy control by two PDAs

ADCS Mission by Magnetic Torquer

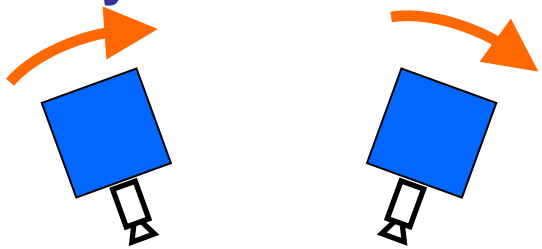
Magnetic Torquer is suitable and easy-use actuator for nano-satellite



3-axes stability



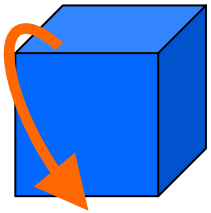
Spinning up



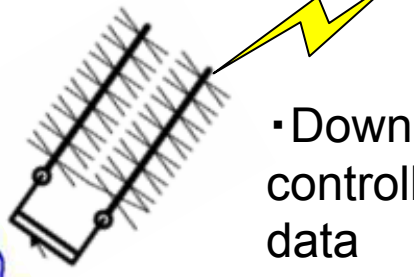
Low speed rotation in earth pointing

・synchronized taking pictures of ground point

- Enable to Upload
- 3-axes attitude control algorithm



No controlling



・Downlink : actual controlled attitude data

Torquer

ADS Sensor

Sun Sensor : photodiode

Gyroscope : AD Inc,

Magnet sensor : Honeywell

Earth Sensor : Camera

APD Mission (Science)

To Demonstrate APD (Avalanche Photo Diode) sensor; the new detector for charged particles

Characteristics

- Very small
- Low power consumption
- High performance

  High speed responses

  High internal gain

APD by Tokyo Tech astronomy lab.

Measure Low-E(E>3 kev) e-/p distributions in SAA and aurora band

APD will be installed on the future large X-ray astronomy satellite.

Digital Repeater Service Mission

World-wide Message Service via Cute-1.7 + APD amateur service

Cooperation with radio amateur community is important

- acquisition of telemetry data
- technical advise

Objectives

・To provide uplink opportunities for world amateurs

・To acquire basic Technique of communication satellite

Service contents and frequency band

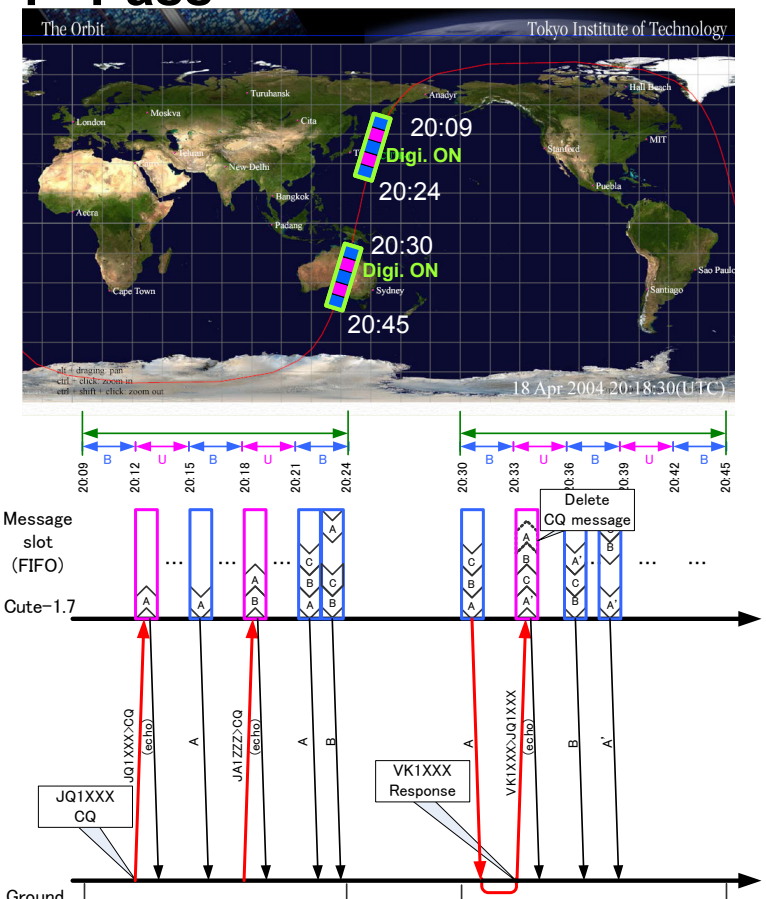
Digital Packet Repeater

Packet Upload : 1200MHz band

Packet Downlink : 430MHz band

Ex: Between Australia and Japan

1st Pass

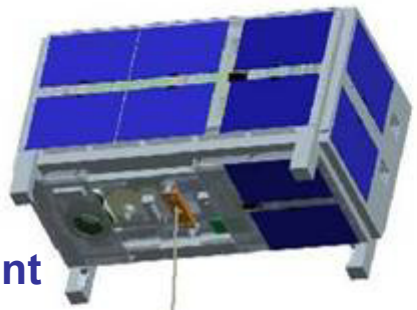


Tether Deployment Mission

Applications of tether deployment techniques

→De-orbit by electrical tether

→Tether attitude control for solar sail



By cutting the nylon thread to fasten, a plate begins to deploy

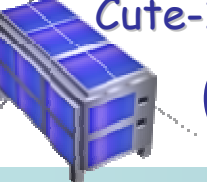
Detection by deployment sensors and camera

To demonstrate fundamental tether deployment for the future several tethered missions

ϕ0.1mm Copper tether

10 m in length

Initial velocity by pushing spring : 30cm/sec on micro gravity experiment at MGLAB, Japan



Cute-1.7

Configuration and Block Diagram

Shape 10cm×10cm×20cm, 3.0kg, Al5052

On Board Computer

Hitachi PDA NPD-20JWL (x2)，4Mbit SRAM (x2 Redundancy)

Communication (Amateur Radio Band)

Beacon Downlink: 430 MHz, CW (Morse), 100mW

FM Downlink: 430 MHz, GMSK/AFSK, 9600/1200bps, 300mW

FM Uplink: 144 MHz, AFSK/DTMF (for command)

1200 MHz, GMSK 9600bps (for Amateur service)

Power Lithium-Ion secondary batery(4400mAh), GaAs solar cell

Mission APD Sensor, Tether deployment mechanism

Attitude Sensor

Gyroscope, Sun sensor

Magnet resistive sensor

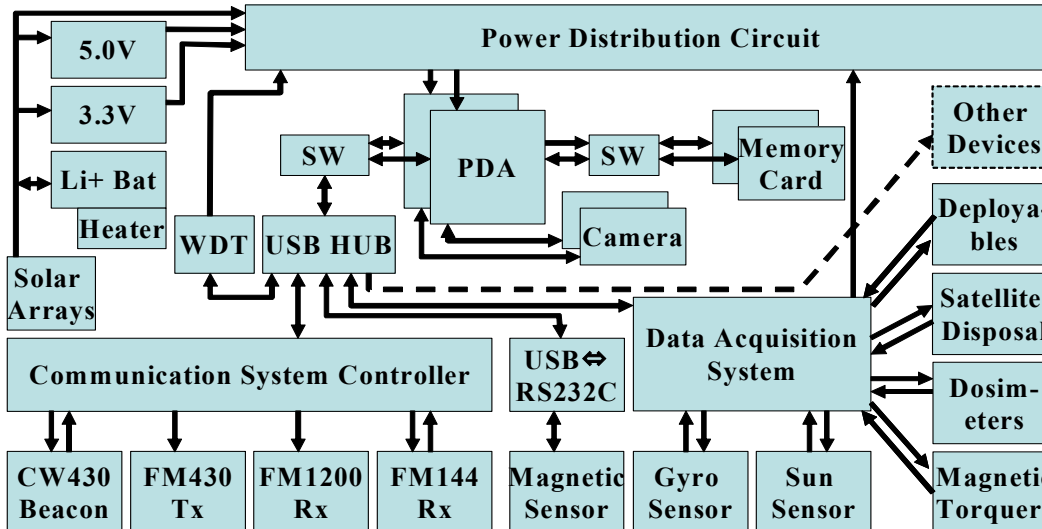
Dosemeter (RADFET)

Attitude Actuator Magnetic torquer

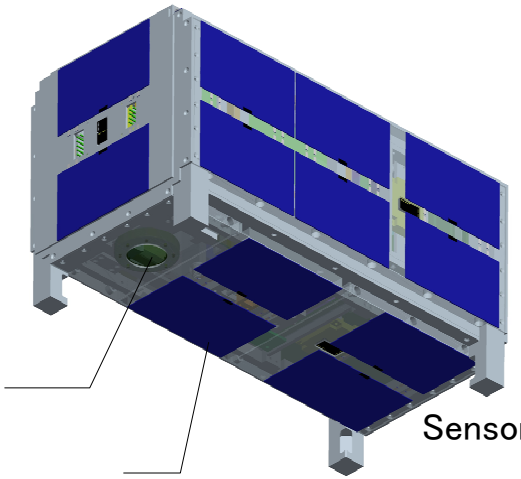
HK Sensors Themo-sensor

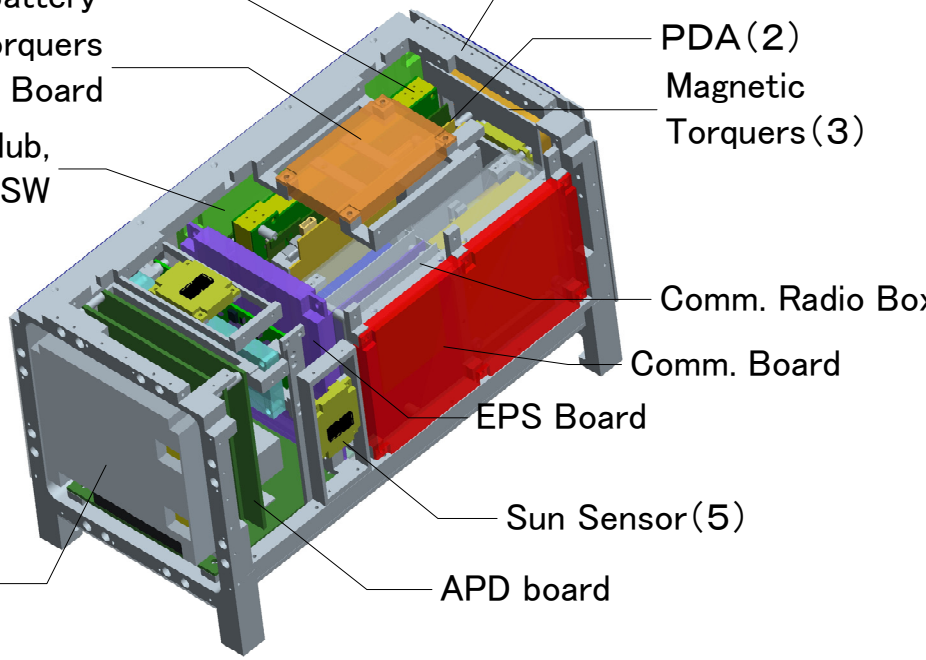
Voltage sensor, Current sensor

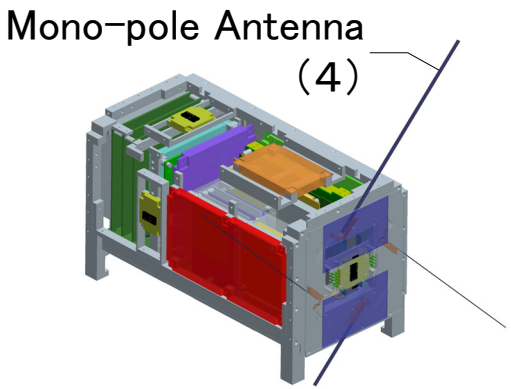
Camera CMOS 1.3M pixels



Structure View

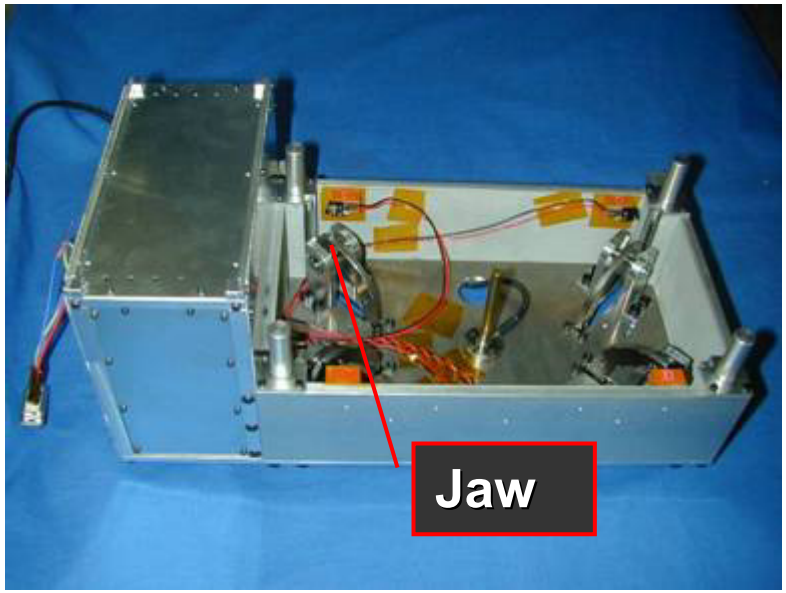


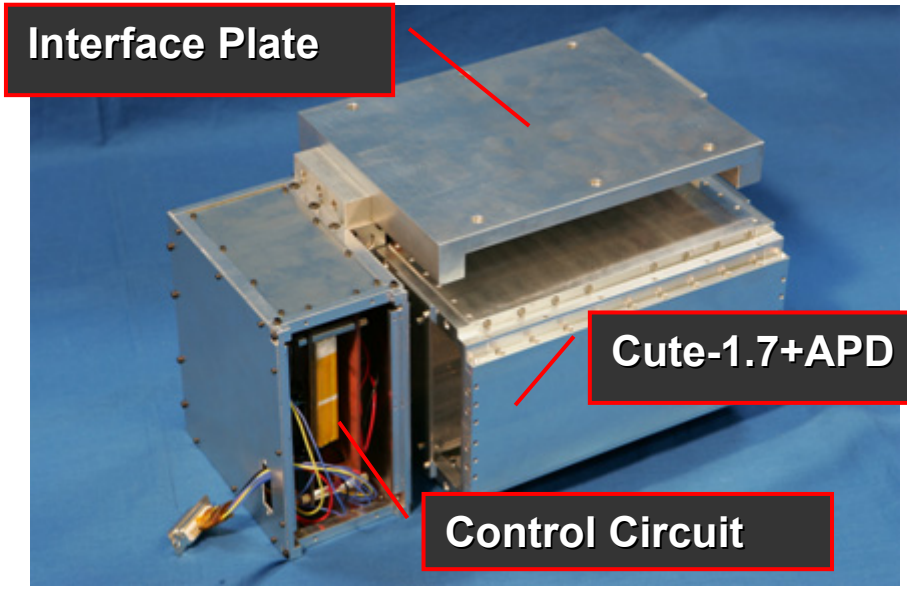




Separation System

- Mechanism
  - Cute-1.7 + APD is fixed by 4 jaws before separation.
  - Cute-1.7 + APD is separated by cutting the nylon thread fastening the jaws.
  - This mechanism is demonstrated by CUTE-I, TSD(Tokyotech Separation Demonstration at M-V#6).

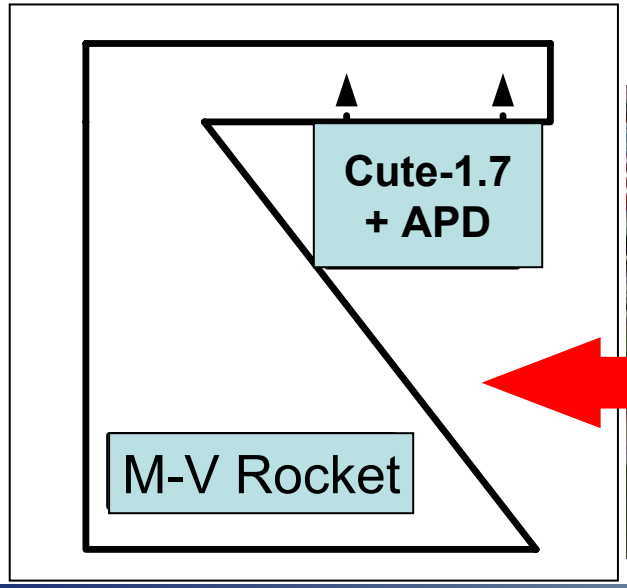


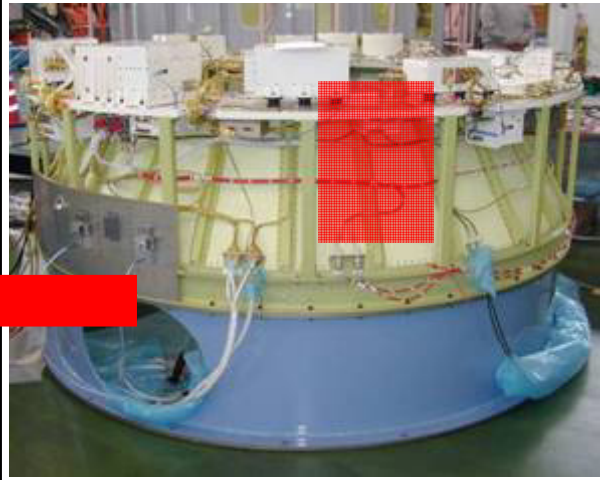


Launch Rocket and Orbit

- M-V Rocket #8 Sub Payload (preappointment)
  - Main Payload : JAXA ASTRO-F
  - Cute-1.7 + APD is Installed as a balance weight of 3rd stage

Perigee:185km , Apogee:800km
Inclination:98.4° Sun Synchronous





Ground Station

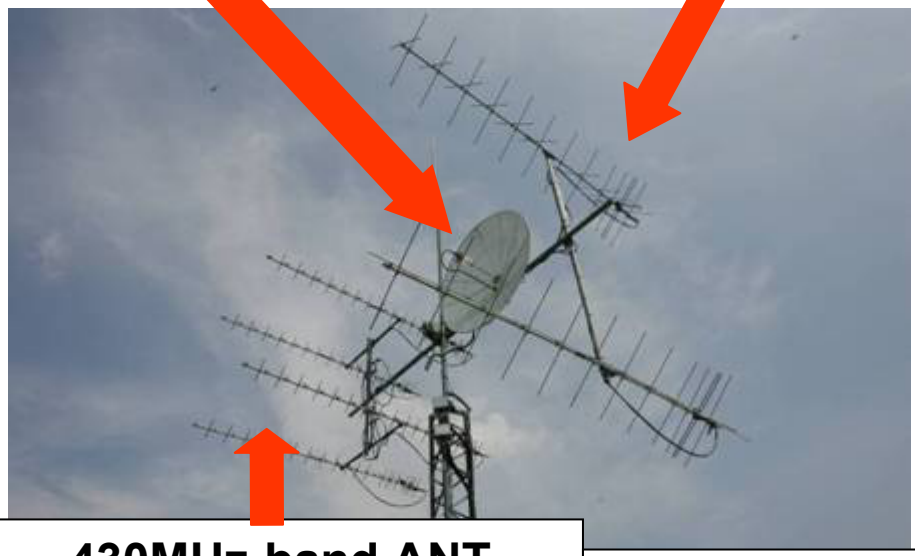
ANTcontroller

1200MHz-band ANT
（1.5D parabola）

144MHz-band ANT
（12ele crossYagi×2）

Control PC

Radio and TNC



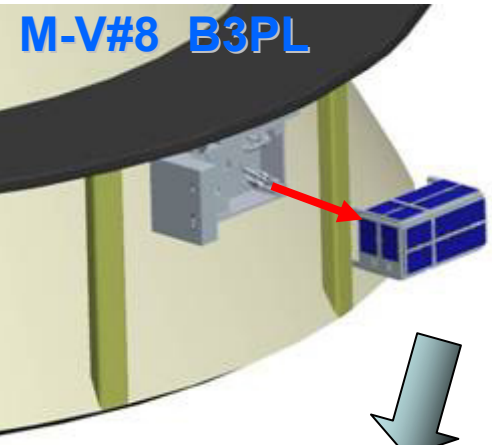
430MHz-band ANT
（20ele cross Yagi×4）

430MHz-band
（3 turn helical）

Operation room
（Tokyo Tech　LSS）

Ground St. ANT
（Tokyo Tech　rooftop）

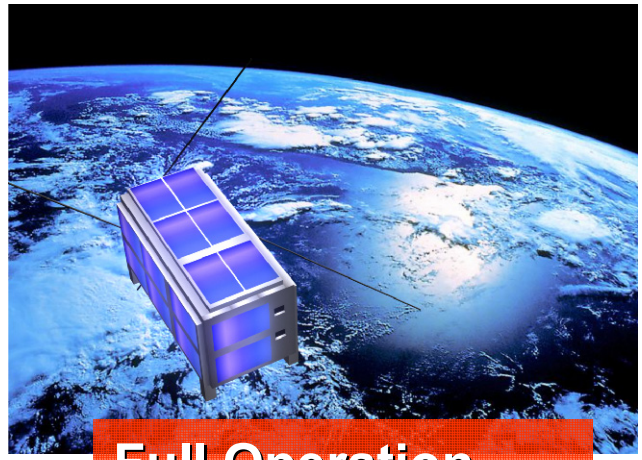
Operation Sequence



Release

Initial Operation

Antenna Deployment



Full Operation

Attitude Control
Photography
Digital Repeater Service
Observation by APD

Command
AFSK / DTMF

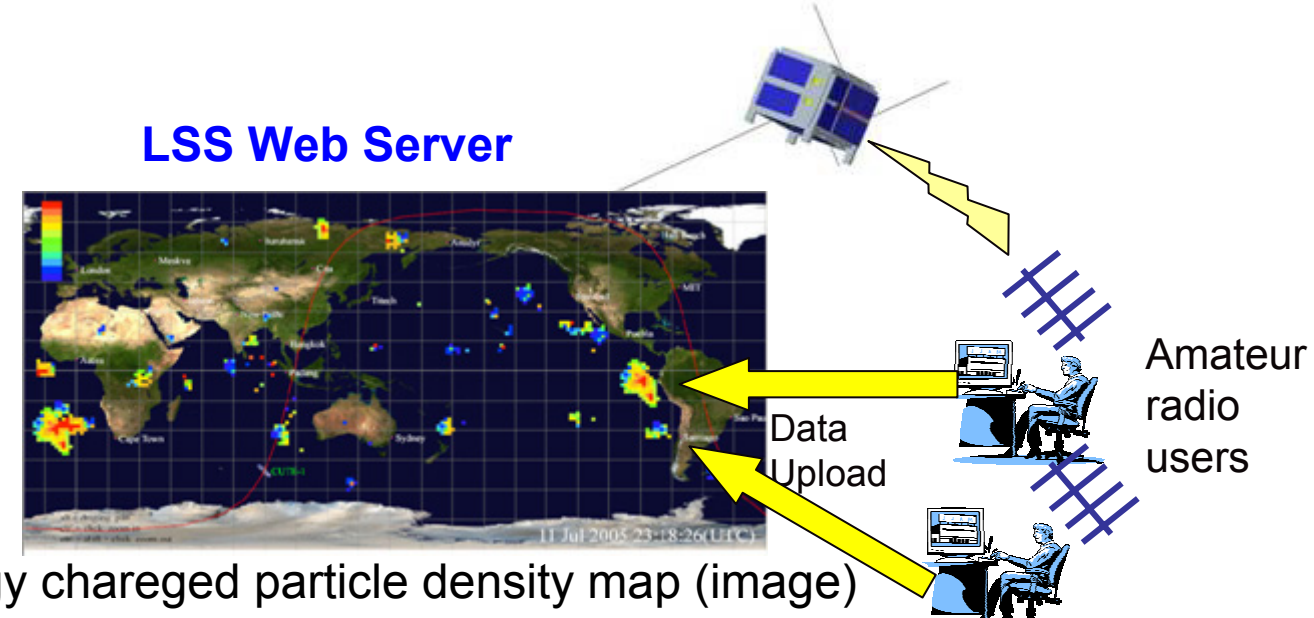
HK, Mission Data
GMSK / AFSK
CW beacon

Tokyo Tech Ground Station

Within few weeks
Atmosphere Entry
Misson Complete

Result Information

- Cute-1.7 + APD Telemetry will be broadcasted via Internet by using our Satellite Contents Provider (SCP)
  - Cute-1.7 + APD Weblog (Coming Soon!)
  - RSS Realtime Telemetry Feed
  - Dashboard Telemetry Casting
  - Cute-1.7 + APD Position & Telemetry System
- Telemetry data acquisition system

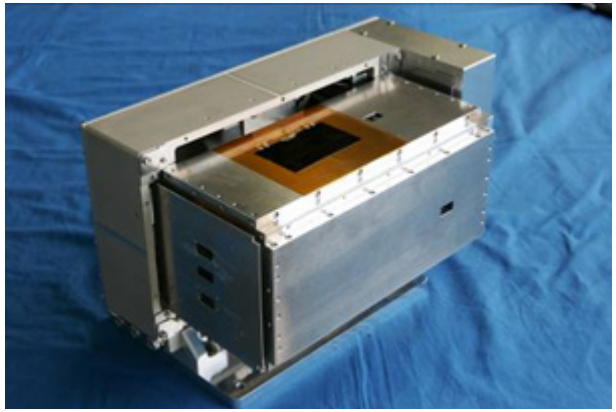


Low energy chareged particle density map (image)

Process of Development

2004. 1 *Cute-1.7 development project started*
2004. 4 *Preliminary Design Review (PDR)*
2004. 7 *Radiation test at Osaka University*
2004.12 *IARU frequency coordination done*
2005. 3 *Micro-gravity test of separation system*
2005. 4 *Engineering Model (EM) integration test*
2005. 6 *Middle distance communication test*
2005. 7 *M-V#6 sub-payload separation system experiment*

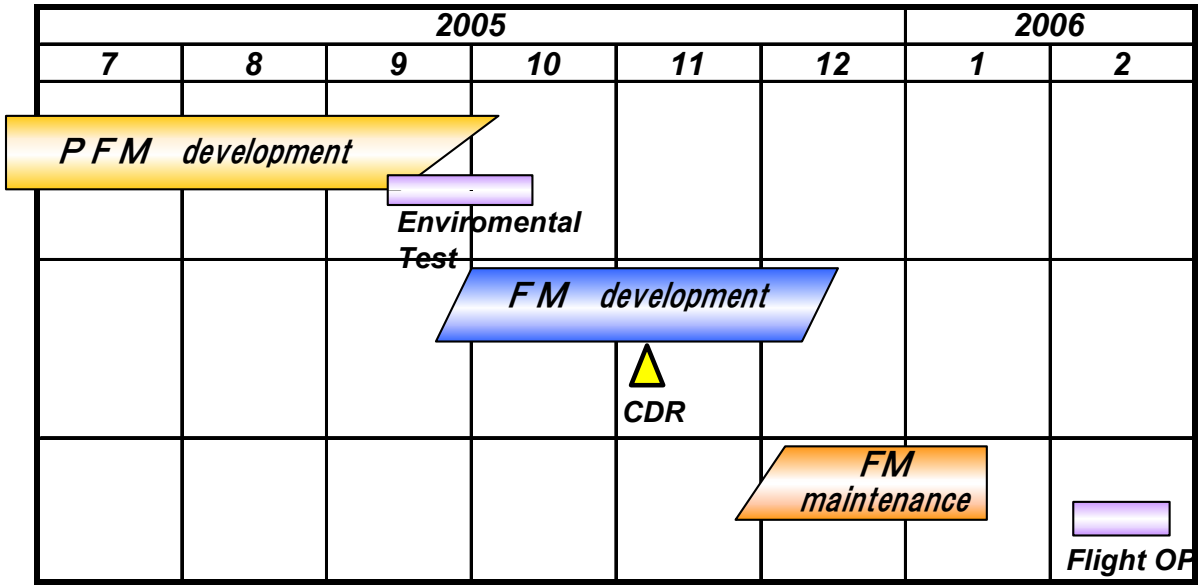
Now Post Flight Model (PFM) has been developed. Various environmental tests (Vibration, Vacume, Thermal) will be conducted this Autumn.



PFM of Cute-1.7 and separation system

Future Works

- Flight Model development phase in this Autumn
- Maintenance phase in this Winter
- Launch is scheduled in February,2006



Conclusion

- Missions of Tokyo Tech 2nd satellite Cute-1.7 +APD
  - PDA based OBC
  - Attitude control experiment using magnetic torquers
  - APD demonstration.
  - Amateur radio service – digital repeater
  - Tether deployment experiment

Cute-1.7 + APD will be launched

by M-V#8 in Feb, 2006.

END

Thank you for listening.

Official website: http://lss.mes.titech.ac.jp/ssp/cute1.7/index_e.html