SSC07-VI-4

Nano-JASMINE: A Small Infrared Astrometry Satellite

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

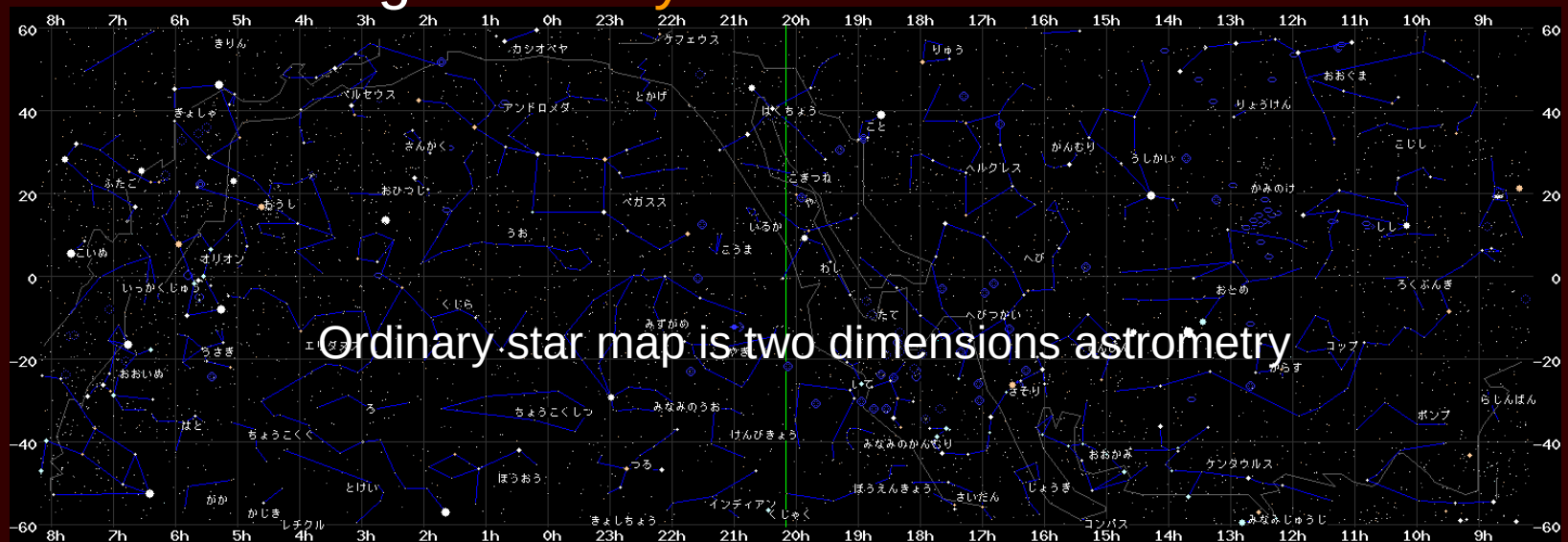
Intelligent Space Systems Laboratory, University of Tokyo
Nobutada Sako, Yoichi Hatsutori, Takashi Tanaka, Takaya Inamori, Shinichi Nakasuka

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



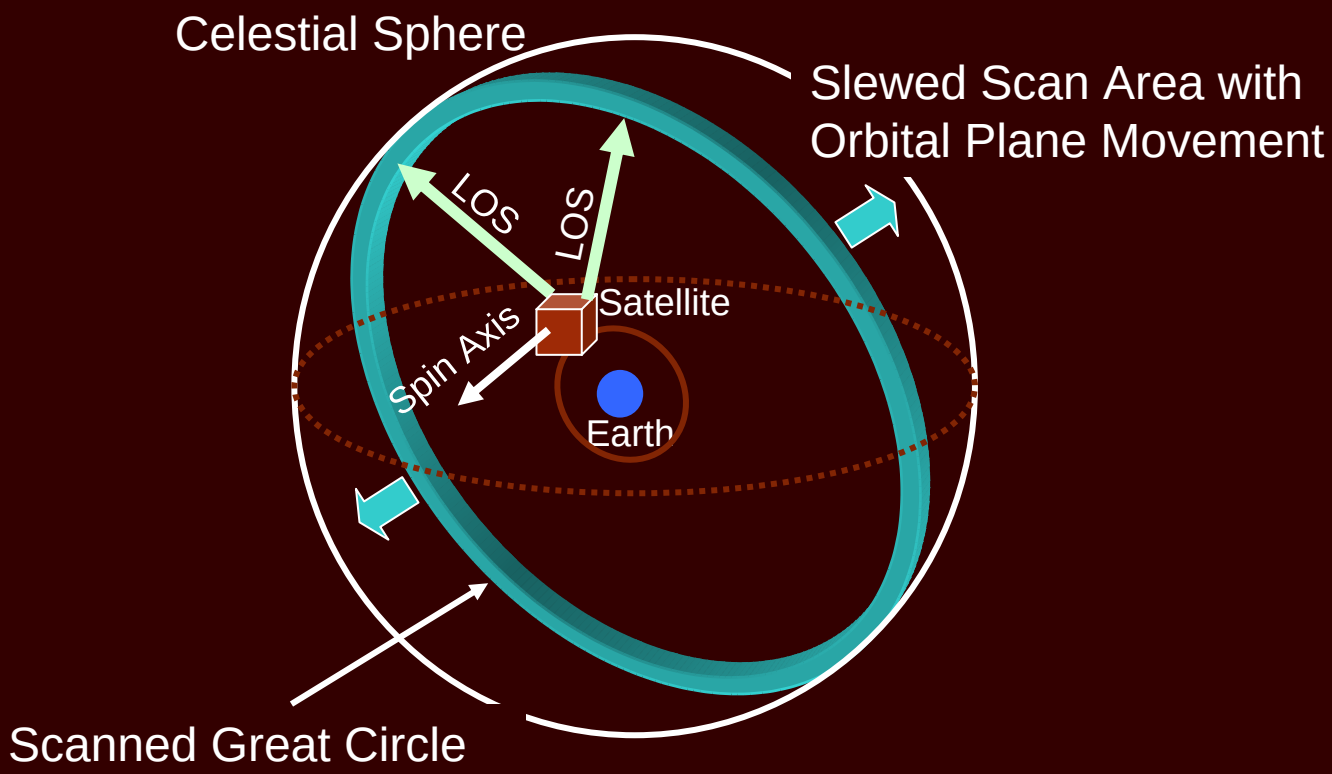
Observation Method[1]

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

Top View

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

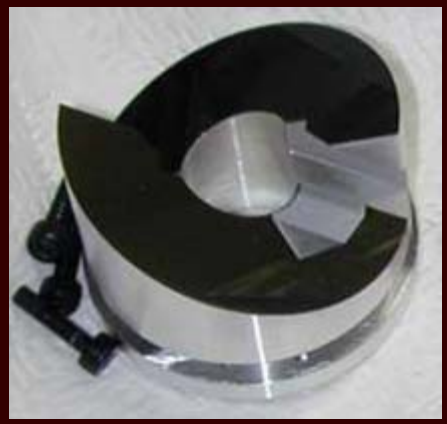
- Astrometry data acquisition
- Demonstration of a beam combiner
- Demonstration of a newly developed CCD
- Demonstration of precise attitude and thermal control
- Integrated satellite simulator development

Astrometry data acquisition

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

Demonstration of a Beam Combiner

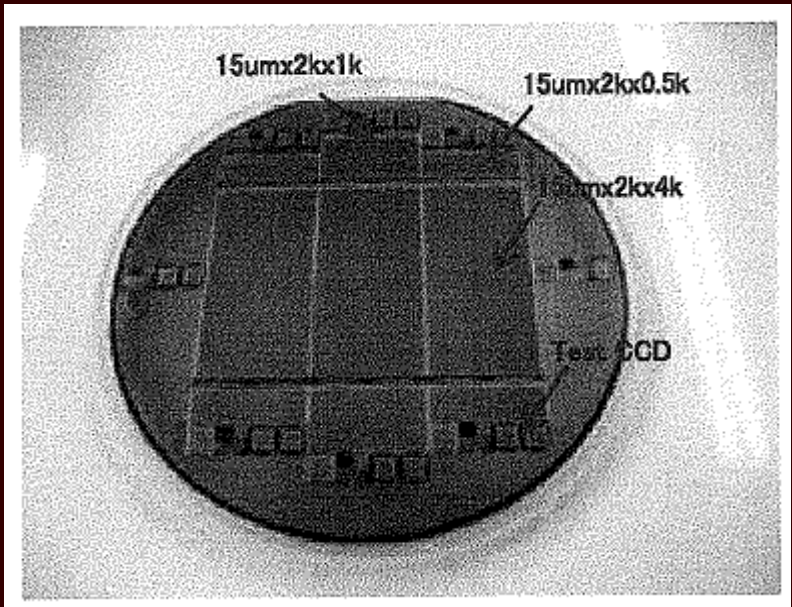
- This component guarantees measurement accuracy.
- Surface accuracy and angle stability is the point.



The beam combiner part (EM)

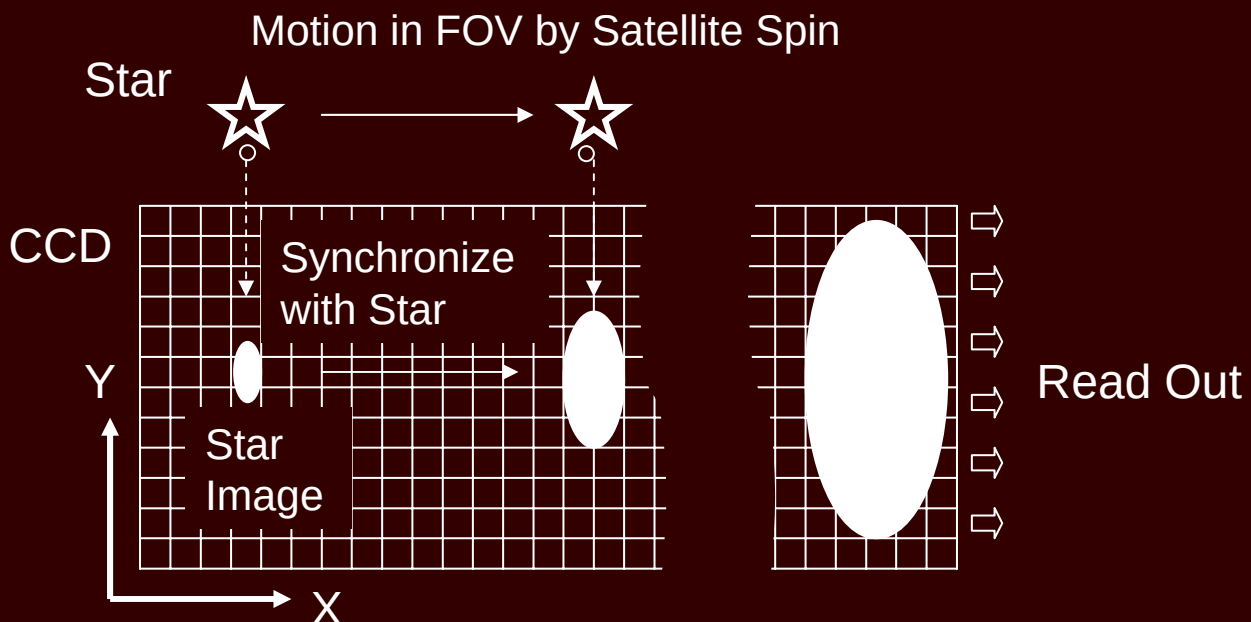
Demonstration of a Newly Developed CCD

- New image detector for JASMINE
  - Full depleted CCD
  - Z band (0.9μm)
  - 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.

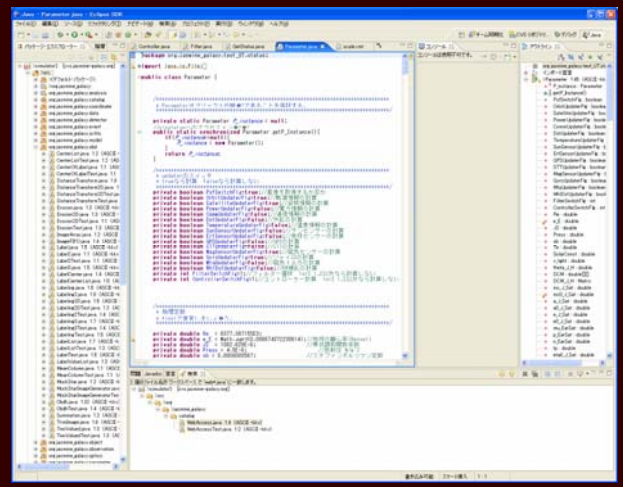


Demonstration of Precise Attitude and Thermal Control

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

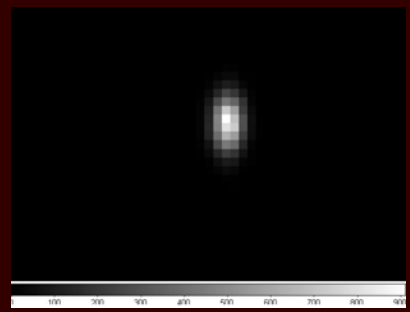
Integrated Satellite Simulator Development

- Satellite simulator to confirm design feasibility.
  - CCD output by calculating one photon behavior from a star.
  - Satellite attitude dynamics.



Development environment

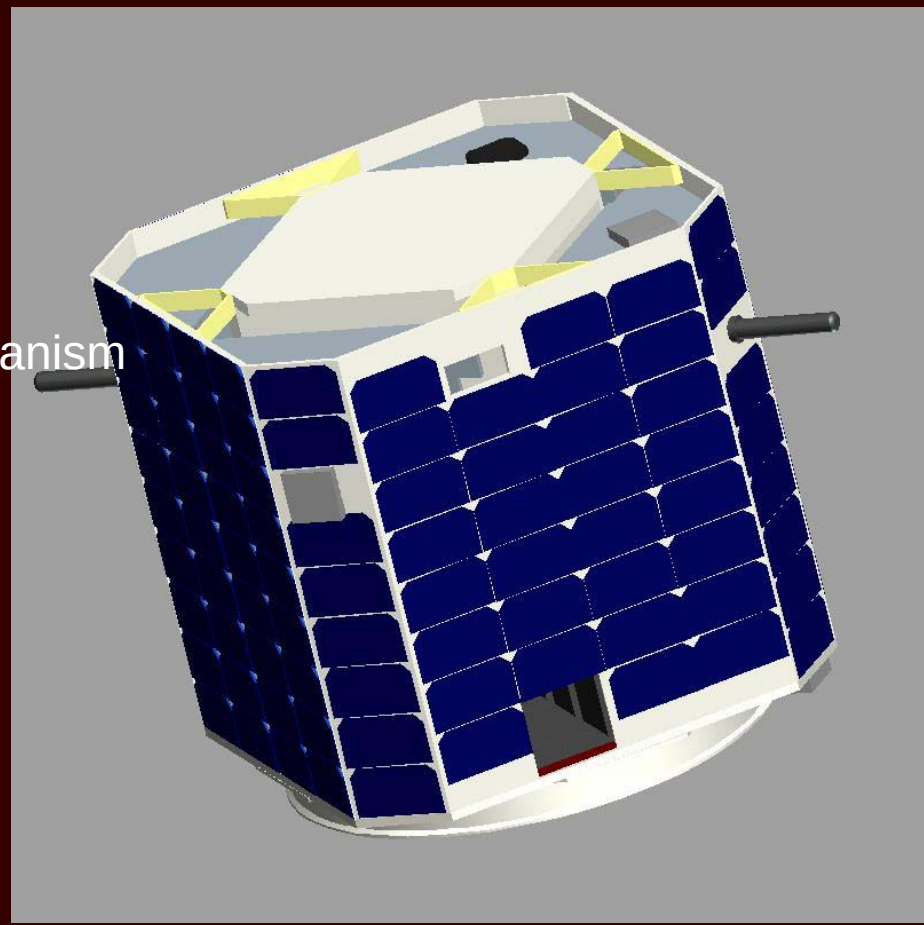
- Design transfer tool for JASMINE project.



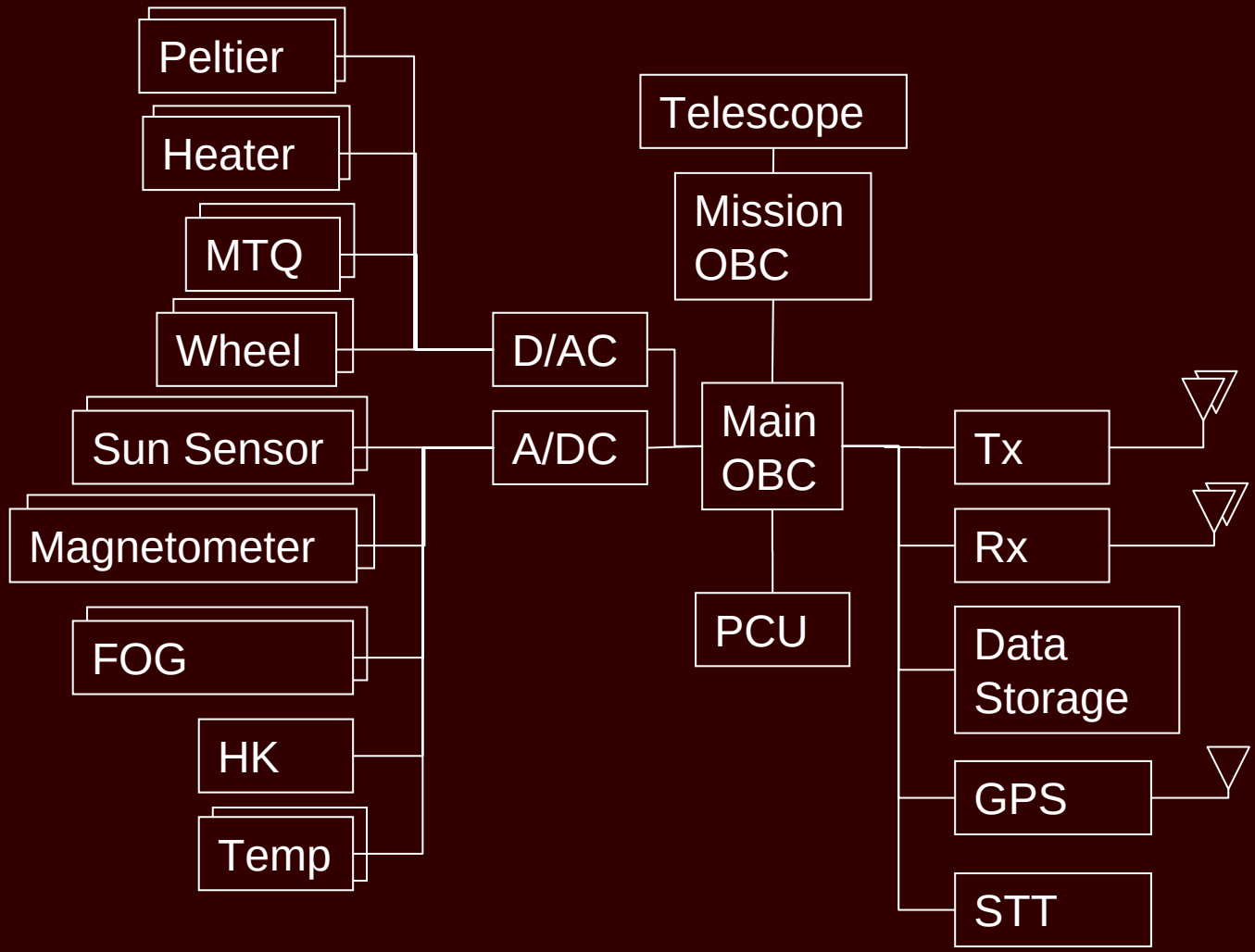
CCD output

Satellite Specifications

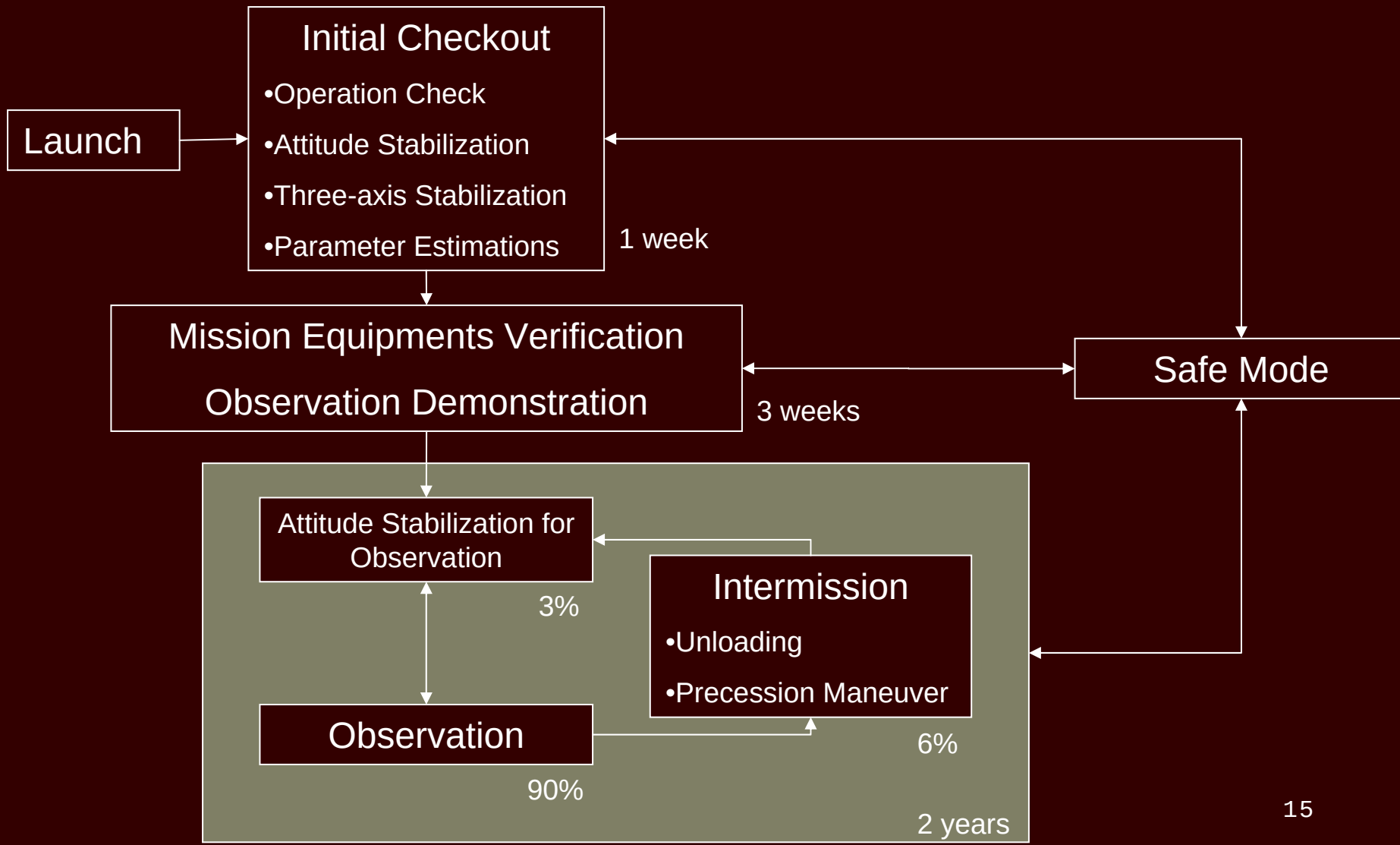
Mission	Infrared Astrometry
Size	50[cm cubic]
Mass	14[kg]
	without separation mechanism
Attitude Control	Three axis stabilization
Communication	S-band/100[kbps]
Mission Life	Two [years]
Orbit	Sun-synchronous Orbit



Functional Block Diagram



Mission Sequence



Telescope

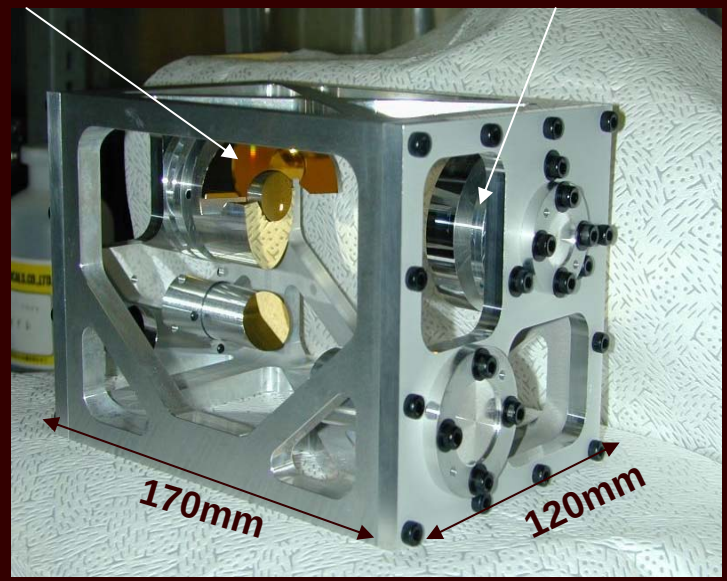
- Telescope is developed by NAO.

specification

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

Beam combiner

Main Mirror(φ5cm)



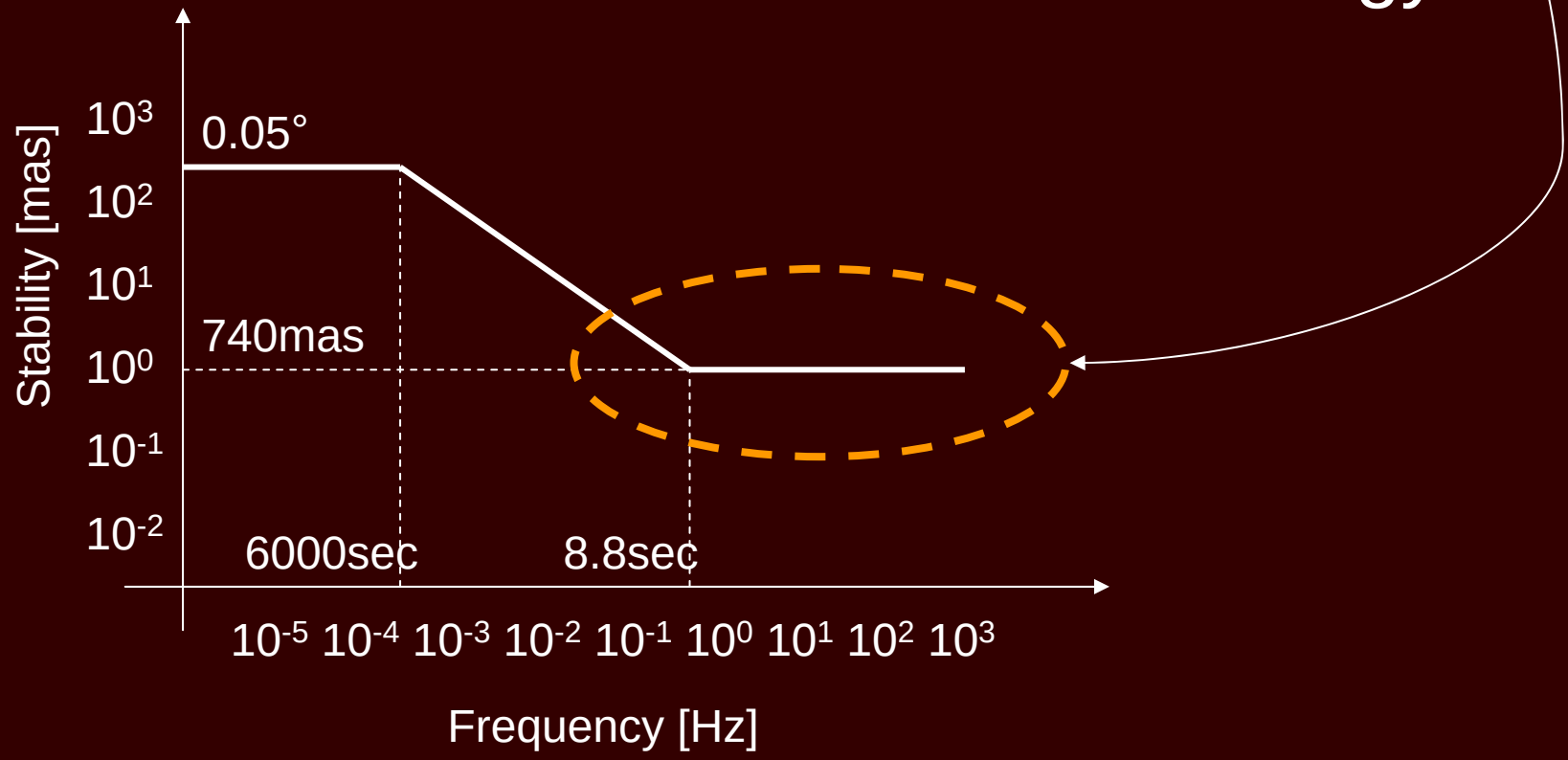
Engineering Model

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[mas] / 8.8[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.

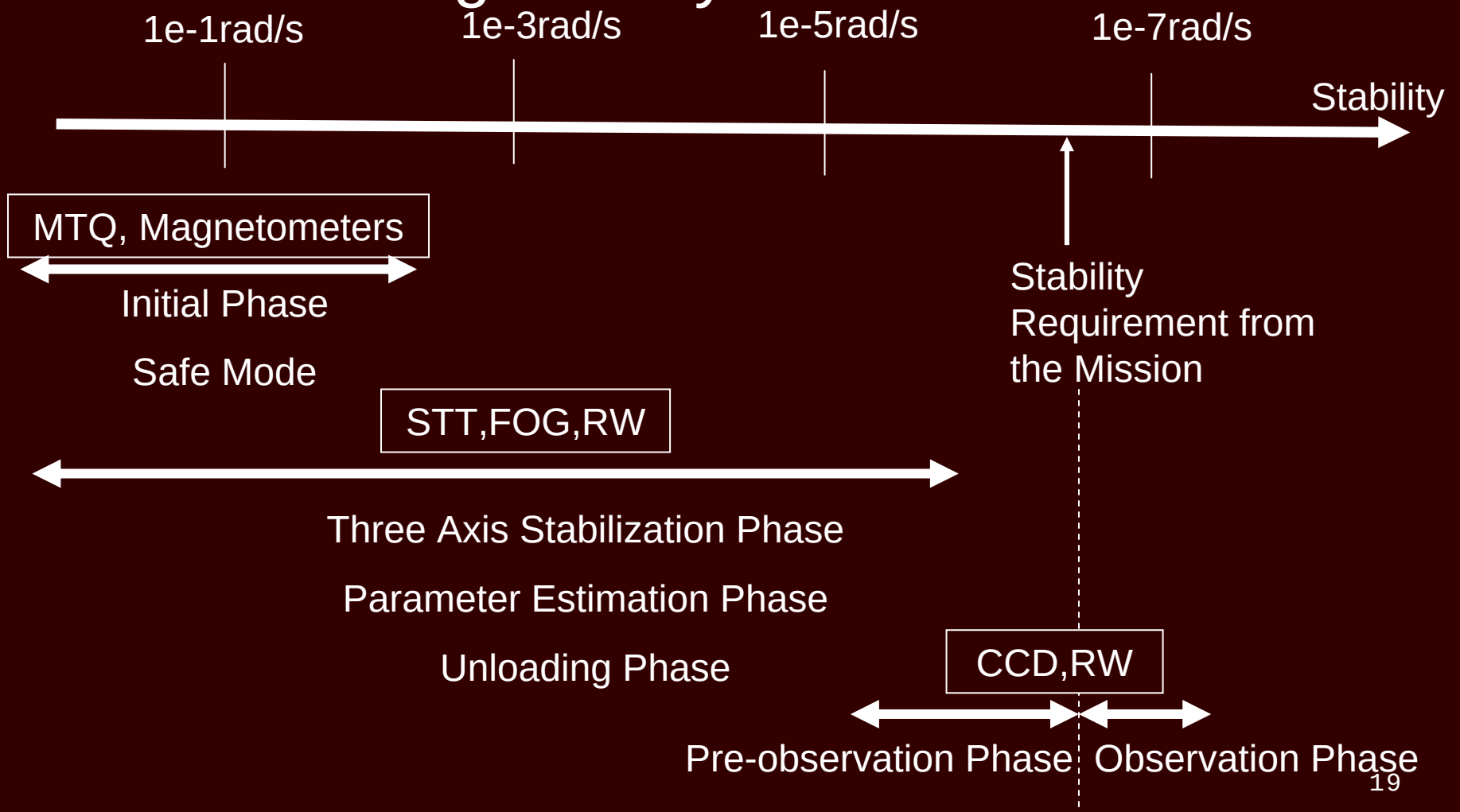
Attitude Control Requirements[2]

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



Attitude Control Strategy

- The satellite gradually stabilizes its attitude.



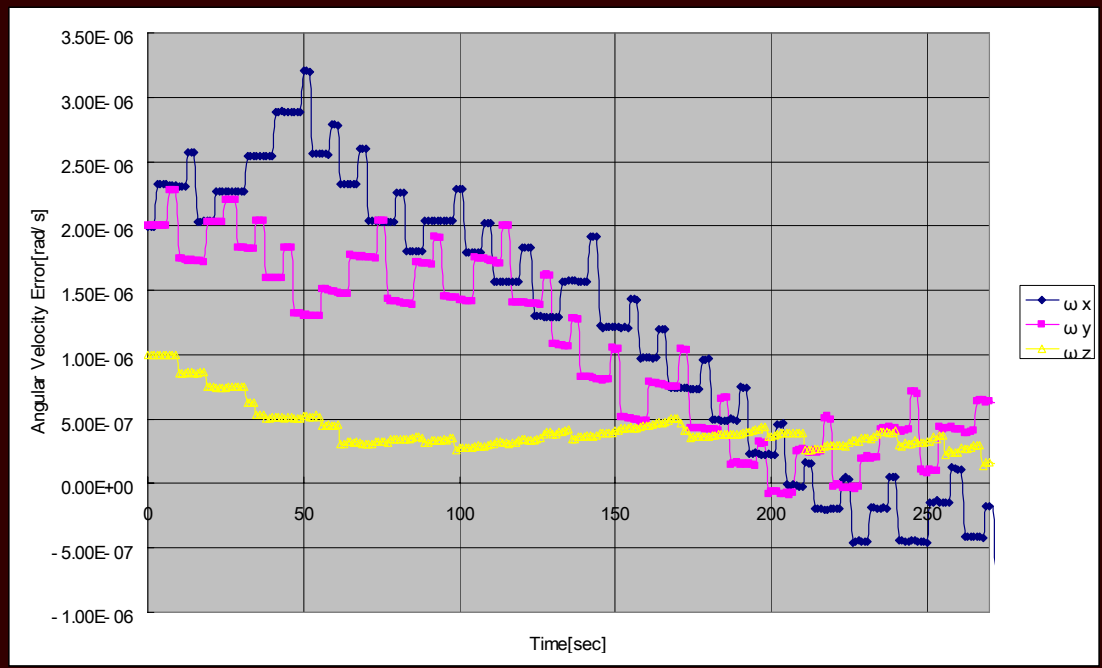
Attitude Control Technology[1]

- 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.



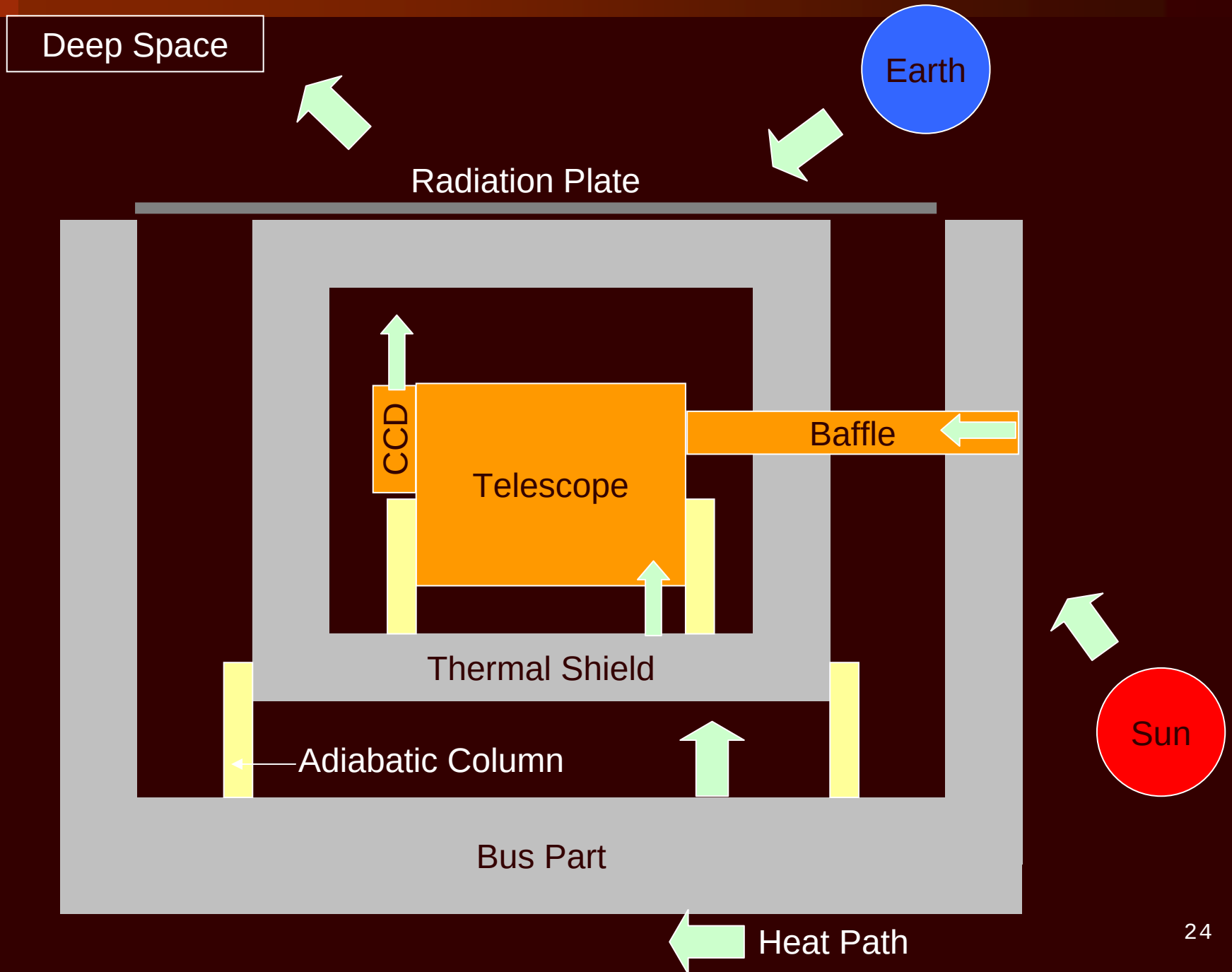
Evaluation by using the simulator

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[℃] or lower for infrared detection.

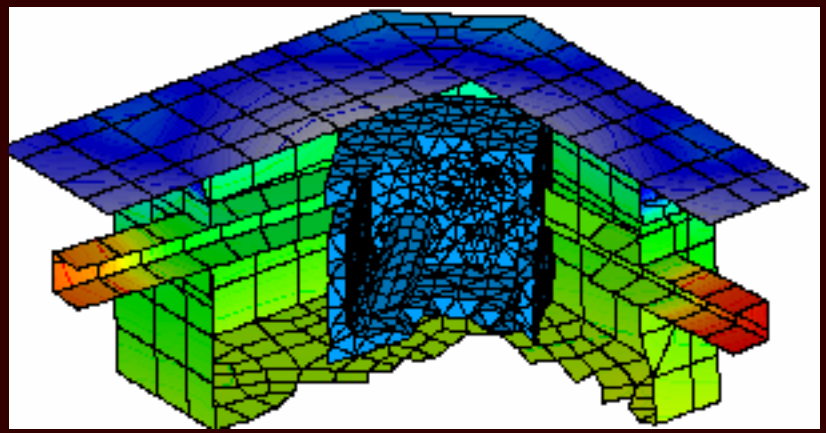
Thermal Control

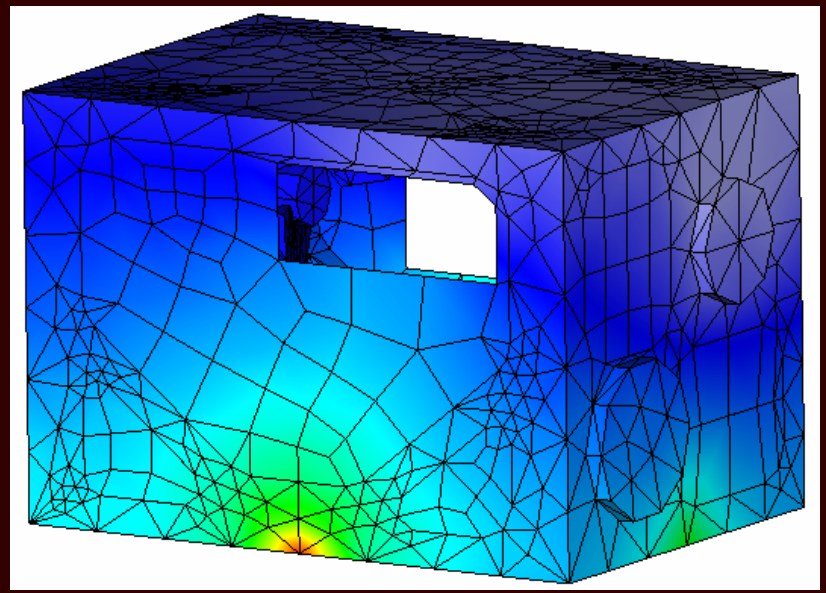
- Orbit uncertainty is the hurdle.
- Telescope part is thermally isolated from the other area.


Deep Space
Earth
Radiation Plate
CCD
Telescope
Baffle
Thermal Shield
Adiabatic Column
Sun
Bus Part
Heat Path

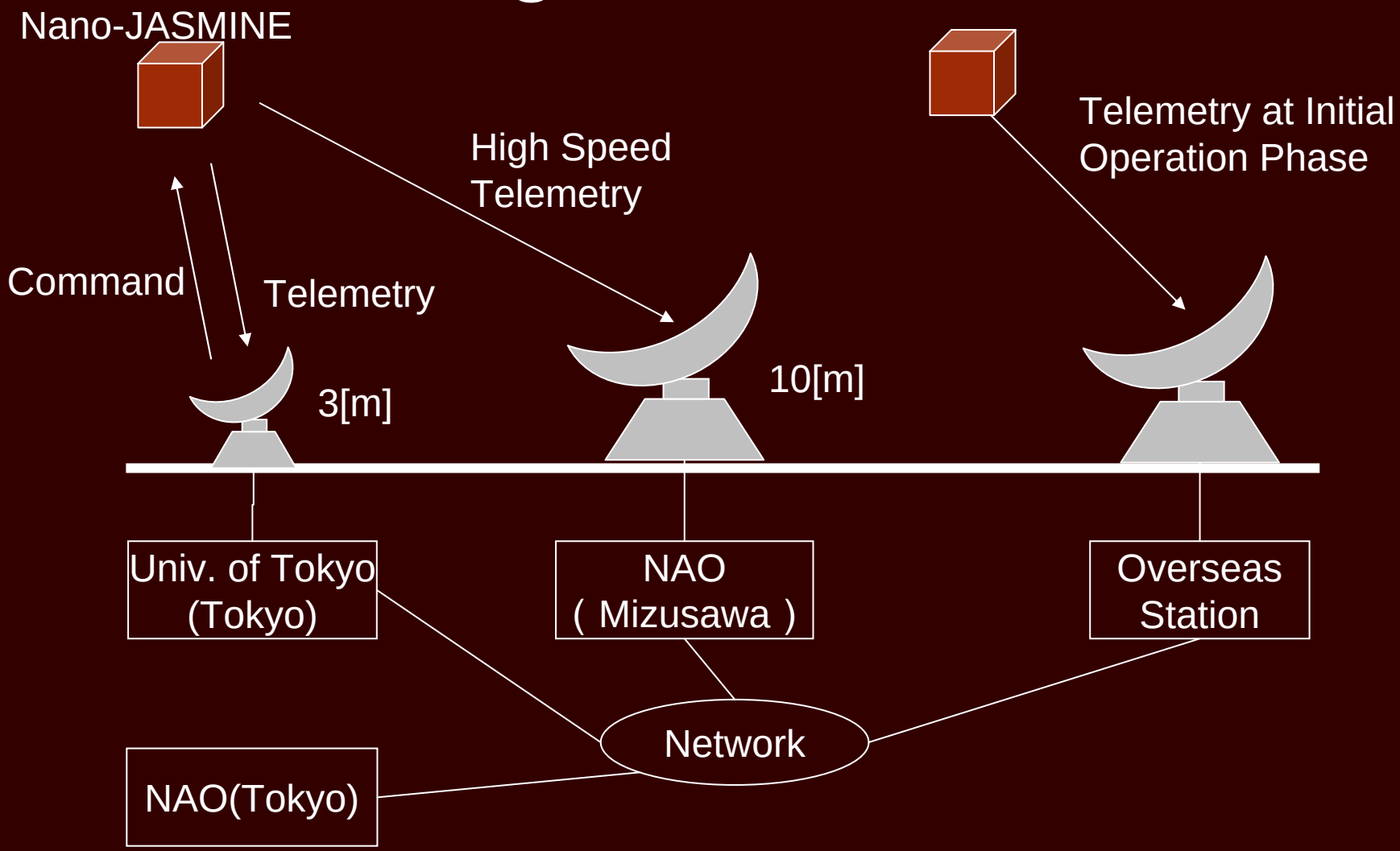
FEM Analysis

- 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 obeservation (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
  - jasmine@space.t.u-tokyo.ac.jp
- WEB site
  - http://www.space.t.u-tokyo.ac.jp