

Nano-JASMINE: A Small Infrared Astrometry Satellite

21st Annual AIAA/USU Conference on Small Satellites
14th/August/2007

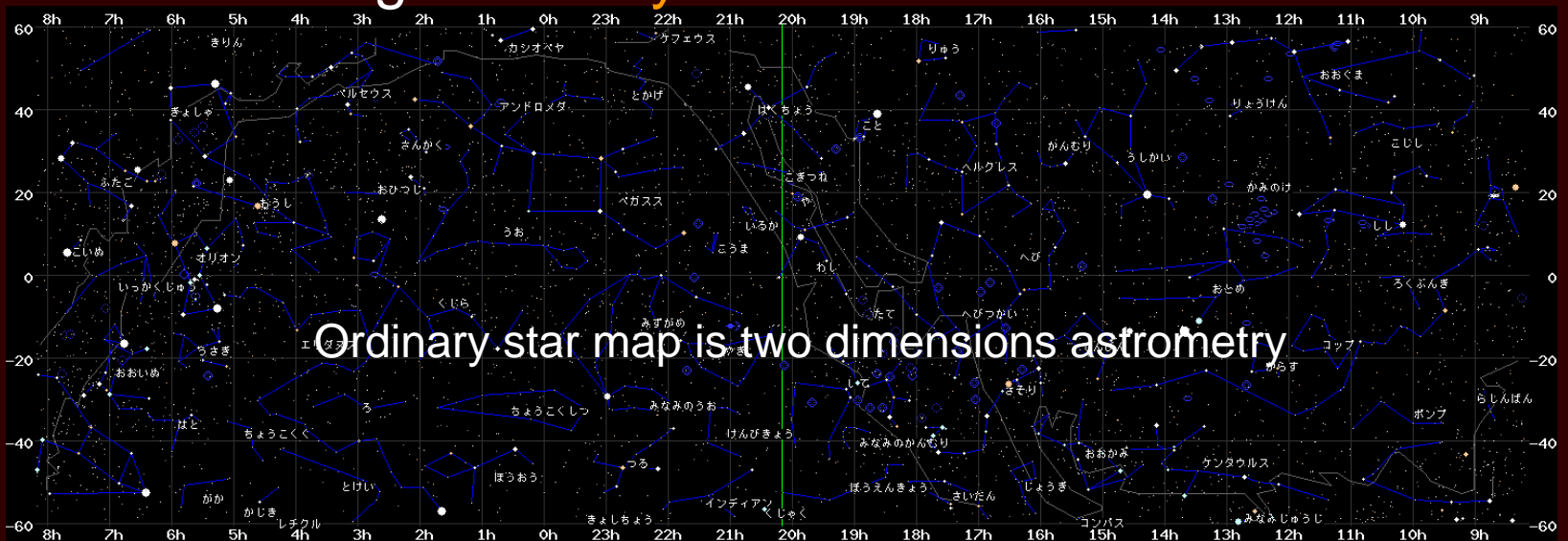
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Nano-JASMINE Project

- Global infrared astrometry satellite developed by Intelligent Space Systems Laboratory, The University of Tokyo and National Astronomical Observatory of Japan.
 - ISSL: New bus technology development
 - NAO: Technical demonstrations of JASMINE
- To be launched in 2009 (TBD).

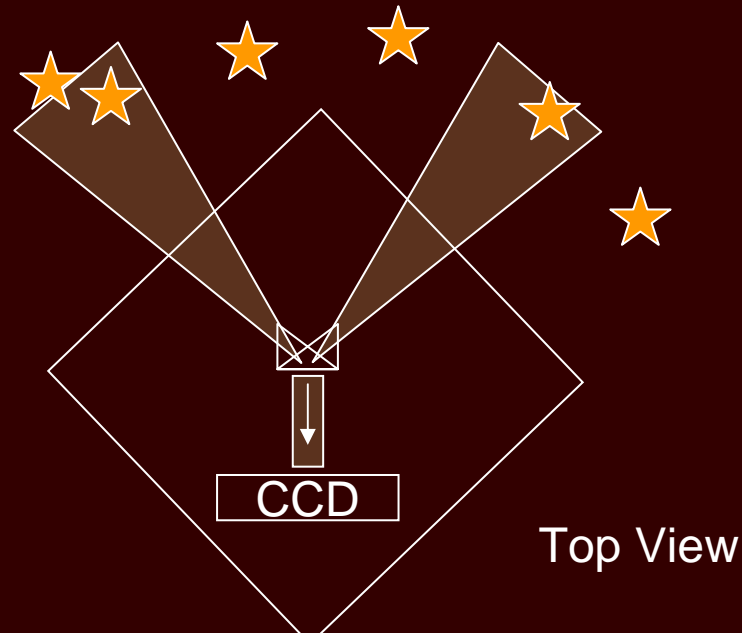
Astrometry

- To measure following six parameters of stars
 - Position on the celestial globe
 - Distance (annual parallax)
 - Crossing velocity (proper motion)
 - Line of sight velocity



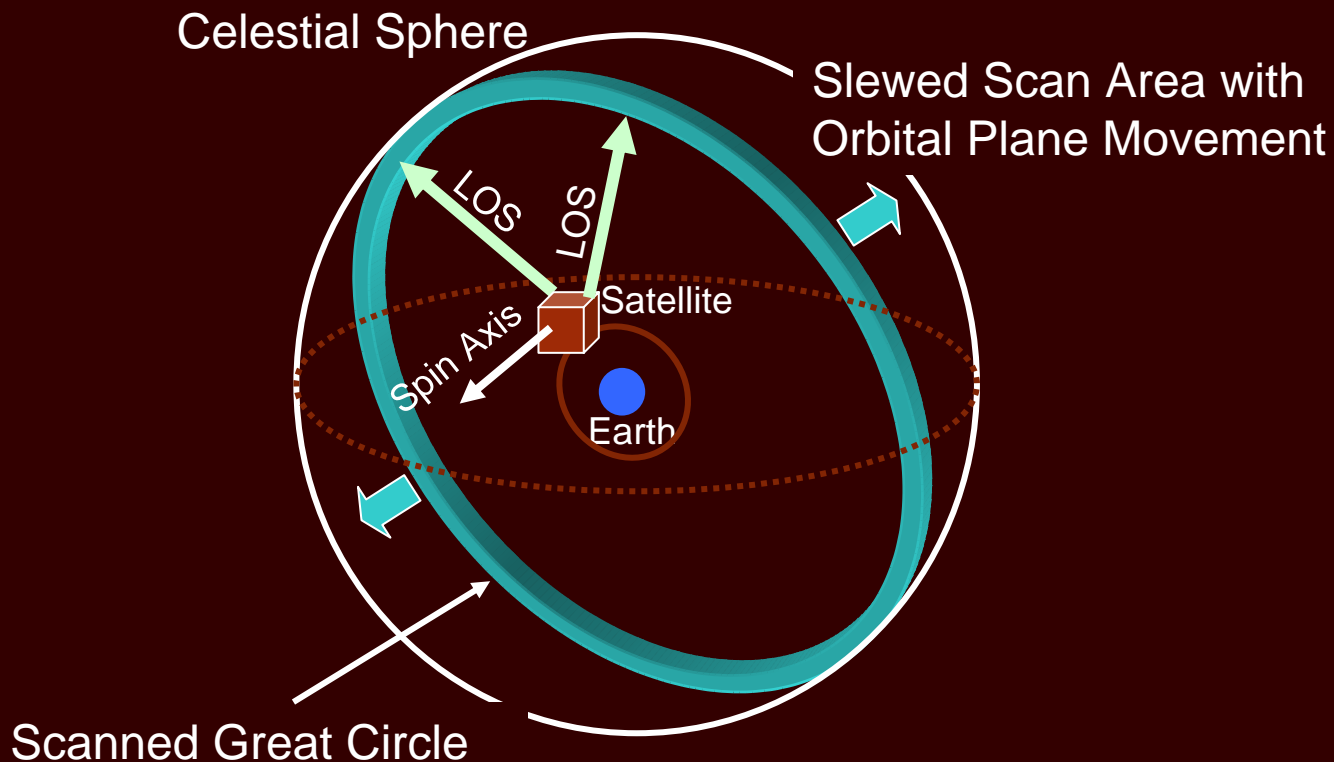
Observation Method[1]

- The satellite has two fields of view in 99.5 degree.
- The images are combined by a beam combiner and projected on a CCD.



Observation Method[2]

- The satellite spins to scan stars on a great circle.
- The spin axis changes its direction slowly and cover the entire sphere over half year.



Nano-JASMINE Missions

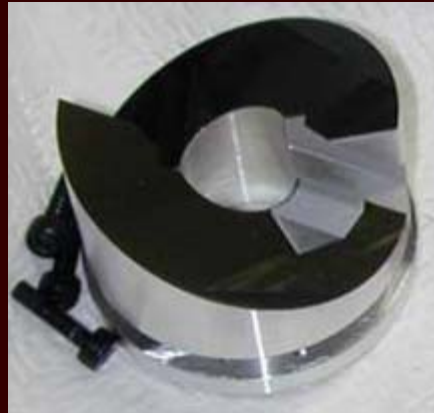
- Astrometry data acquisition
- Demonstration of a beam combiner
- Demonstration of a newly developed CCD
- Demonstration of precise attitude and thermal control
- Integrated satellite simulator development

Astrometry data acquisition

- Nano-JASMINE will be the second astrometry satellite after HIPPARCOS by ESA.
- 3 [mas] measurement accuracy at 7.5 magnitude stars.

Demonstration of a Beam Combiner

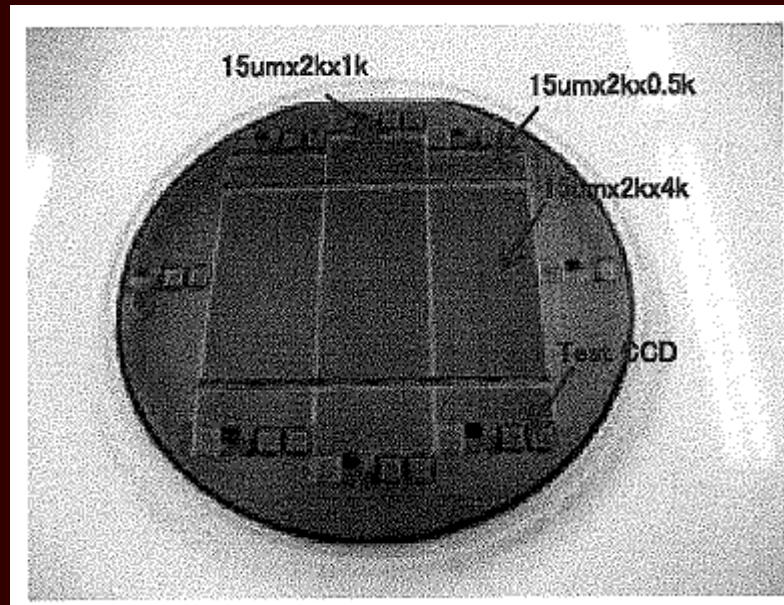
- This component guarantees measurement accuracy.
- Surface accuracy and angle stability is the point.



The beam combiner part (EM)

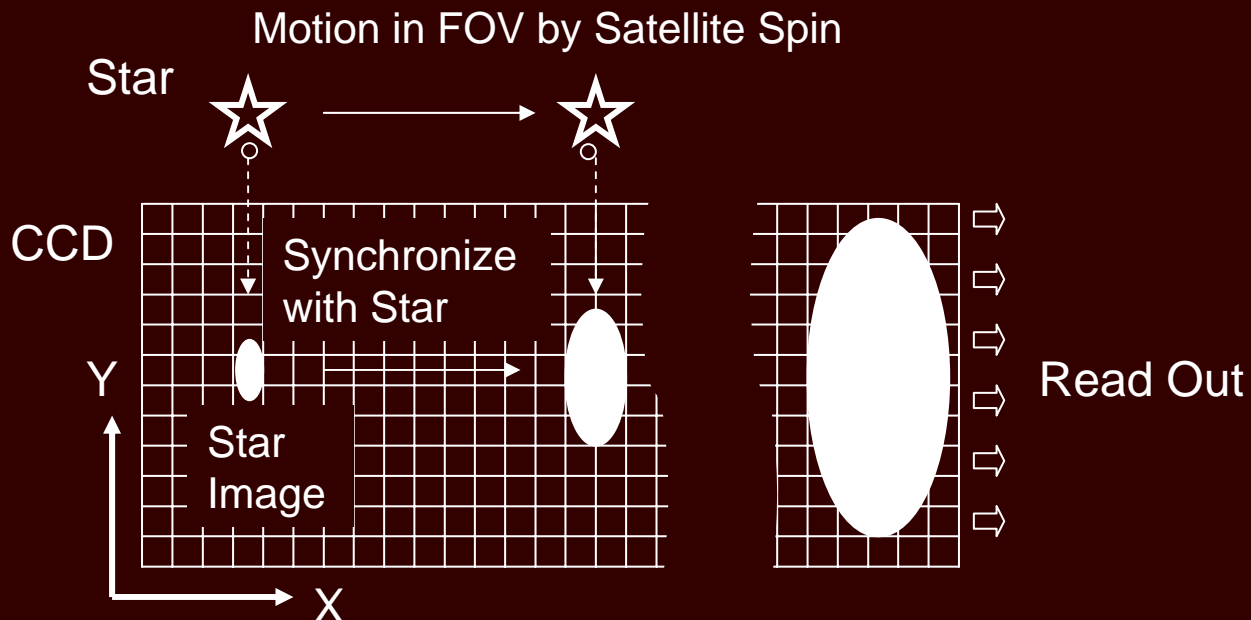
Demonstration of a Newly Developed CCD

- New image detector for JASMINE
 - Full depleted CCD
 - Z band ($0.9\mu\text{m}$)
 - Used in time delayed integration (TDI) mode



TDI Mode

- TDI is used for suppression of read out noise and continuous observation.
- Output isn't a one shot image but column data is continuously generated.

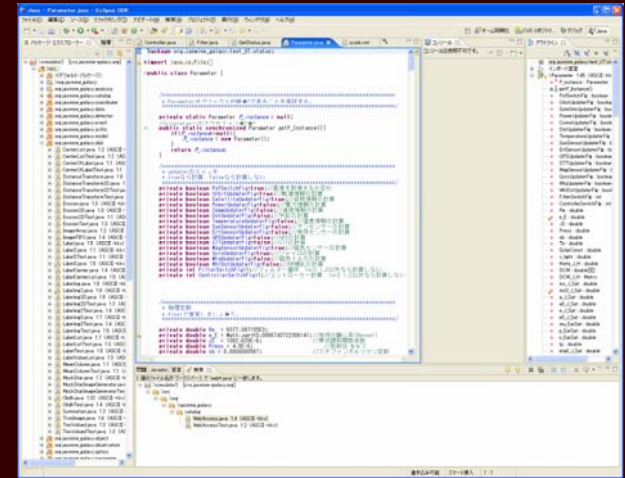


Demonstration of Precise Attitude and Thermal Control

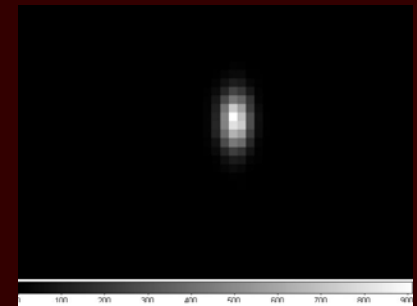
- Precise control is required to catch up with large satellite achievement.
 - 1[arcsecond] attitude control
 - 1[mK] thermal control

Integrated Satellite Simulator Development

- Satellite simulator to confirm design feasibility.
 - CCD output by calculating one photon behavior from a star.
 - Satellite attitude dynamics.
- Design transfer tool for JASMINE project.



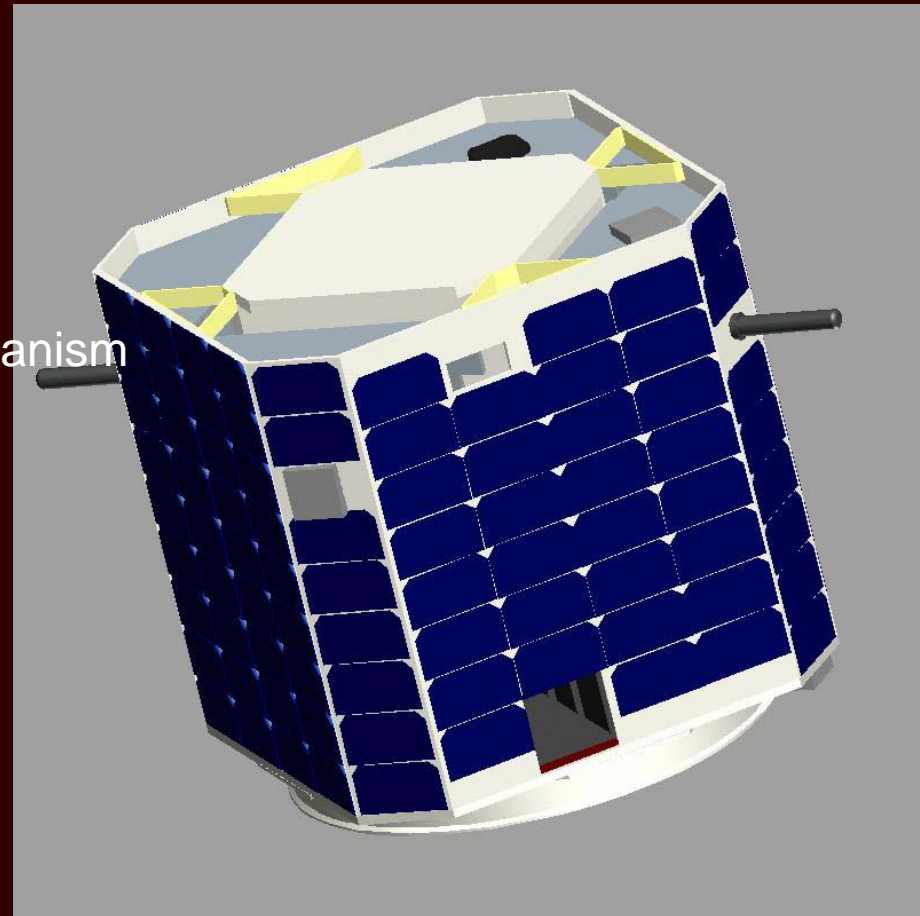
Development environment



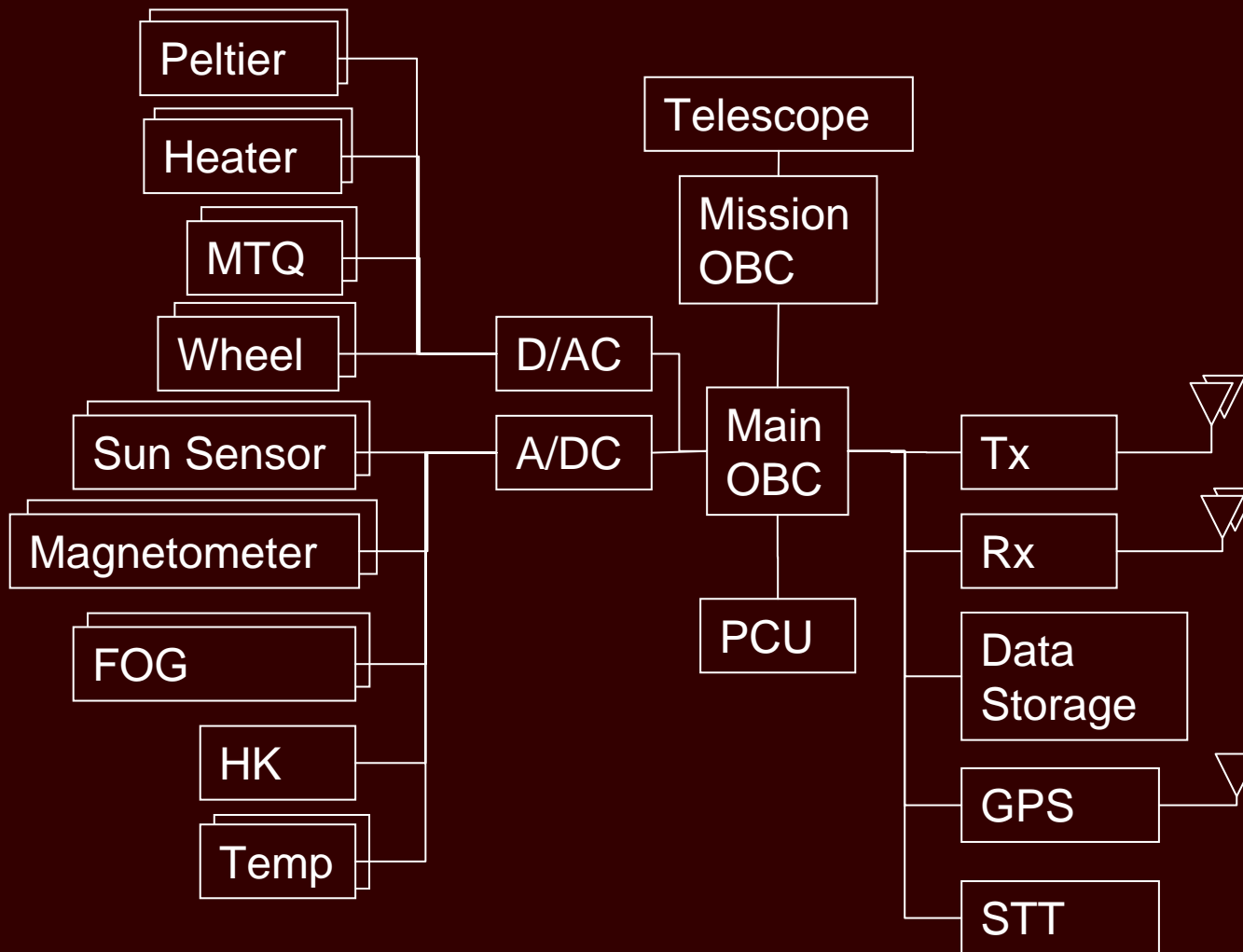
CCD output

Satellite Specifications

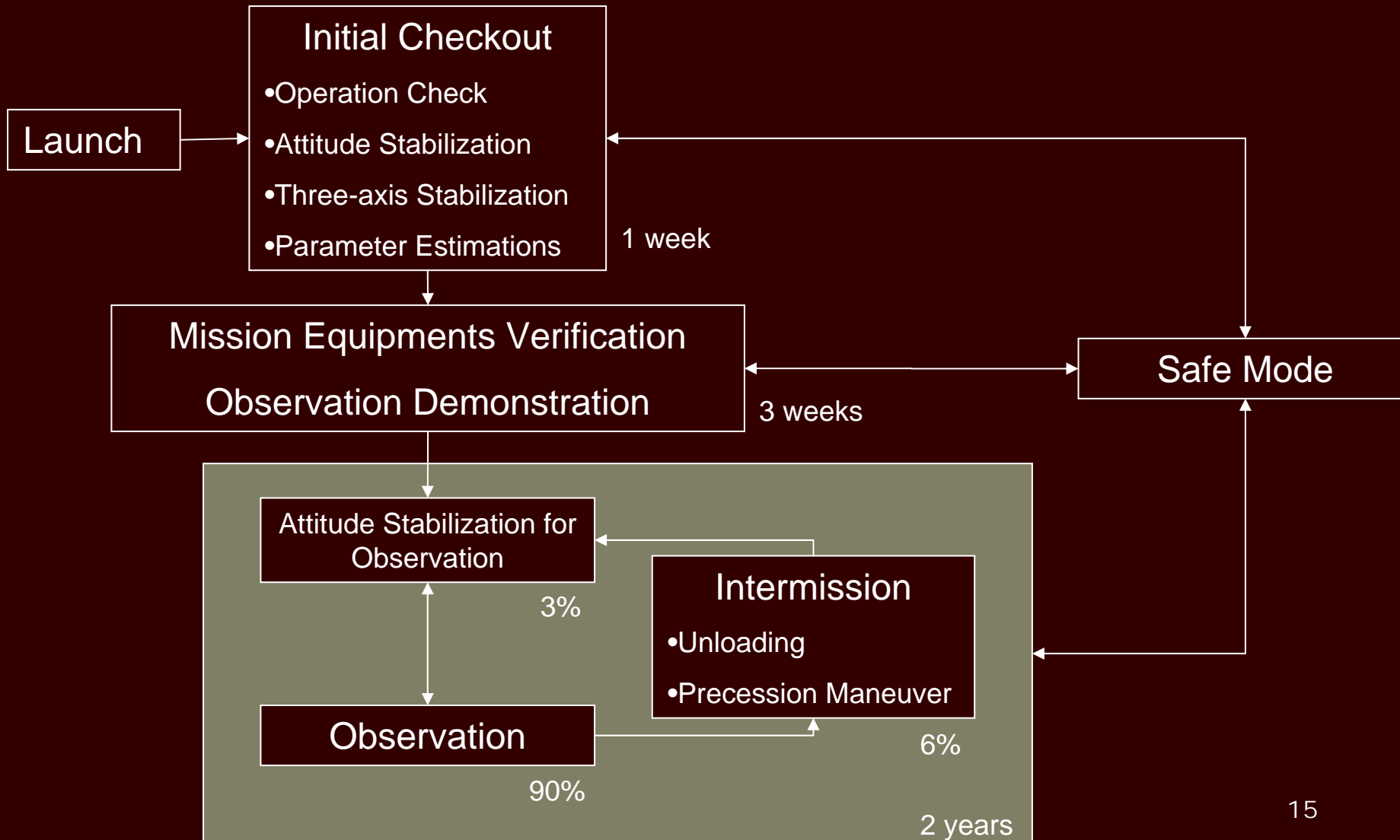
Mission	Infrared Astrometry
Size	50[cm cubic]
Mass	14[kg] without separation mechanism
Attitude Control	Three axis stabilization
Communication	S-band/100[kbps]
Mission Life	Two [years]
Orbit	Sun-synchronous Orbit



Functional Block Diagram



Mission Sequence



Telescope

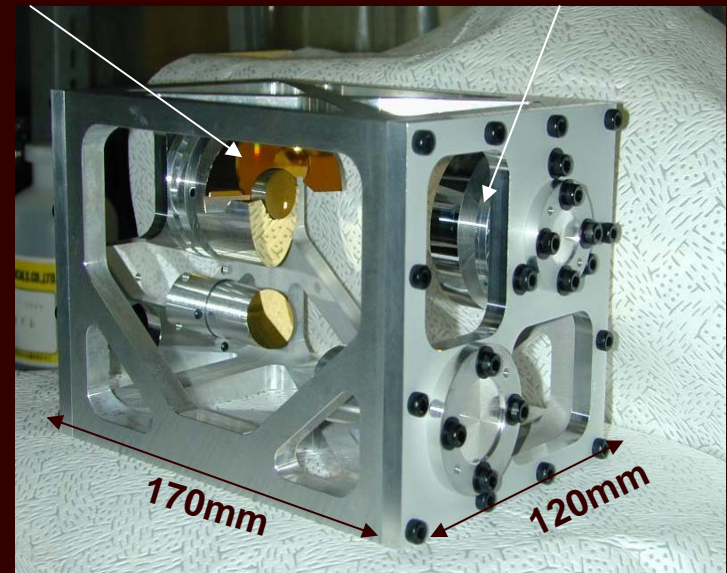
- Telescope is developed by NAO.

specification

Beam combiner

Main Mirror($\phi 5\text{cm}$)

Telescope Type	Korsch
Diameter	5[cm]
Focal Length	1.66[m]
Detector	z- band:1K× 1K
Num. of Detector	1
1pixel size	15[μm]
FOV	0.53[$^{\circ}$]× 0.53[$^{\circ}$]
Airy Disk	4[pixels]
Mirror Material	Aluminium
Structure Material	Aluminium
Exposure Time	8.8[s]



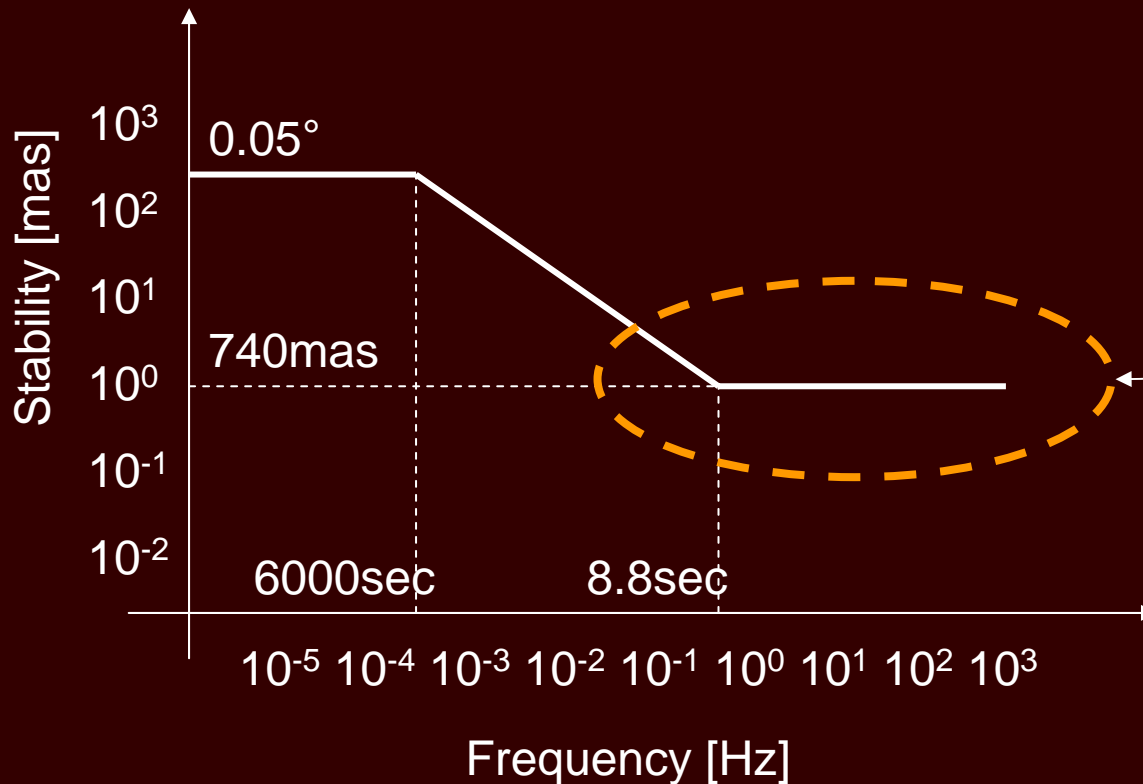
Engineering Model

Attitude Control Requirements[1]

- Short period stabilization
 - CCD image blur prevention.
 - 1[pixel] disturbance per detector transit time 8.8[sec]: It is equivalent to $740[\text{mas}] / 8.8[\text{sec}]$.
- Middle period stabilization
 - The spin axis follows the orbit rotation and scans the celestial sphere.
 - 0.05[deg] per orbit period 100[min].
- Long period stabilization
 - The spin axis precession maneuver to improve measurement.
 - 10[deg] per few days.

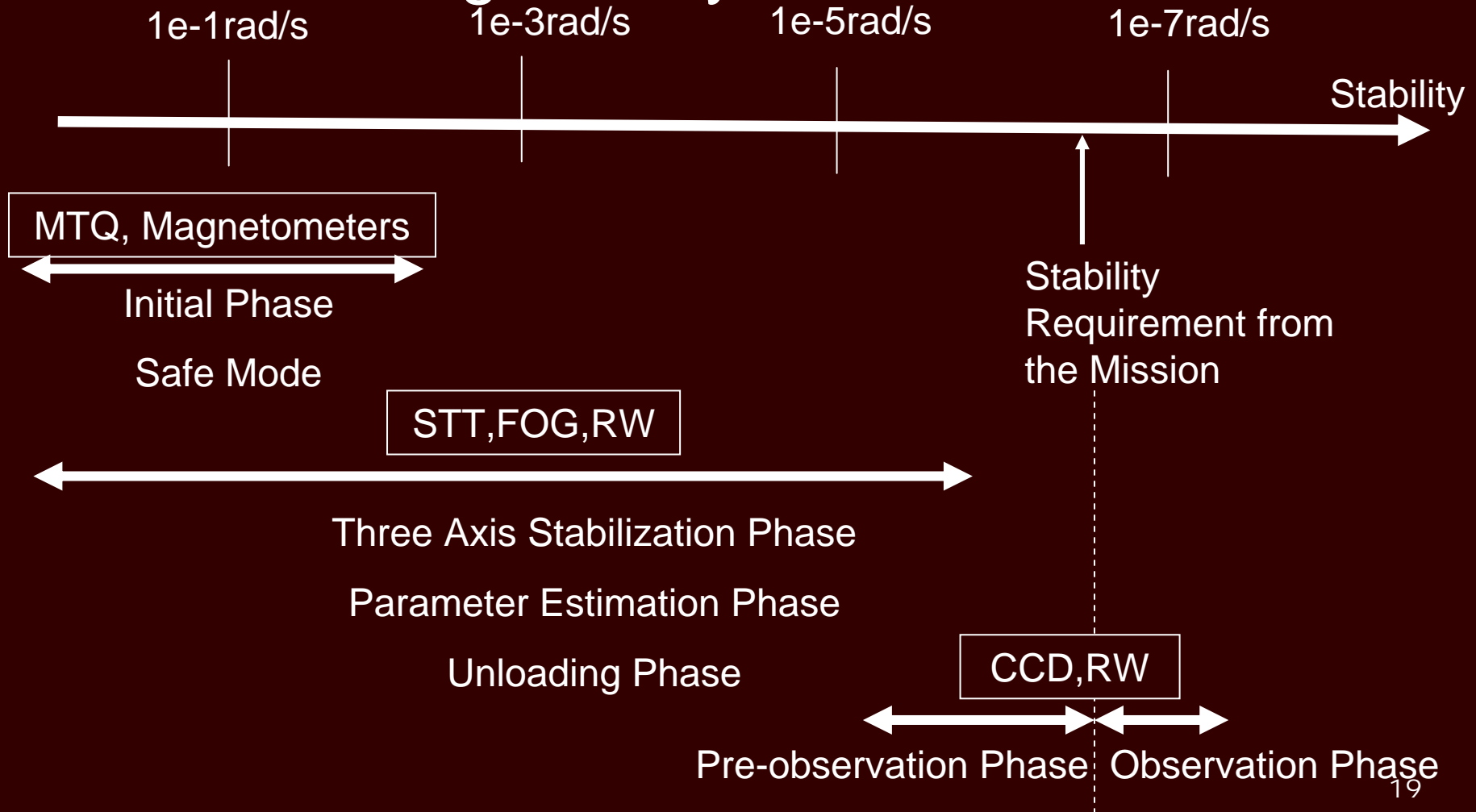
Attitude Control Requirements[2]

- The short term stabilization requirement is strict for current nano-satellite technology.



Attitude Control Strategy

- The satellite gradually stabilizes its attitude.



Attitude Control Technology[1]

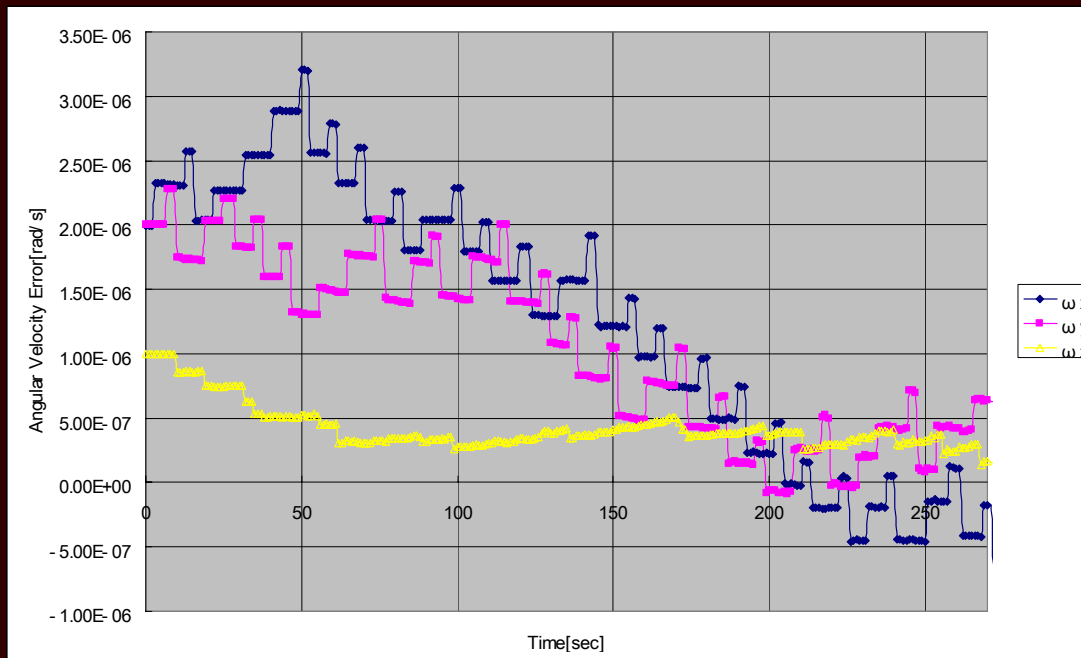
- Customize FOG for about 3 [arcsec] measurement.
- Magnetic shield against residual magnetic moment.



Prototype FOG

Attitude Control Technology[2]

- Telescope output is used as a fine attitude sensor.
 - Point spread function distortion is measured.



Thermal Control Requirements

- Beam combiner angle stability
 - 1[mas] per two orbit periods.
 - →1[mK] temperature stability.
- Telescope frame temperature
 - 1[K] for focus.
- CCD unit
 - -50[°C] or lower for infrared detection.

Thermal Control

- Orbit uncertainty is the hurdle.
- Telescope part is thermally isolated from the other area.

Deep Space

Earth

Radiation Plate

CCD

Telescope

Baffle

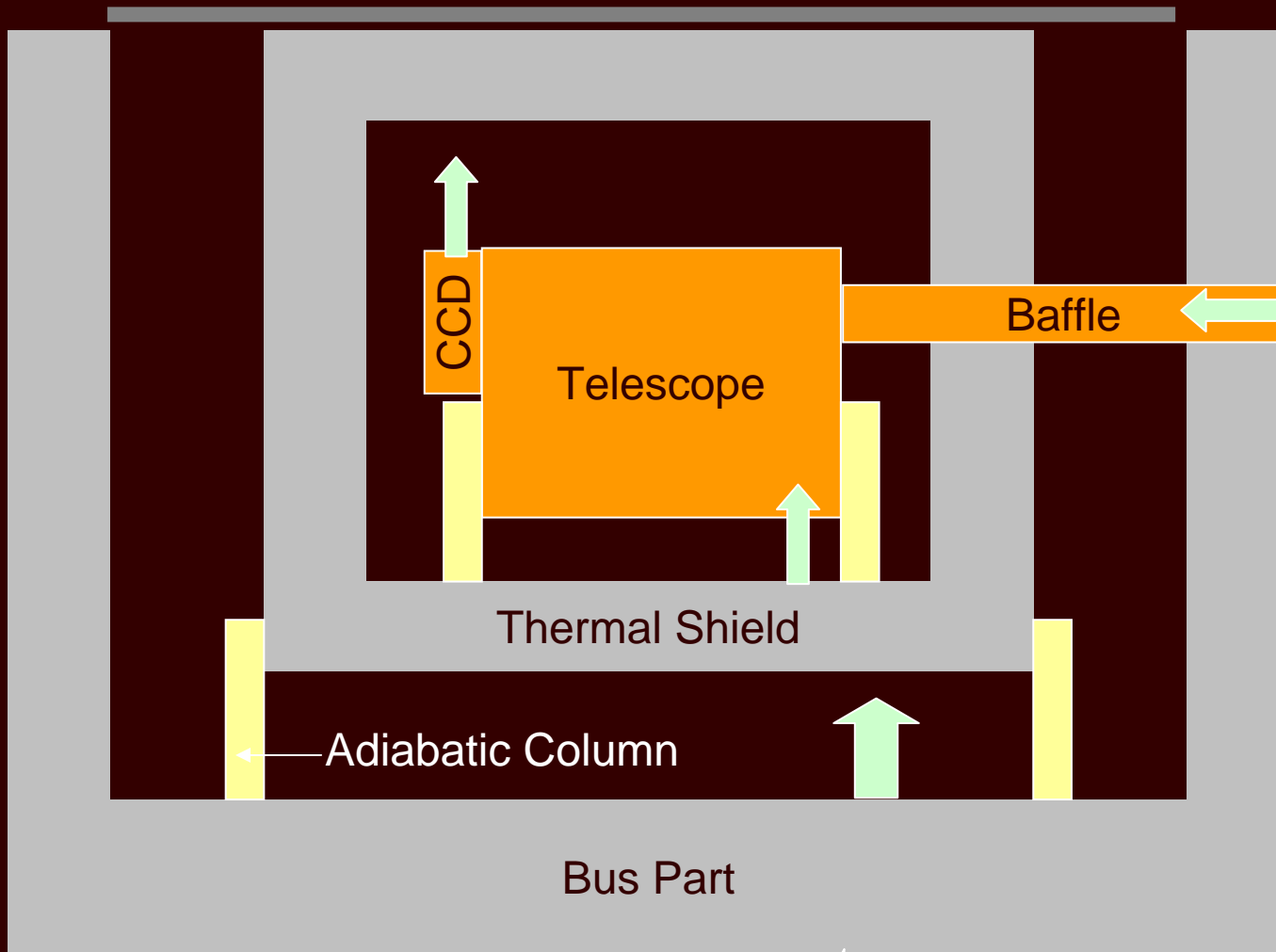
Thermal Shield

Adiabatic Column

Bus Part

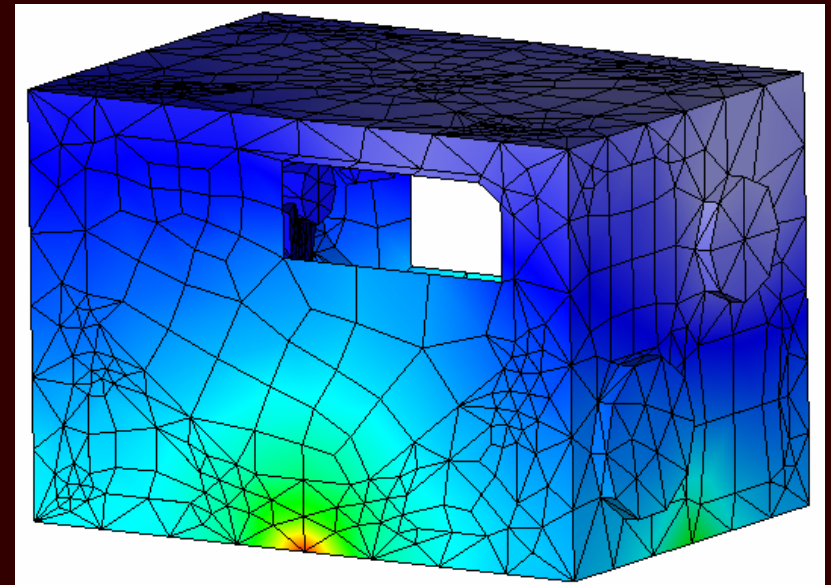
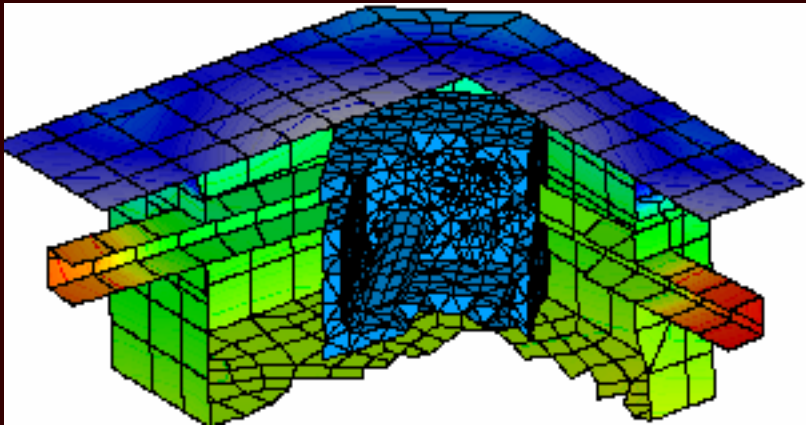
Sun

Heat Path

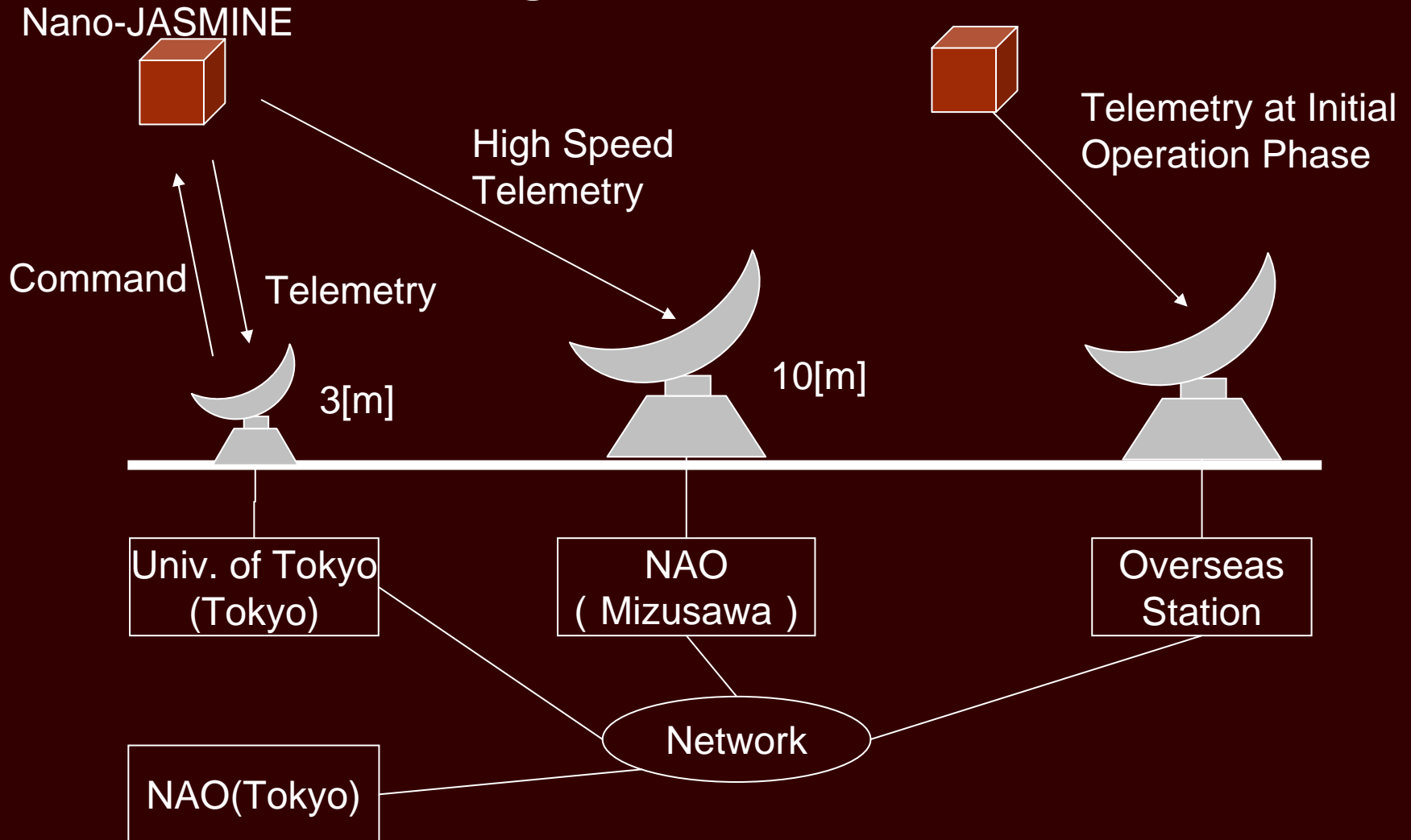


FEM Analysis

- Temperature change is calculated by FEM.
- STM test is also planned.



Ground Segment



Ground Station



ISSL station (under construction)



Mizusawa station

Schedule

Date	Events
Apr. / 2003	First meeting between NAO and ISSL Small astrometry satellite is examined.
2003	50kg class infrared astrometry satellite "ASAGAO" conceptual design
2004	10kg class infrared astrometry satellite "Nano-Jasmine" conceptual design
Apr. / 2005	Nano-JASMINE is authorized as a project
Sep. / 2005	Prototype of satellite simulator
Nov. / 2006	PDR
2009	Launch of Nano-JASMINE (TBD)
2011	End of observation (TBD)
2014	Launch of JASMINE

Conclusions

- Nano-JASMINE, a small infrared global astrometry satellite, is developed by ISSL/UT and NAO.
- It is small but have enough ability for current space science.

Thank you very much.

- Contact point

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- WEB site

- <http://www.space.t.u-tokyo.ac.jp>

