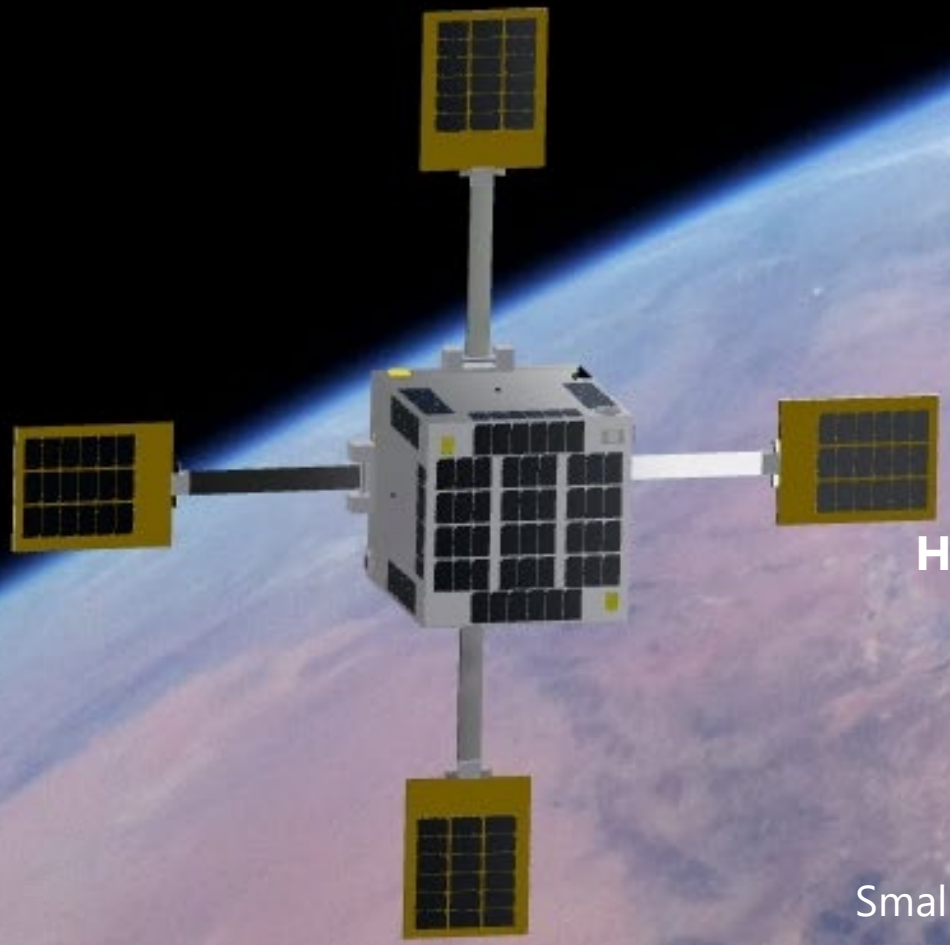
Concept Design and Development of 30kg Microsatellite HIBARI for Demonstration of Variable Shape Attitude Control



○ Kei Watanabe

Yuhei Kikuya, Yusuke Shintani, Kenich Sasaki,

Hiroki Ando, Tsuyoshi Nakashima, Kiyona Miyamoto,

Kaoru Matsubara, Yoichi Yatsu, Saburo Matunaga

Tokyo Institute of Technology

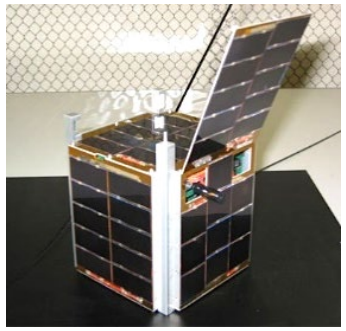
Small Satellite Conference

Tokyo Tech SmallSat Projects

2003

World 1st CubeSat **CUTE-I**

- Launched by Rockot
- Acquisition of bus technologies
- Is operating for over 16 years !



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- Launched by M-V-8
- Trying new design methodology
- Had been operating for a month

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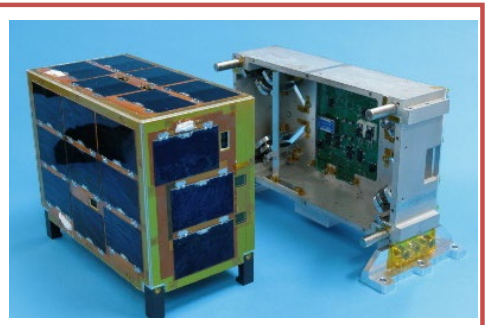

4U

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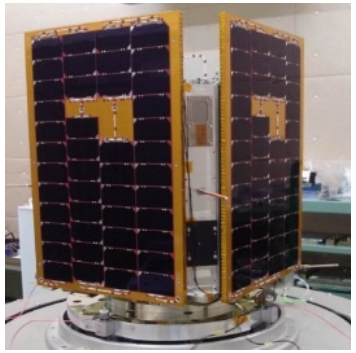
TSUBAME

- Launched by Dnepr
- Polarized g-ray burst observation using CMGs

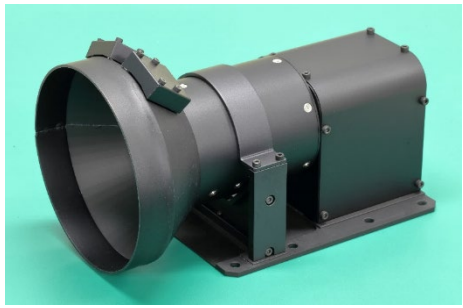


50kg

2019

DLAS : Deep Leaning Attitude Sensor

- Mounted on JAXA's RAPIS-1 and Launched by Epsilon
- 3-axis attitude determination earth sensor using machine learning



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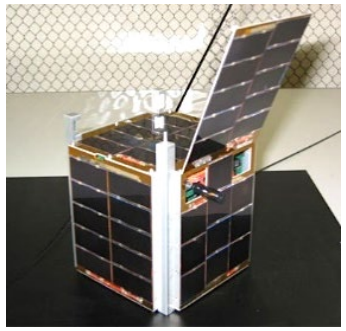

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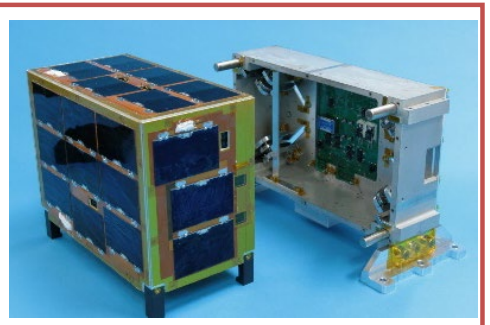

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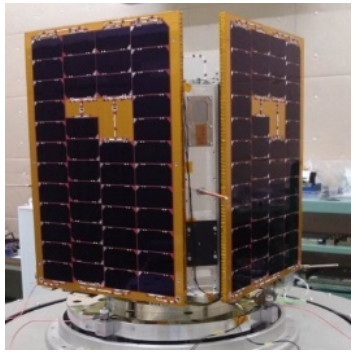

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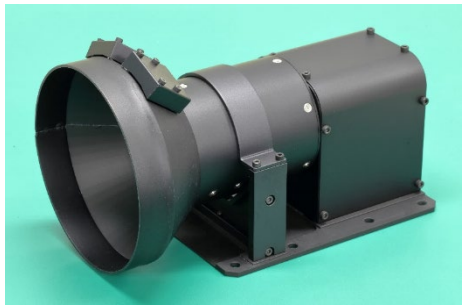

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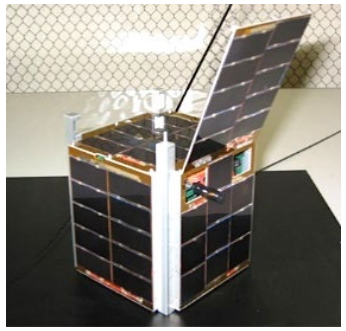

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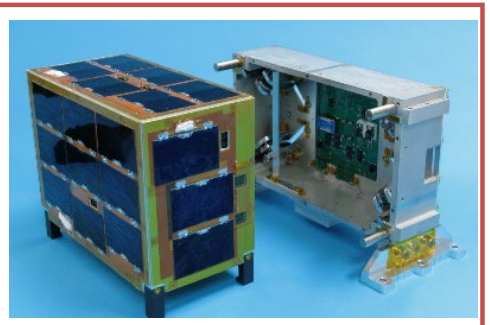

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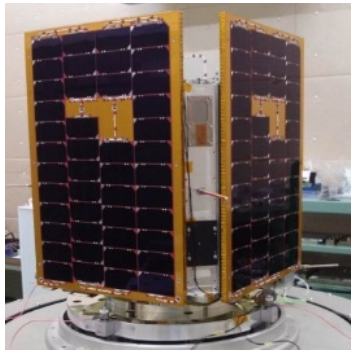

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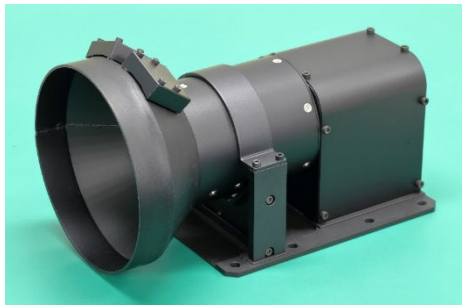
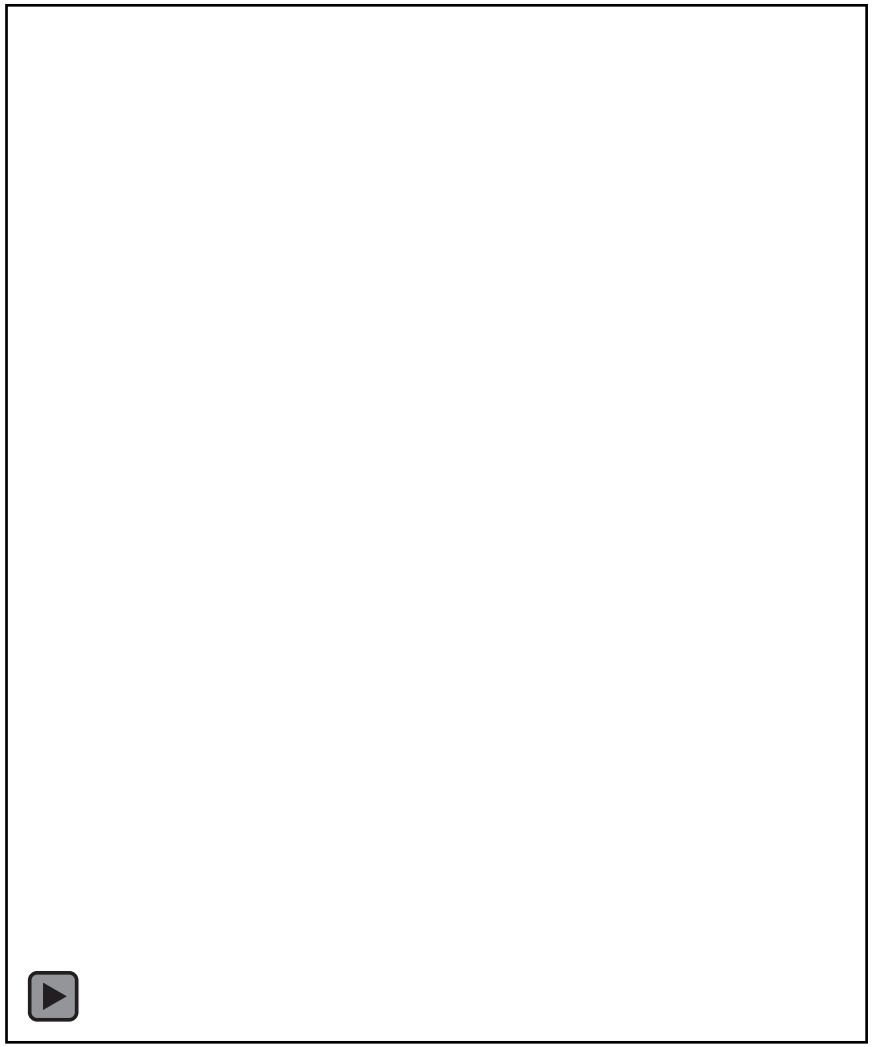


11:15 AM, Thursday, Technical Session XII

Development and Initial On-orbit Performance of Multi-Functional Attitude Sensor using Image Recognition

We are developing now

30 - 40kg microsatellite HIBARI



- demonstrates **VSAC** (Variable Shape Attitude Control)

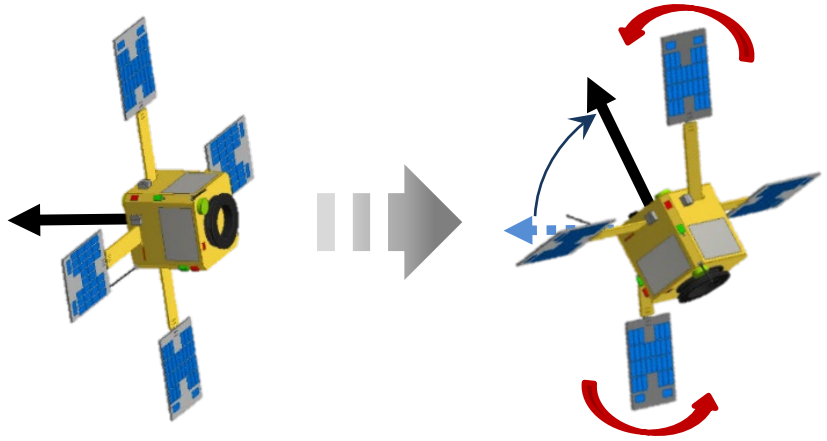
  → Attitude maneuvering by driving solar array paddles

- Will be launched in FY2021, as “Innovative Satellite Technology Demonstration” led by JAXA

VSAC : Variable Shape Attitude Control

- using Internal Torque

Agile maneuver



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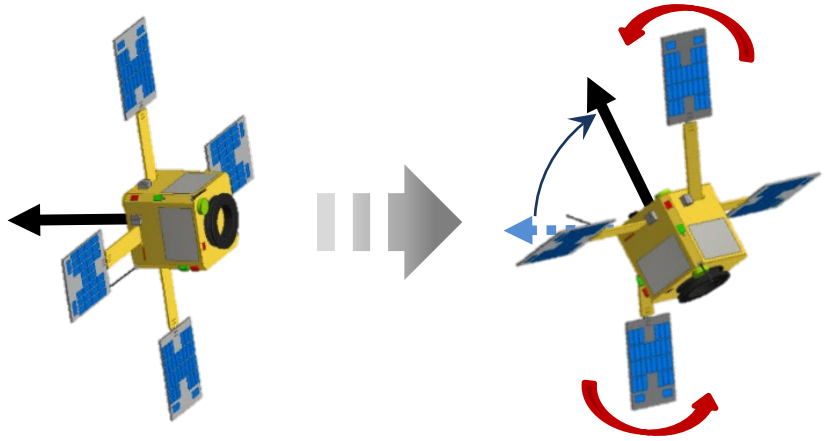
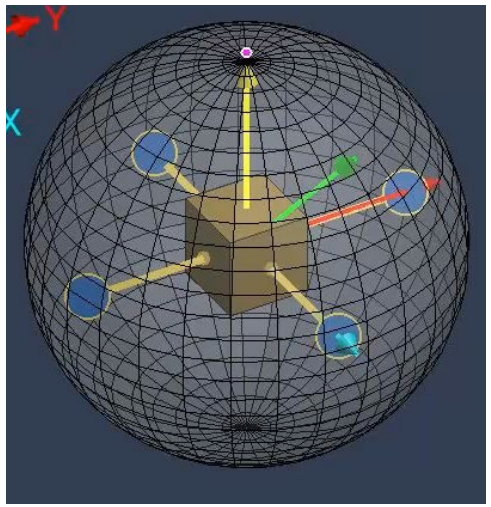


Non-holonomic attitude control



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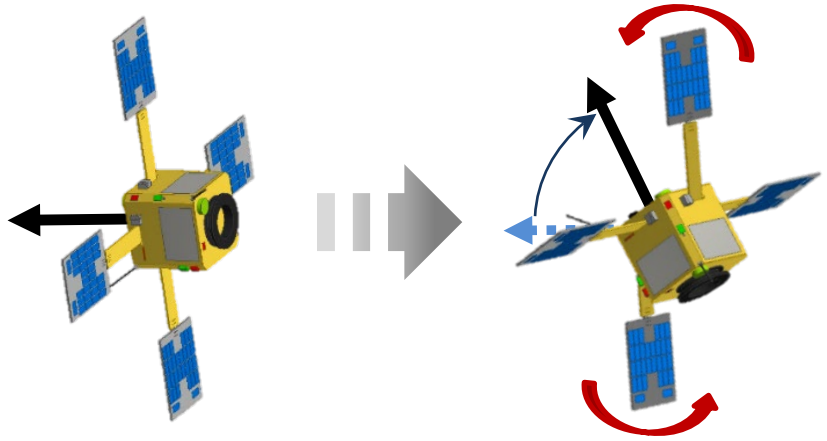

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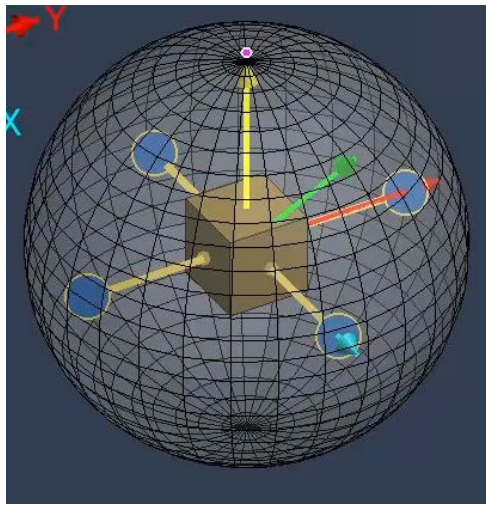
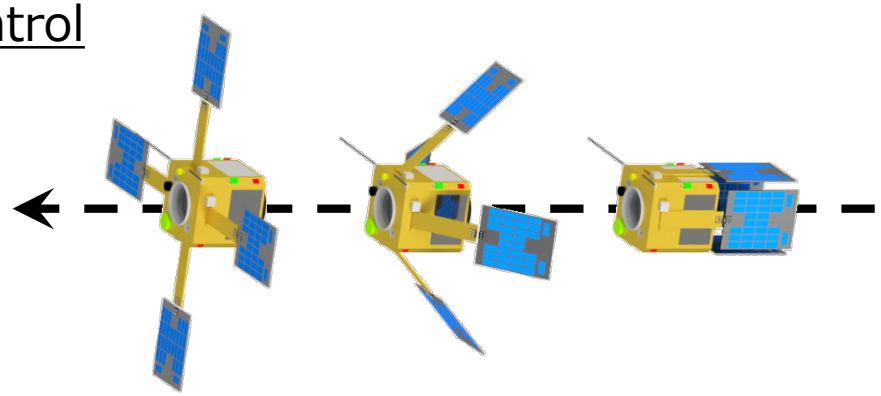
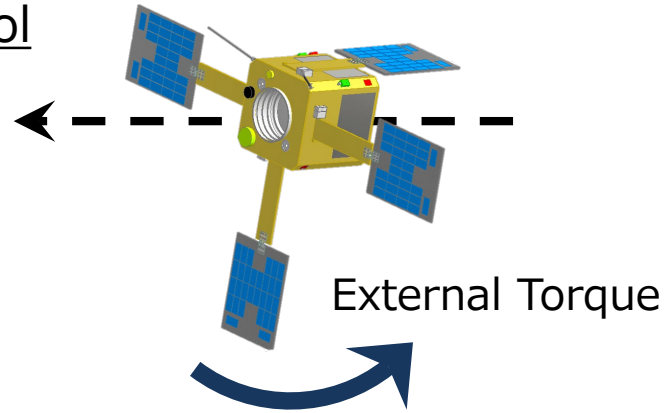


- using External Force / Torque

Orbit Control



Attitude Control



Mission

Demonstration of VSAC （Variable Shape Attitude Control）

Success Criteria

Minimum	• Attitude maneuver by variable shape function
Full	• VSAC performance evaluation ◦ target agility：**40deg/20sec**
Extra	• VSAC performance evaluation ◦ target agility：**40deg/10sec** ◦ target stability：**300arcsec/10sec** • non-holonomic attitude control • orbit / attitude maneuver with control aerodynamic force

Future, transient objects observation mission utilizing agility and stability

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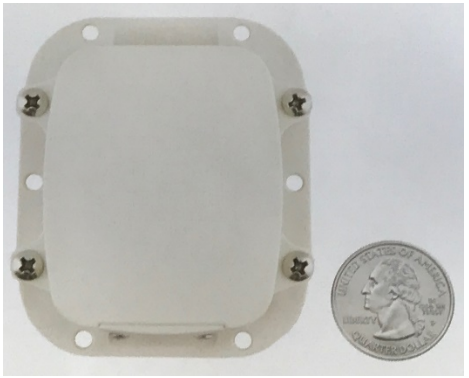
Future, transient objects observation mission utilizing agility and stability

Sub Missions

- Development of microsatellite standard bus system
  - adopt components that can be mounted on Cubesat as much as possible

- Real-time communication with ground
  - demonstration for future transient object observation
  - Use SmartOne C as Tx antenna of Globalstar



SmartOne C

- 3-axis attitude determination using earth camera
  - Use DLAS (Deep Leaning Attitude Sensor) which we developed

DLAS

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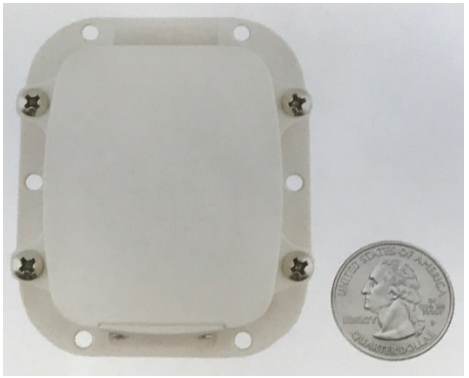

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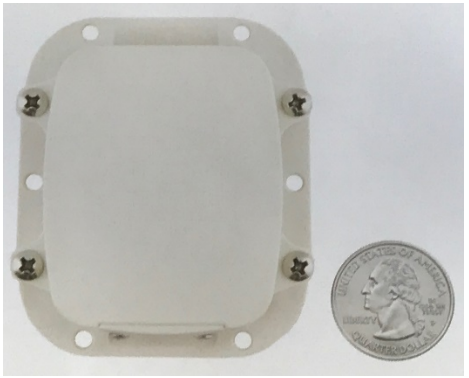

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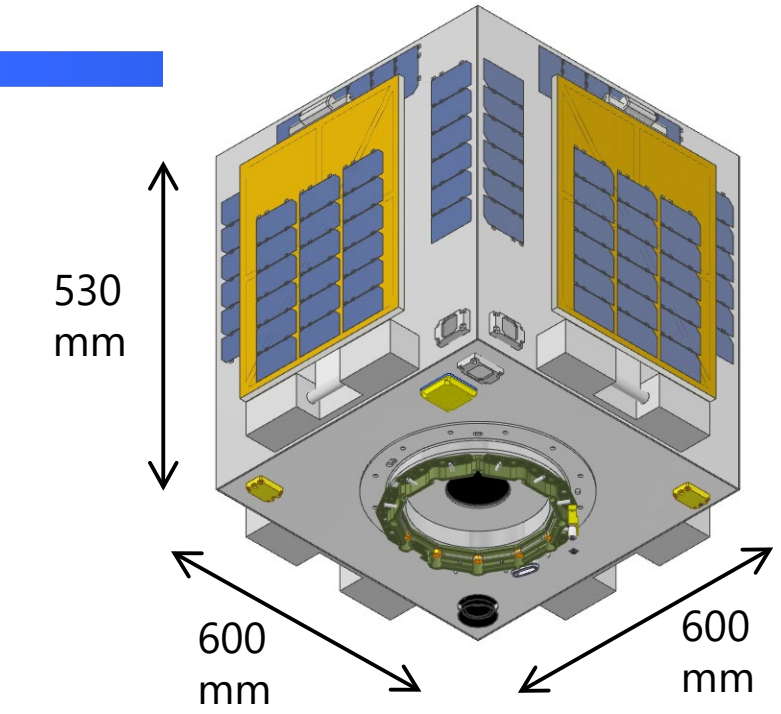
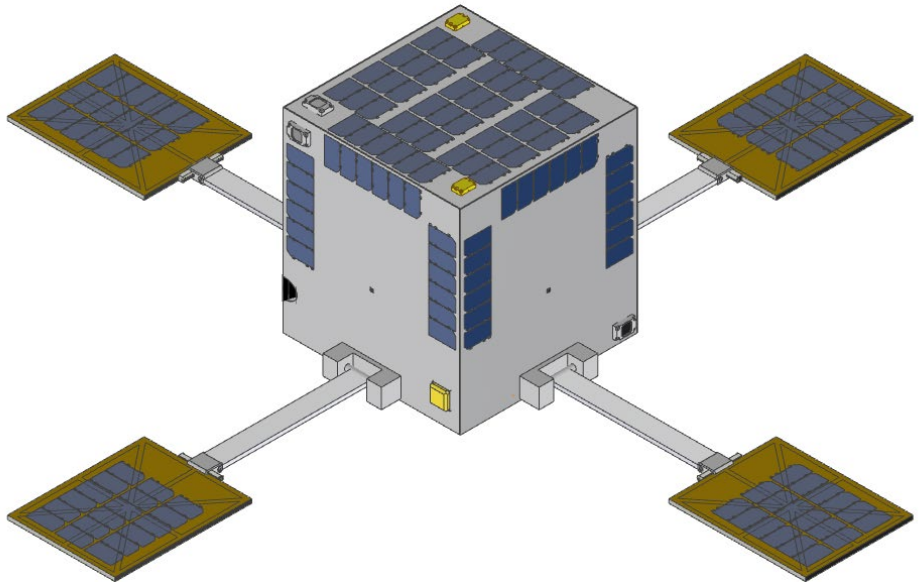
DLAS

Spec.

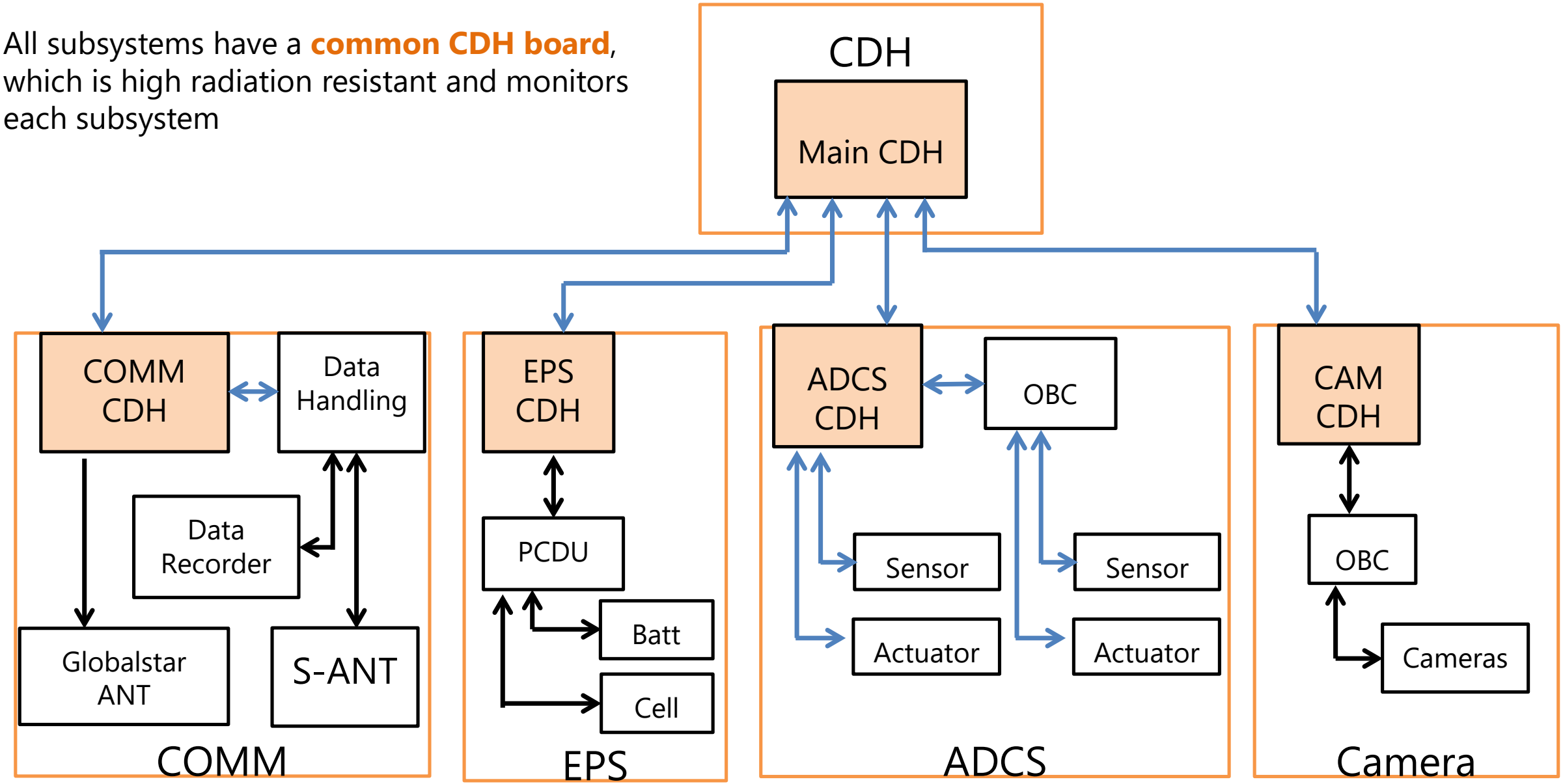
Size	600 x 600 x 530 mm^3 (TBD)
Mass	Bus: 30kg (TBD), Paddle: 2kg
Actuator	Paddle x 4, MTQ x 3 , RW x 3
Telecom	S-band Tx / Rx x 2 Globalstar Tx x 1
Power	Li-ion Battery 160Wh
Orbit	500km Sun synchronous orbit





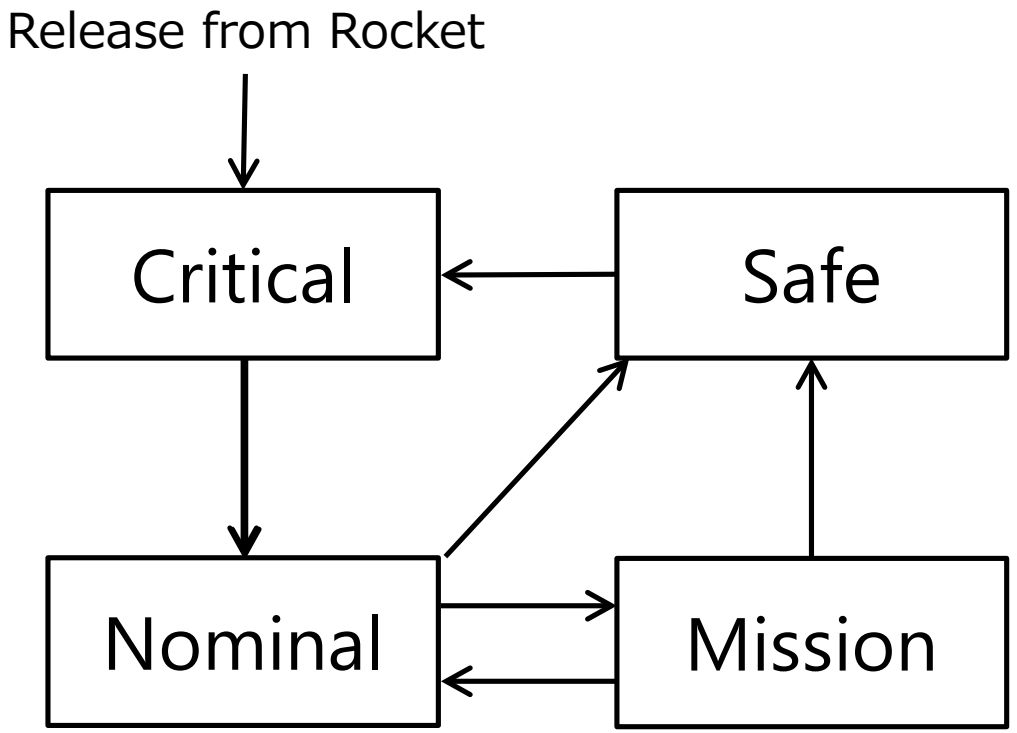
System Diagram

All subsystems have a **common CDH board**, which is high radiation resistant and monitors each subsystem



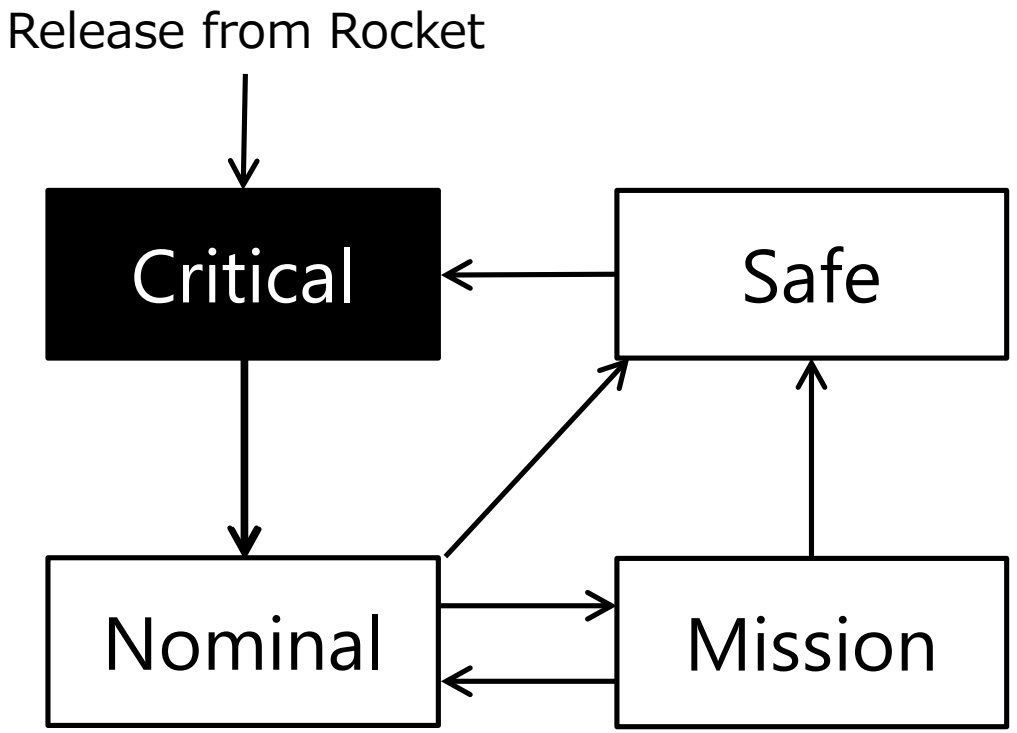
Planned Operation Mode

Prepare only 4 operation modes with emphasis on simplicity



Planned Operation Mode

use MTQ
- De-tumbling
- Sun pointing
- Paddle deployment



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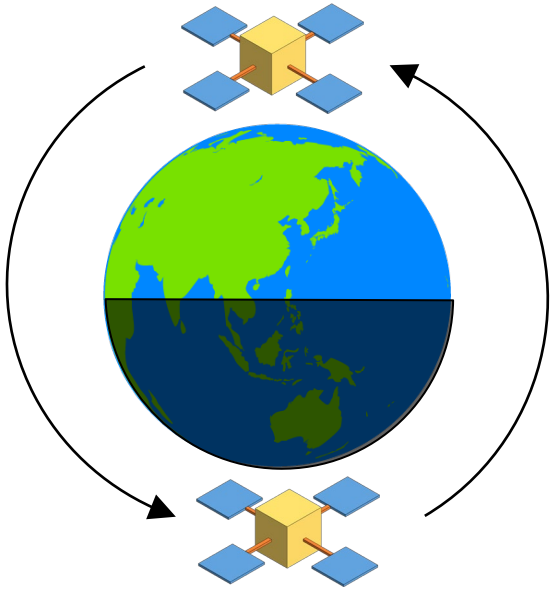
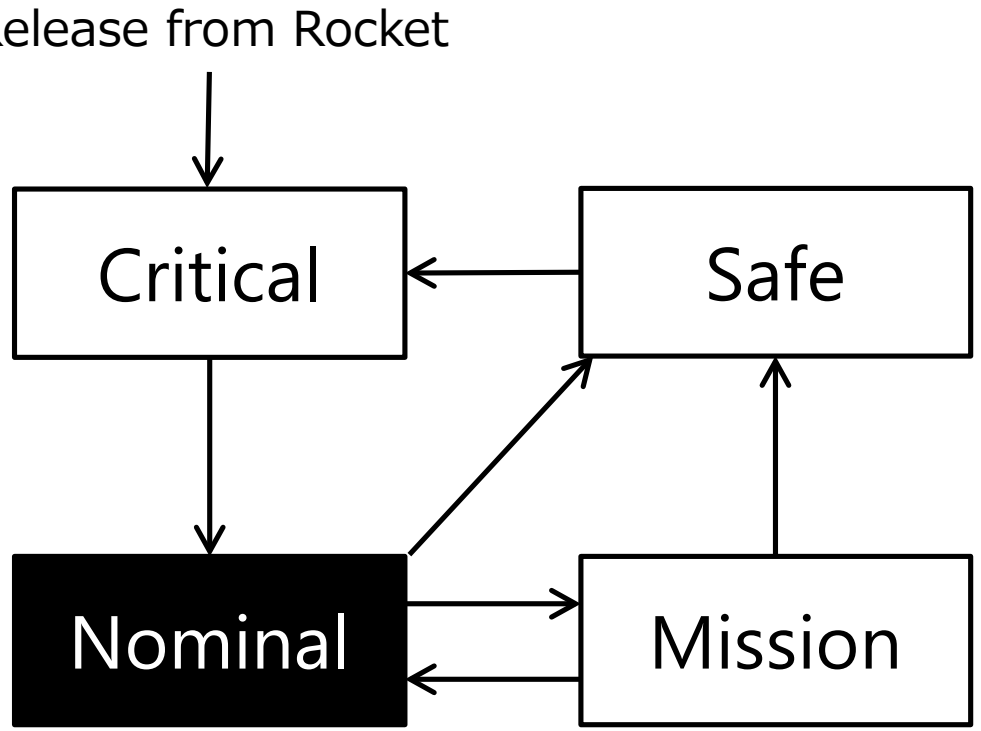


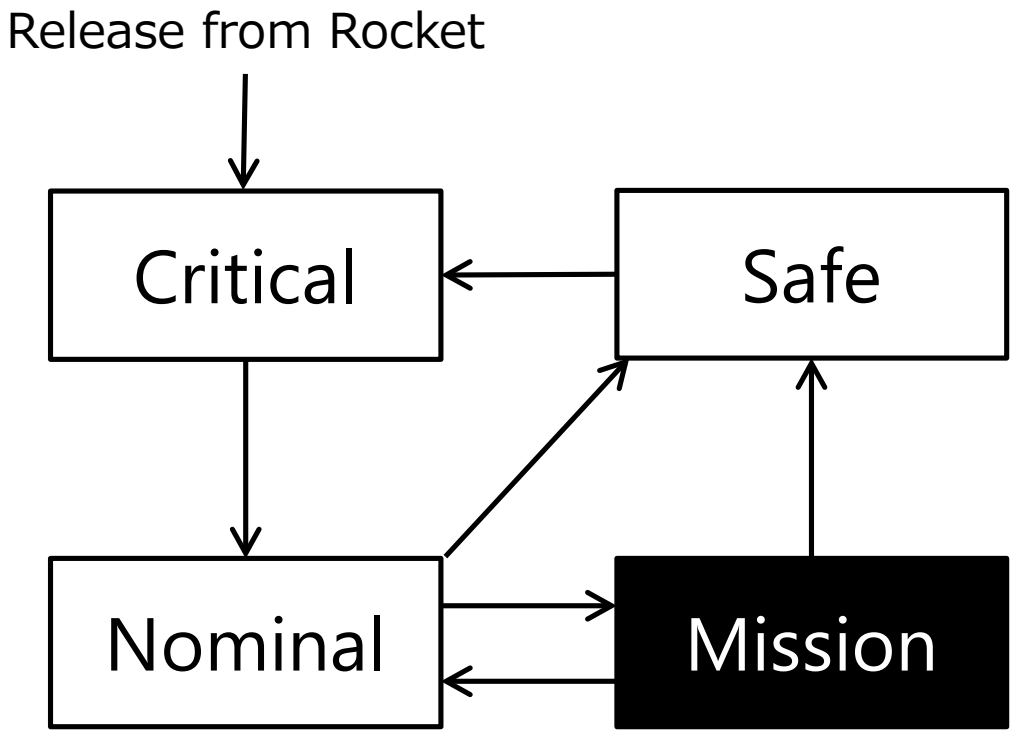


Sun pointing, Earth/celestial observation

① Spin stable using MTQ

② 3-axis stable using RW

Planned Operation Mode



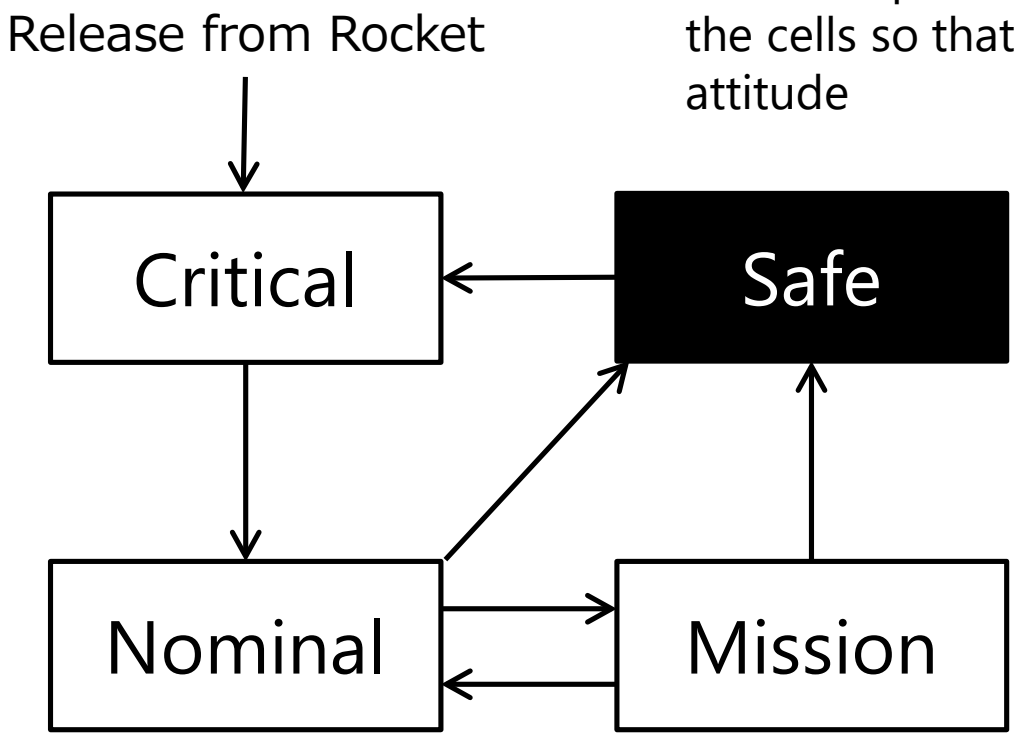
Attitude control experiment

- VSAC
- VSAC + RW

Planned Operation Mode

Dealing with power shortage and other problem

- no control
- Minimize power consumption (10 W) , and arrange the cells so that power balance is positive in any attitude



Schedule

Will be launched by Epsilon Rocket

	FY2019	FY2020	FY2021
Review	◇MDR ◇PDR	◇CDR	◇PQR
Except Structure	BBM EM ◇Elec Integrate	◇TVAC/Vib	
Structure	BBM EM ◇Paddle deploy ◇ Vib	◇TVAC/Vib ◇Mass balance ◇Paddle deploy	
Common	◇SEE ◇TID	FM ◇EMC ◇Paddle deploy ◇Mass/Fit check ◇Alignment ◇Vib/Alignment	

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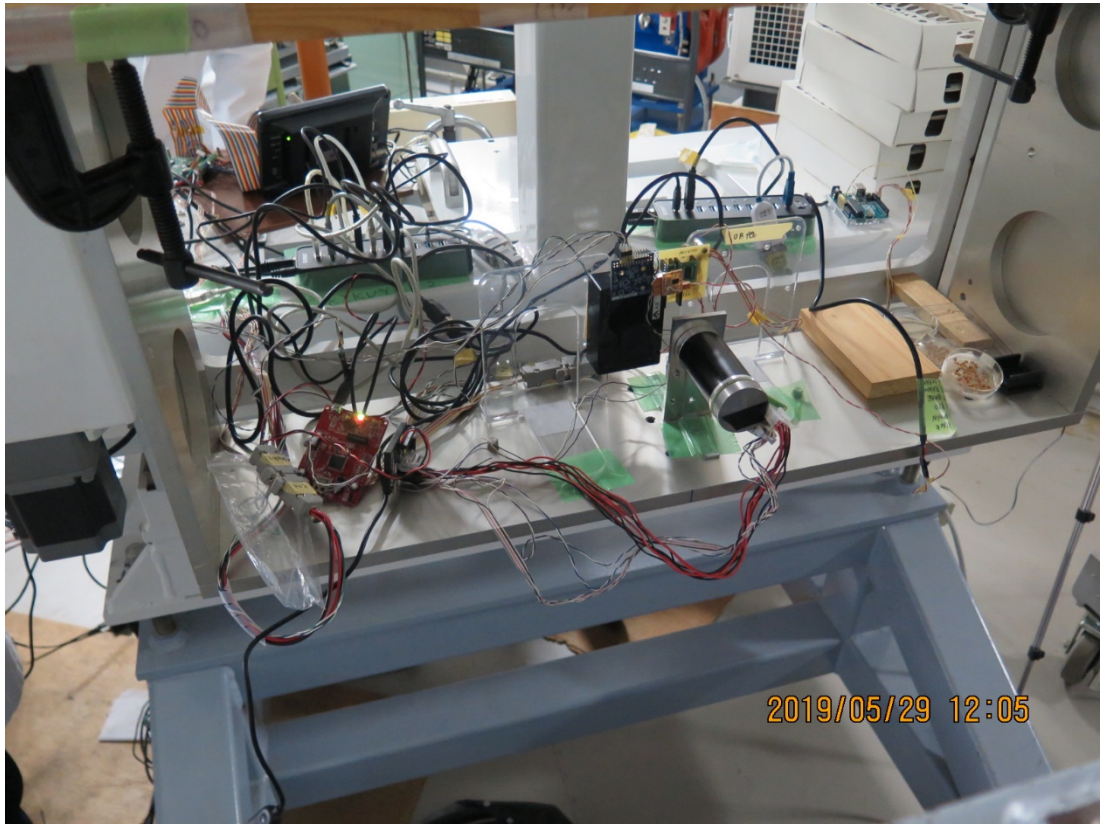
SEE / TID test

selected devises through radiation tests

SEE(Single Event Effects) test

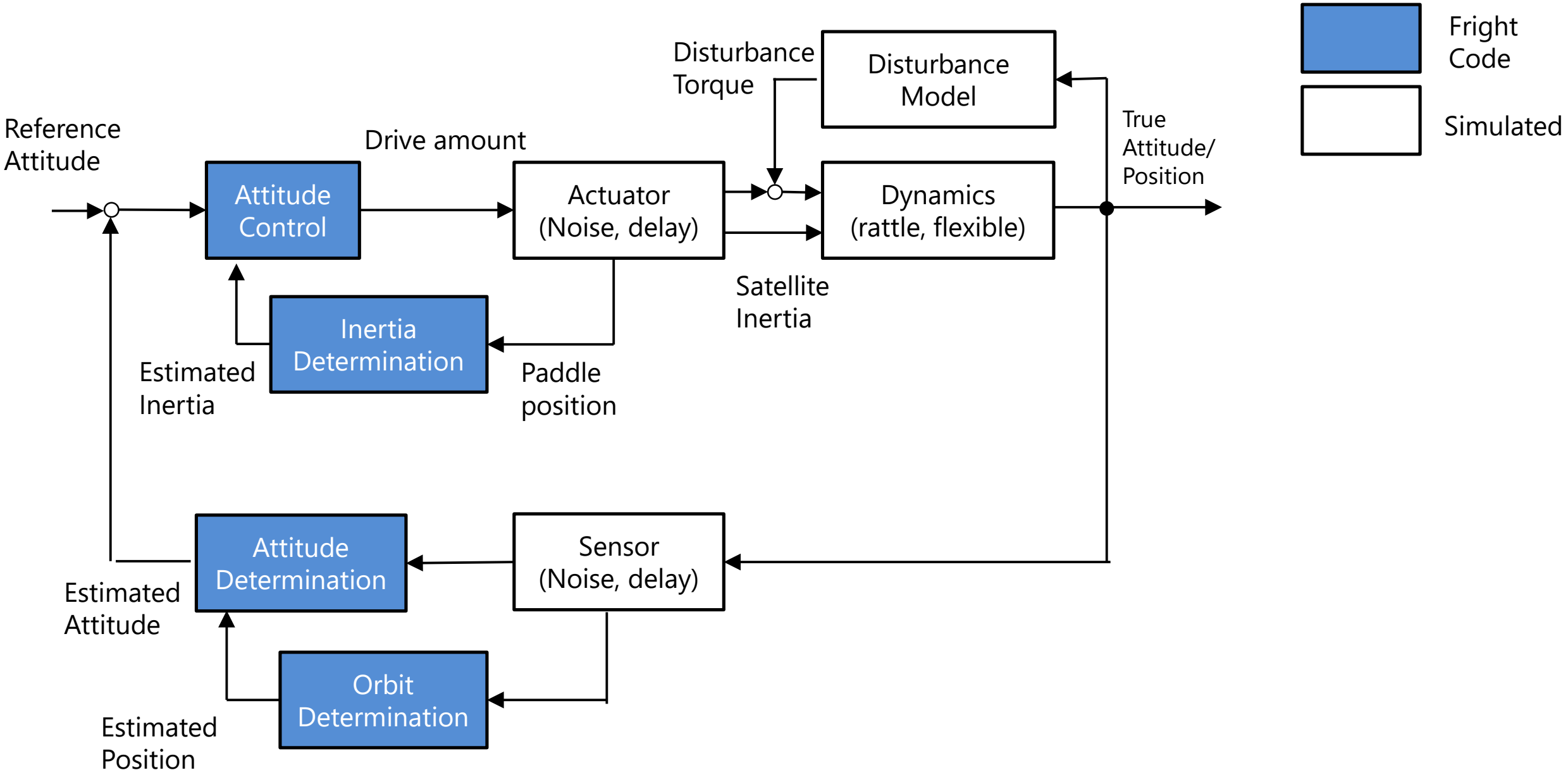


TID(Total Ionizing Dose Effect) test

BBM test

Established the function / communication between CDH and COMM most relevant to the life and death of the satellite

Software in the Loop Simulator



Conclusion

- We are developing 30 - 40kg microsatellite **Hibari** for demonstration of **VSAC** (Variable Shape Attitude Control)
- VSAC is a method of attitude control by driving solar array paddles
- This satellite will be launched in **FY2021**, and currently in the BBM phase