Tokyo Tech Small Satellite Development Projects - Cute-1.7 and TSUBAME -

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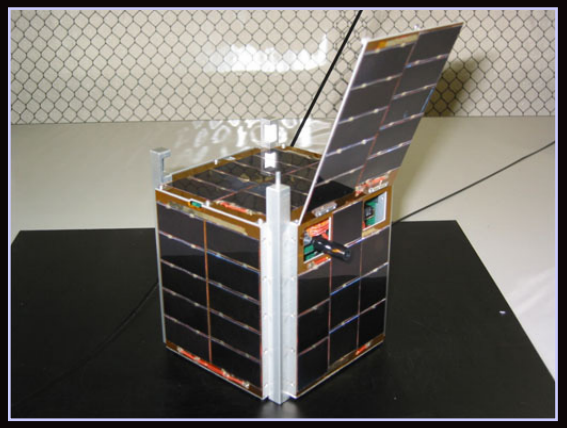
Cubesat Project - CUTE-I

- Laboratory for Space System(LSS) at Tokyo Tech 1st satellte



CUTE-I

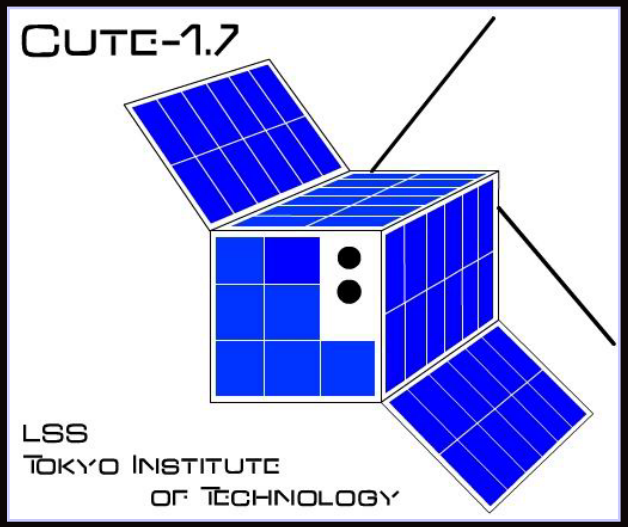
10cm × 10cm × 10cm

1kg

Acquisition of satellite bus technology

June, 2003 Plesetsk, Russia

Beyond CubeSat

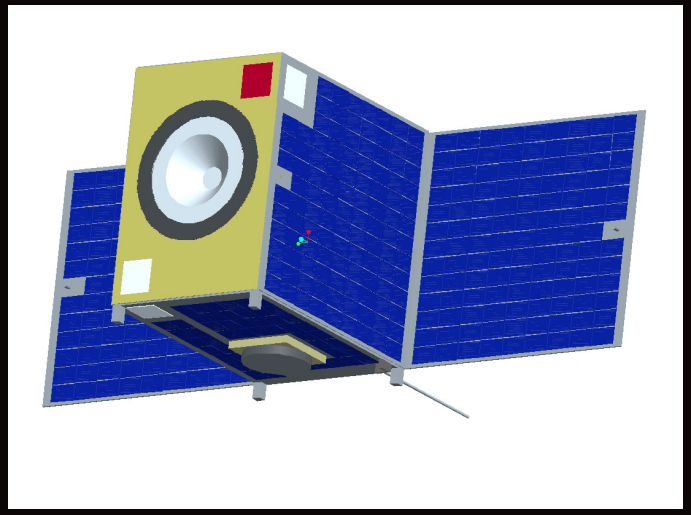


Cute-1.7

20cm × 10cm × 10cm

2kg

Demonstration of new design methodology



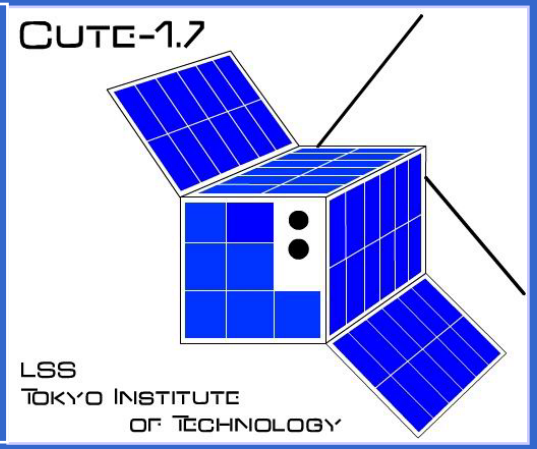
TSUBAME

30cm × 30cm × 20cm

16kg

Science observation

Cute-1.7 Project



Purposes of Cute-1.7 Project

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

⇒ Use of PDA and its peripheral devices.

- To demonstrate newly developped observation equipment

⇒ Use of low energy particle sensor named APD

- To share experiment opportunities using real satellite with space engineering community.

⇒ Advanced magnetic torquers control algorithm

PDA as an OBC

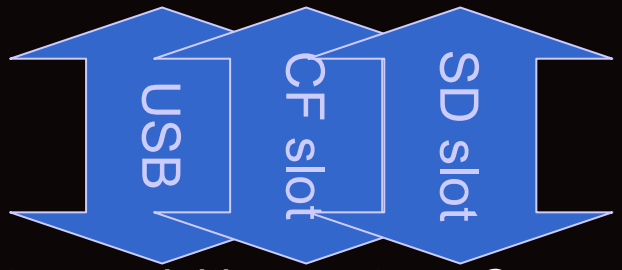
- To facilitate development

PDA has merits of ・・・

  - COTS
  - Programming Enviroment
    (Windows CE.NET)
  - Variety of I/F
    (USB, Memory card slot, etc)

- Radiation Test (at Osaka Univ.)
  Low probability of SEU or SEL

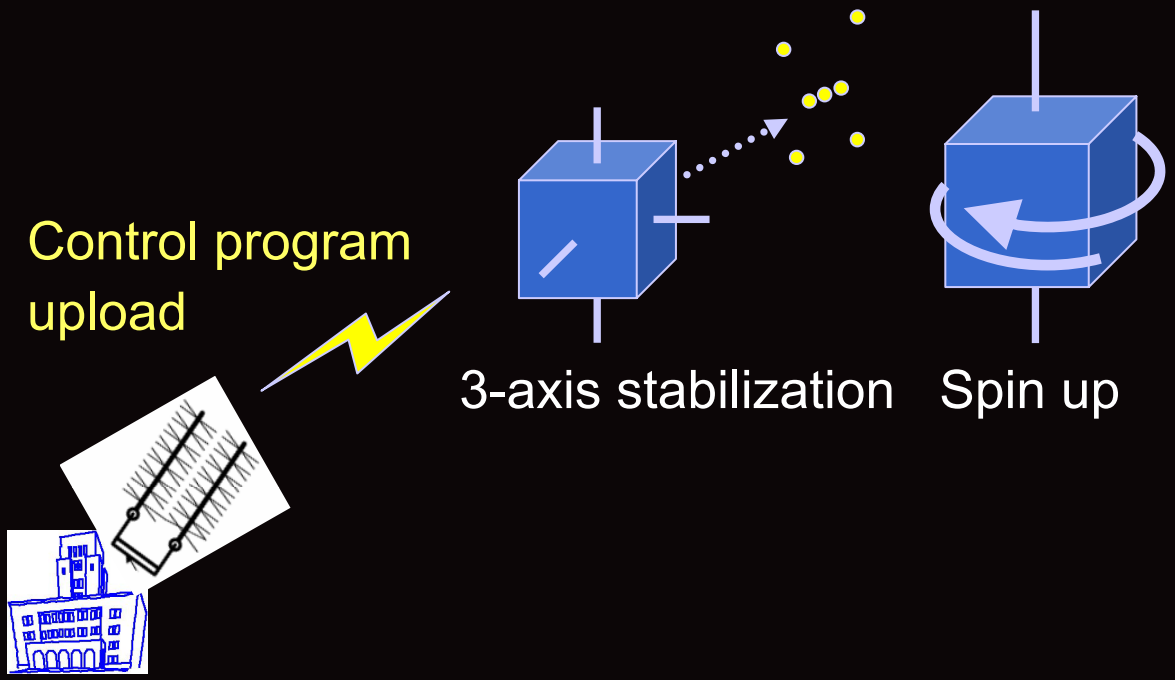
Hitachi PDA NPD-20JWL

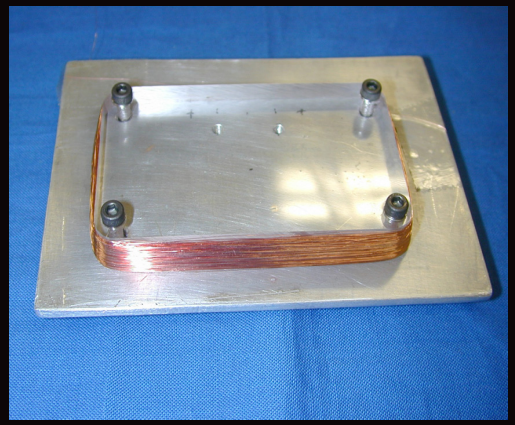


Data acquisition system, Comm
controller, Camera, Memory car

Magnetic Torquers

- Simple, reliable mechanism
  -Best suit picosatellites





Cute-1.7 satellite is equipped with three magnetic torquers.

Offer Cute-1.7 as a test bed to space engineering community

Functionality for Radio amateurs

- We have used and will use amateur radio frequencies
  - To provide communication resources for the general amateur radio community
- To return something to amateur radio community, Packet Repeater is installed.
  - Uplink: 1.2GHz
  - Downlink: 430MHz (shared with telemetry line)

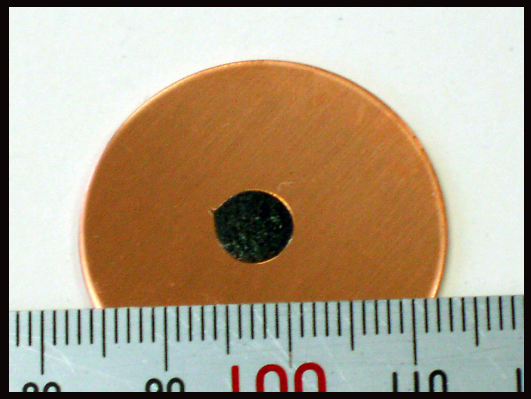
Satellite Disposal by Tether

- Small Satellites: Short lifetime & Many

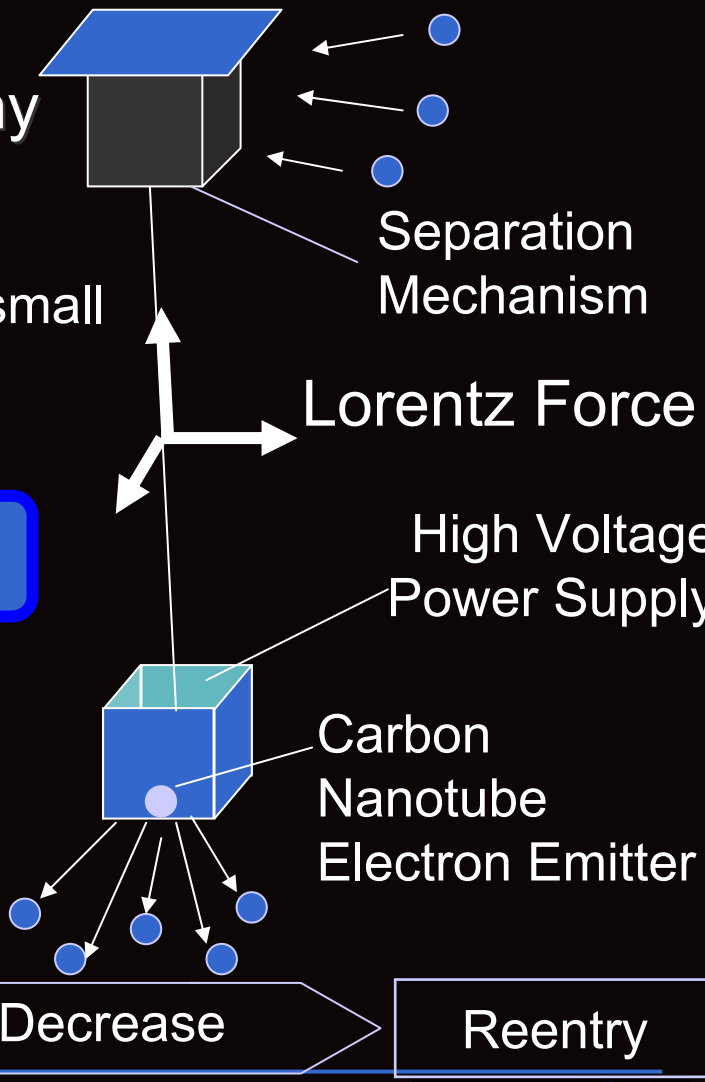
→ Become Debris. Difficult to track.

→ Debris reduction measure affects if use of small satellites grow.

Disposal by Electrodynamic Tether



Electron Emitter(CNT)



APD Demonstration

Avalanche Photodiode (APD) is a new charged-particle detector

Characteristics

- Very small
- Low-power consumption
- High performance
  i. High speed response
  ii. Internal gain

APD by Tokyo Tech astronomy lab.

Considering to equip it with much larger satellite in the future

Separation System

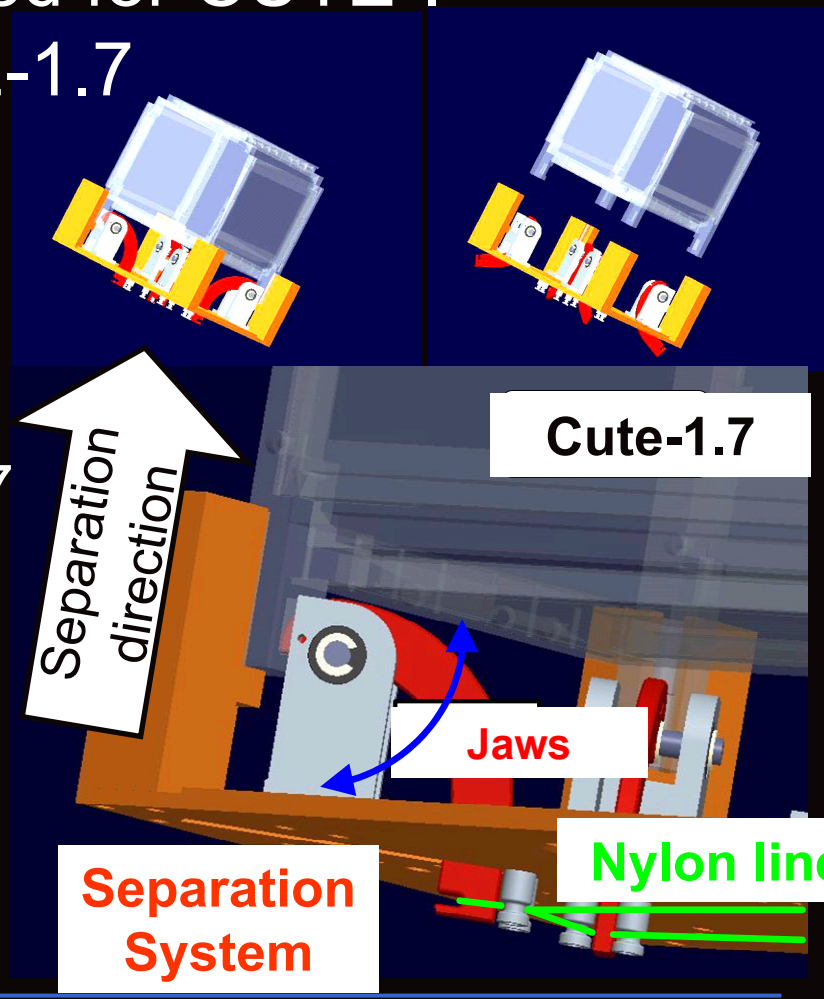
Same mechanism as one used for CUTE-I
The size is adjusted to CUTE-1.7

It consists of
4 jaws, a nylon line and a heater

These jaws hold pillars of CUTE-1.7
and are tightened by the nylon line.

The nylon line is heat to be cut.

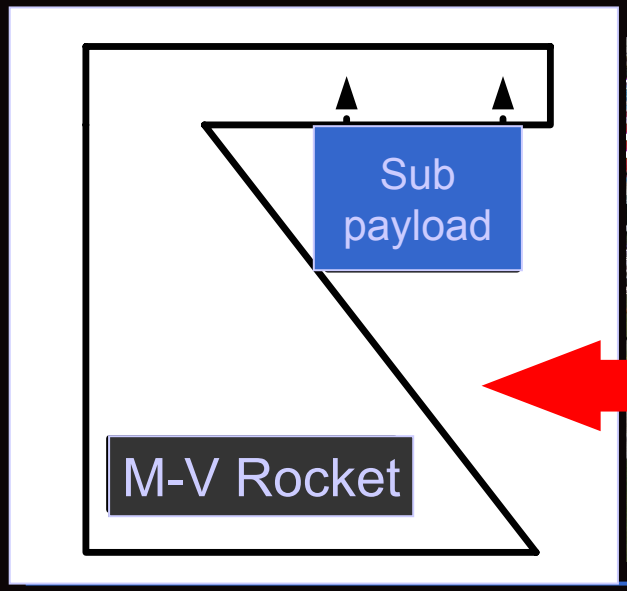
The jaws release the
CUTE-1.7 pillars.

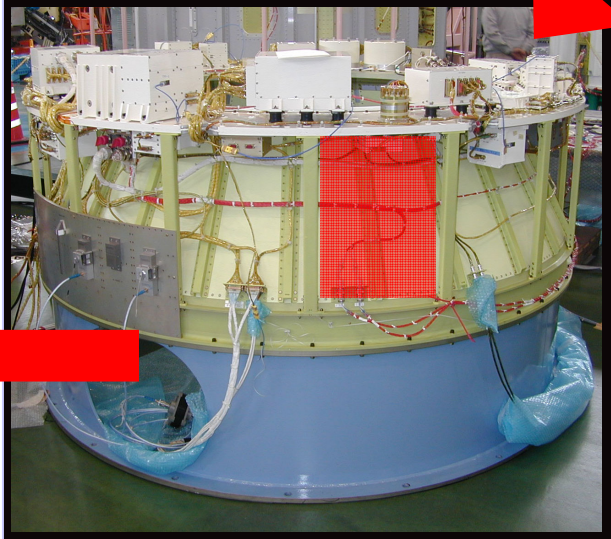


Launch Rocket

- **M-V Rocket #8 Sub Payload**
  - **JAXA / ISAS solid rocket**
  - **balance weight space in 3rd stage**

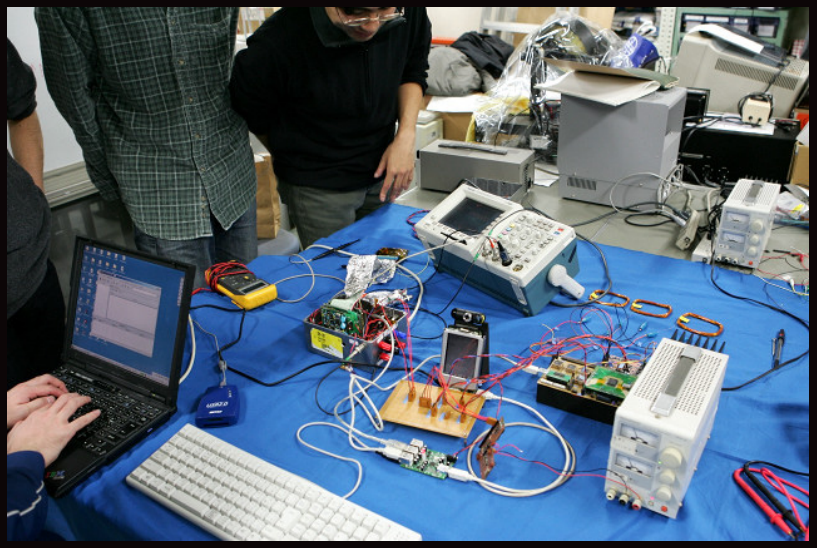
orbit: Perigee h=185km apogee h=800km



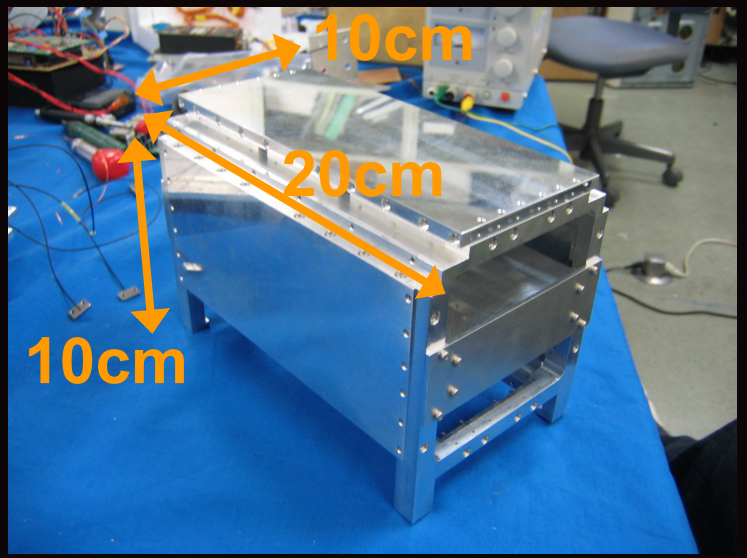


Current Status of Project

- EM integration test with APD has been done.
- Launch is scheduled in 2005.

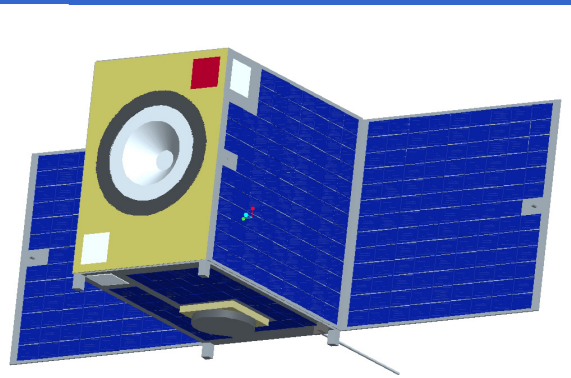


EM integration test



Body structure

TSUBAME Project



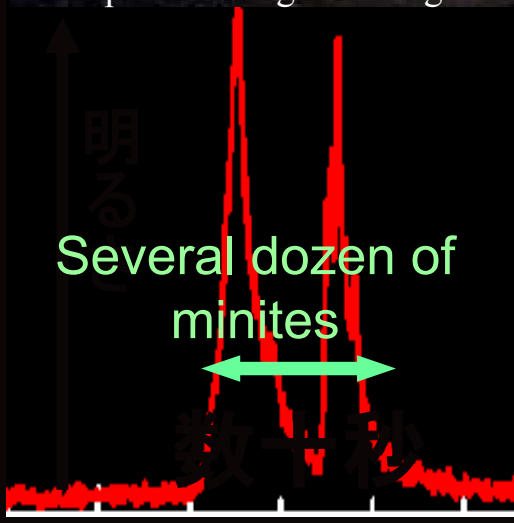
Mission Background - GRB

- Gamma-ray Burst (GRB)
  - The biggest explosion phenomenon since the Big Bang
  - Early phase of genesis is not understood

Origin of high energy radiation, magnetic field structure (gamma-ray burst, active galaxy, supernova remains)

- Drawback of Observation
  - Extremely short
  - Observation within 10sec is desired, but big satellite has poor maneuverability

http://heasarc.gsfc.nasa.gov/



RIKEN Space Radiation Lab

Mission Background - Polarization

Observation approaches

- Photometry
- Spectroscopy
- Imaging
- **Polarization**

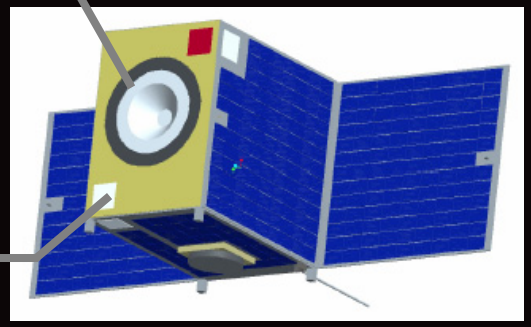
Only polarization is still kept intact. Polarization is expected to elucidate origin of high energy radiation or magnetic structure, due to its completely different aspect of the observation approach.

TSUBAME observes polarization of astronomical burst objects

Mission Overview

Scattering type hard X-ray polarization detector

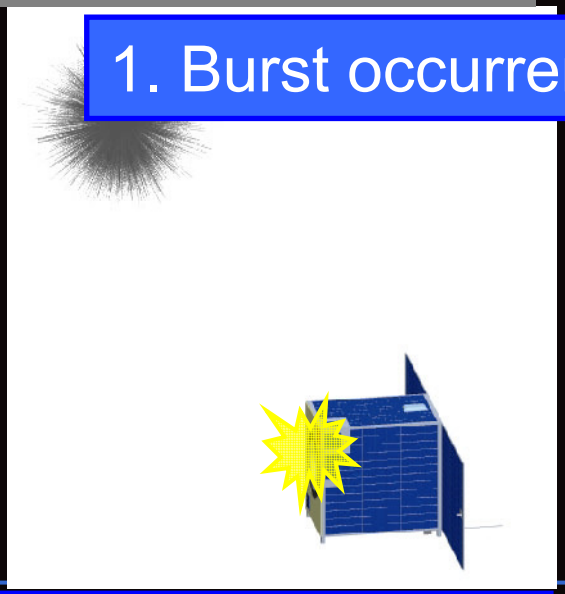
Gamma-ray burst direction detector



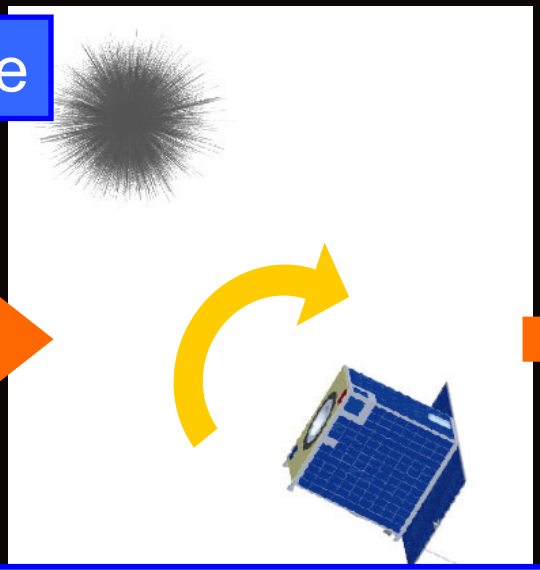
2 detector observe polarization of gamma-ray burst

(Using APD sensors)

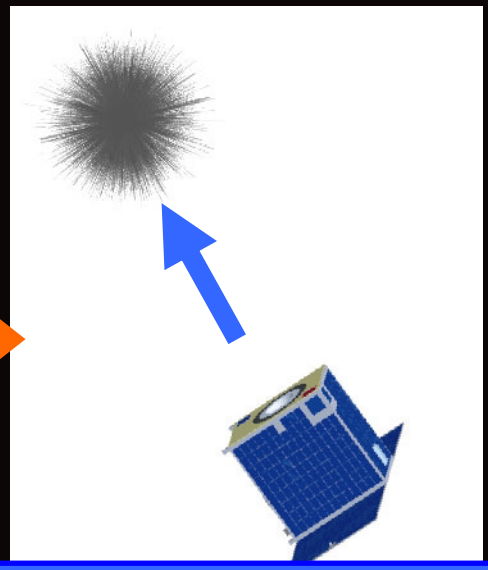
1. Burst occurrence



2. Detect direction



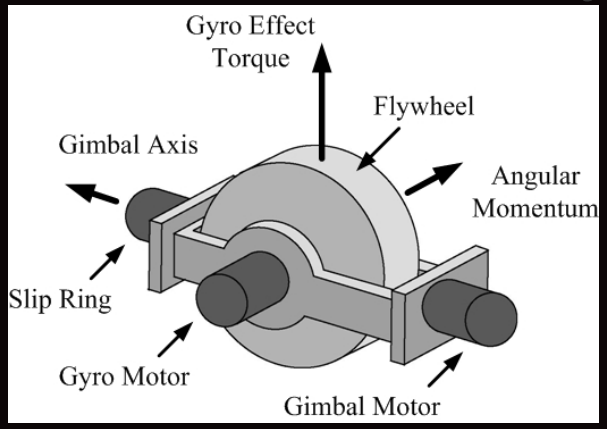
3. Prompt attitude maneuver

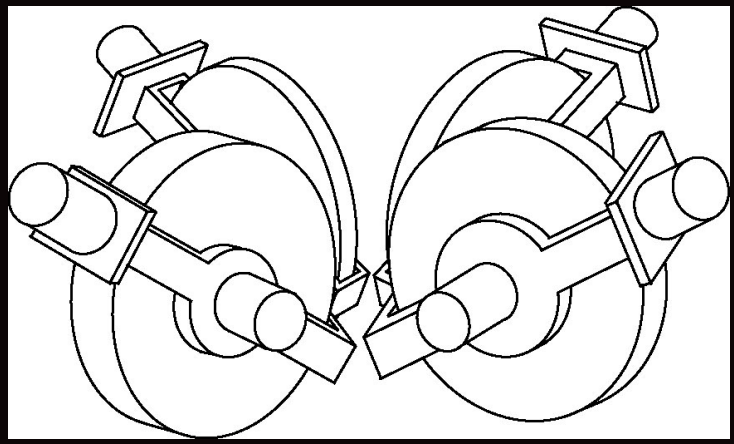


4. Within 10 sec, observation starts

ADCS – CMG

Control Momentum Gyro（CMG）





For large spacecraft (ISS, Mir ,etc)

CMG specifications

Density (material: brass)	8920kg/m^3
wheel diameter	50mm
wheel thickness	12mm
wheel weight	200g

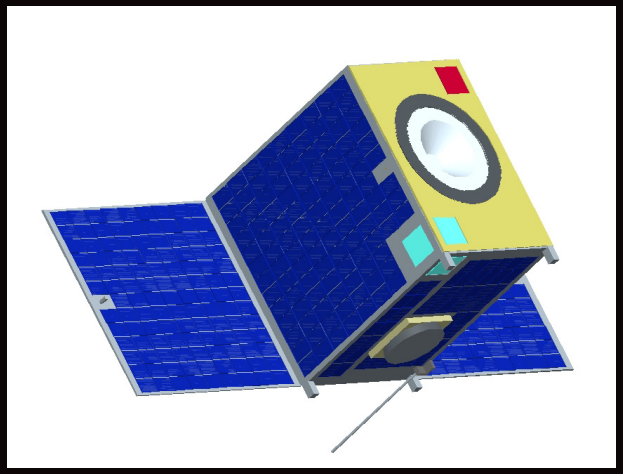
Ave. output torque $\overline{T} \approx 40mNm$

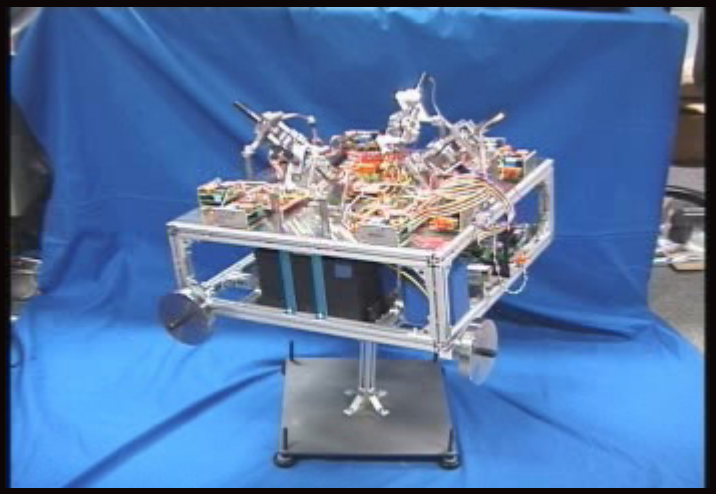
Realization of Prompt Attitude maneuvers

Low inertia
Small satellite

+

High torque output
CMG





Prompt attitude maneuver meets the requirement

Advanced Technology Demonstration

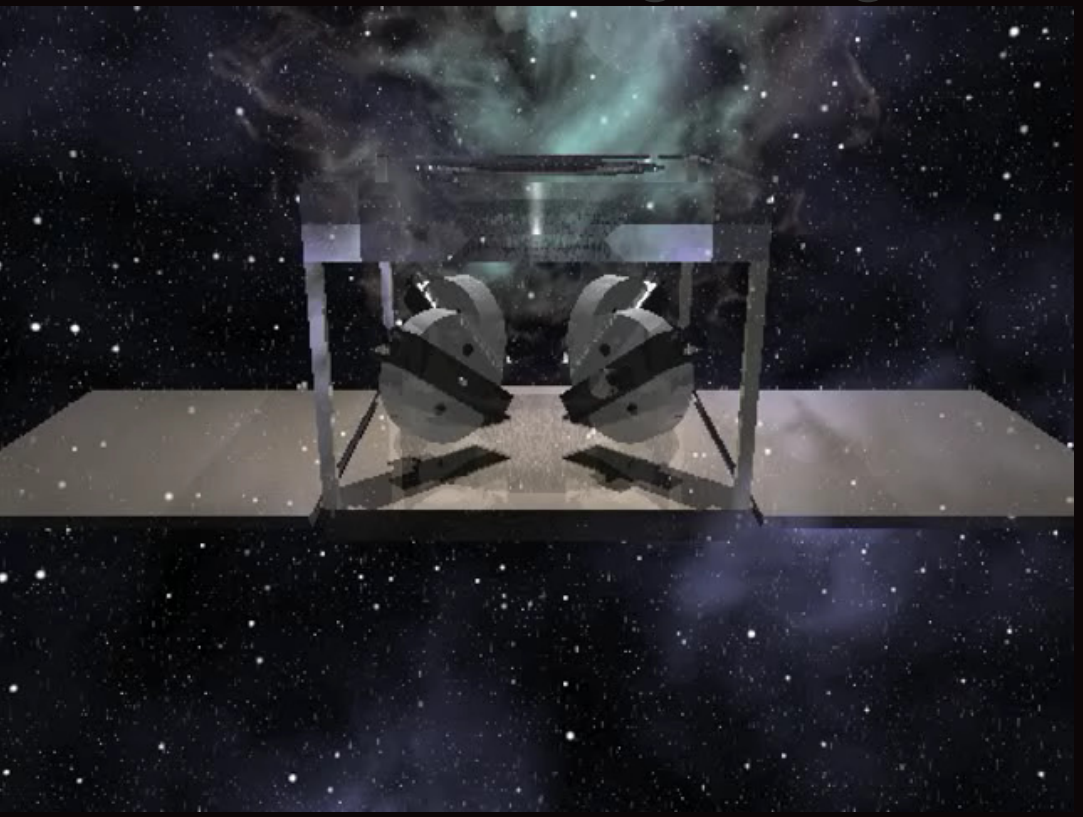
- Technical challenges
  - Downsizing design (Low energy, weight)
  - Robust and singularity avoidance control

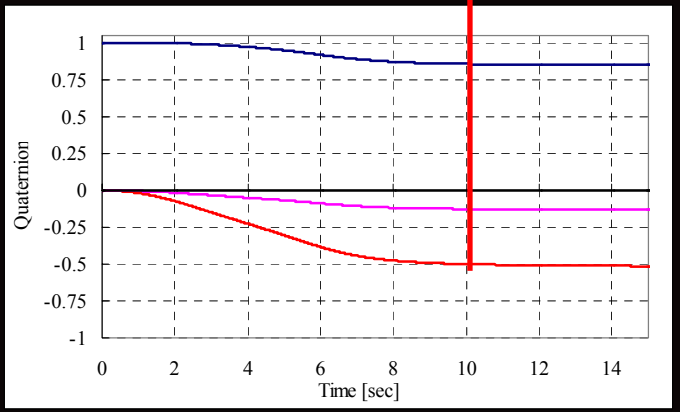
Small satellite is a suitable platform for the early demonstration of study results

Simulation result of CMG

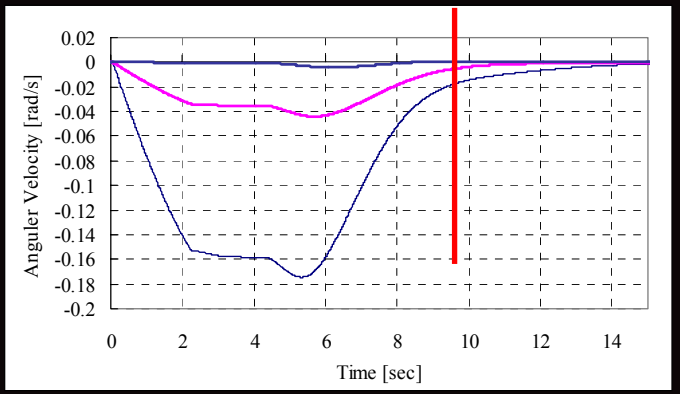
from wheel acceleration

to observation beginning





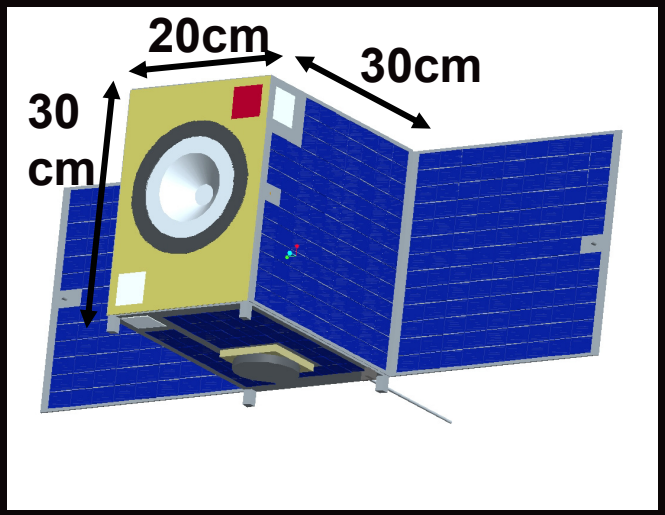
attitude angle(quaternion

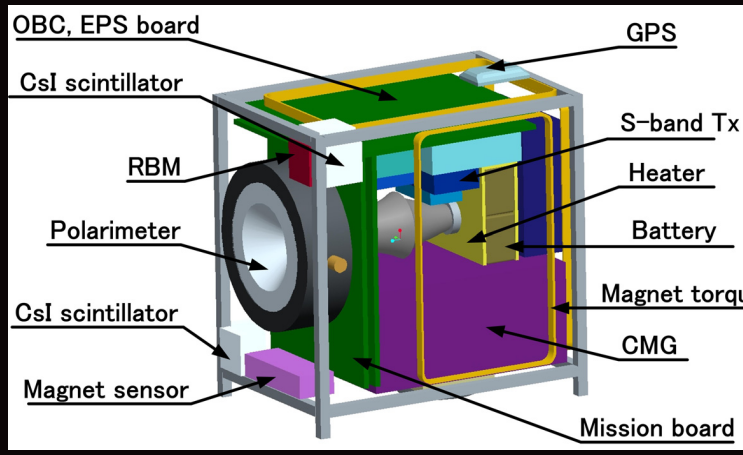


angular rate

Concept design of satellite system

Size	30cm×20cm×30cm
Weight	16kg
Orbit	Sun-synchronize：Altitude 800km, Inclination 98.6°
Life-time	1 year
Mission	Gamma-ray burst direction sensor (CsI & APD) Polarimeter (P-Sci & PMT)
ADCS	Control：CMG, Magnet torquer Determination：Gyro, Sun sensor, Magnet sensor
C&DH	32bit MPU (COTS)　SDRAM 32MB
Comm.	S-band Tx (Mission data) BPSK 200kbps S-band Tx（HK data）BPSK 9600bps S-band Rx（Command data）PM 9600bps S-band mono pole / patch antenna
EPS	Multi-junction cell（efficiency 22%） Power generation approx. 40W Li-ion battery　Peak power tracking system
Structure	Paddle unfolding mechanism Passive thermal control





Present status and future works

- Conceptual design level now
  ⇒ BBM fabrication phase
- Launch date is assumed in 2007
- Cooperation with JAXA

Conclusion

Tokyo Tech satellite development projects "Cute-1.7" and "TSUBAME"

- Cute-1.7 is a 2kg Cubesat using PDA as a main computer, and has a science mission of on-orbit demonstration for an advanced high quality APD sensors
- TSUBAME is expected to pursue a full-fledged science observation mission, and also demonstrate small-sized CMG system performance for prompt attitude maneuvers.

END

Thank you for listening.

Tokyo Institute of Technology