Satellite Technology Research Center (SaTReC)
Korea Advanced Institute of Science & Technology (KAIST)

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"Laser Retroreflector Array Development for STSAT-2"

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STSAT-2 Overview

- Mission objectives
  - Domestic development of a low earth orbit 100kg satellite which will be launched by KSLV-1 from the domestic space center, NARO space center
  - Development of advanced technology for small spacecraft
  - Development and operation of world-class space science payloads

- Payloads
  - Dual-channel Radiometers for Earth & Atmosphere Monitoring (DREAM)
  - Laser Retroreflector Array (LRA)

- Anticipated launch date
  - The anticipated launch date of STSAT-2A is two quarters of the next year, between April and June, 2009 and STSAT-2B is around December 2009

STSAT-2 Overview

- Expected life time : > 2 years
- Total mass : 100kg

- Orbit
  - STSAT-2 have the elliptical orbit which have 300km at the perigee an d 1500km at the apogee.
  - Inclination is 80 degrees

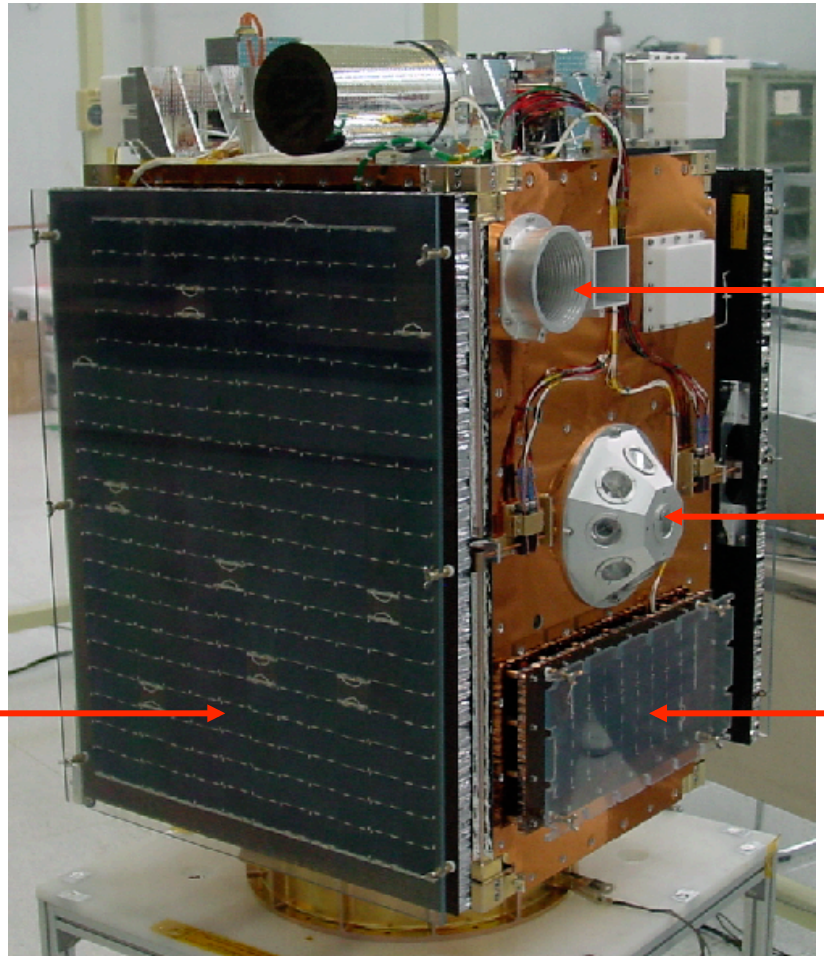
- Responsible organization
  - STSAT-2 have been developed one of Korea government space progr ams.
  - The responsible organization is Ministry of Education, Science and Te chnology (MEST, Korean government)
  - KARI (Korea Aerospace Research Institute) manages the STSAT-2 pr ogram, KAIST SaTReC develops spacecraft development and operati on and sub-payload, and GIST is responsible for the main payload de velopment

SLR Objectives

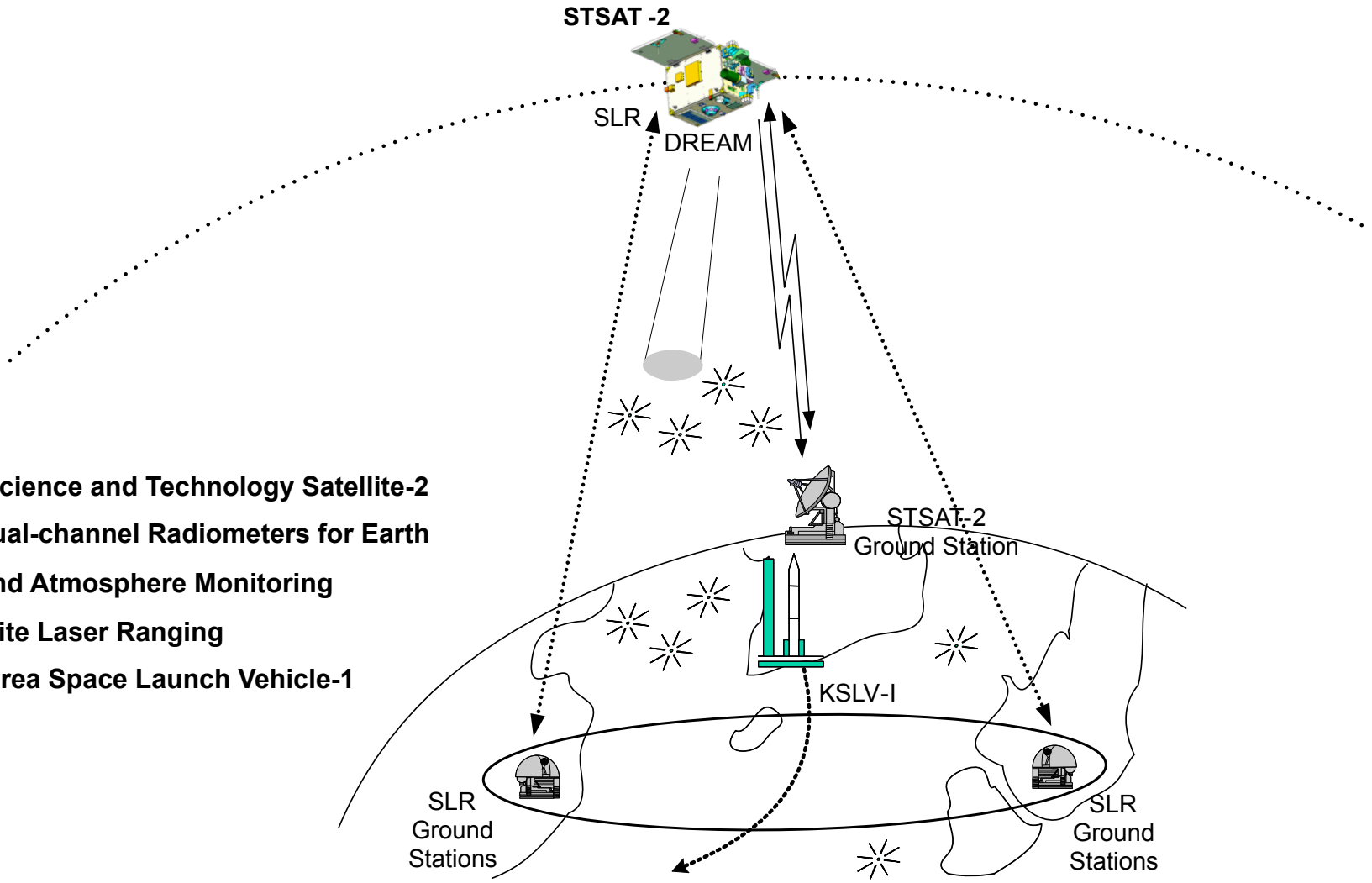
- SLR objectives for STSAT-2
  - To determine the precise orbit of STSAT-2
  - To calibrate the main payload (DREAM)
  - To support the science research

STSAT-2 Configuration

- LRA is mounted on the earth-facing side center of the satellite



STSAT-2 Operation Overview



STSAT-2: Science and Technology Satellite-2

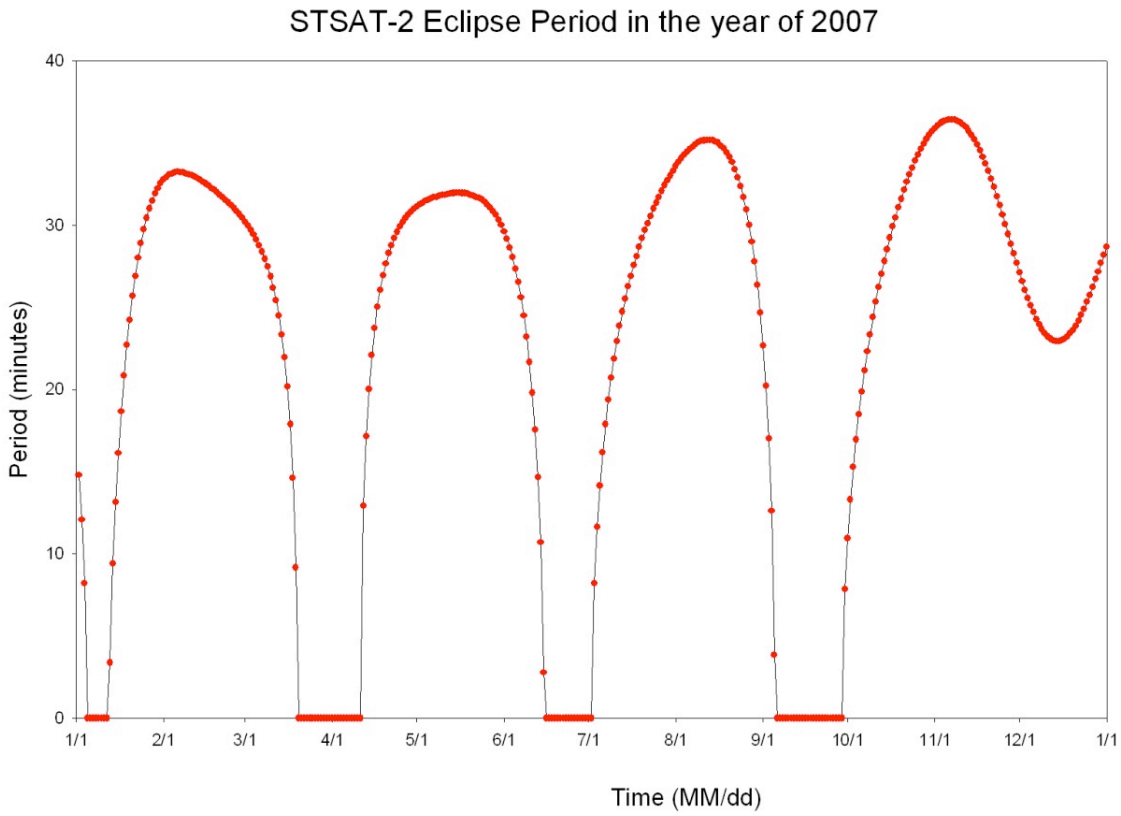
DREAM: Dual-channel Radiometers for Earth and Atmosphere Monitoring

SLR: Satellite Laser Ranging

KSLV-1: Korea Space Launch Vehicle-1

Eclipse Time Analysis of Orbit

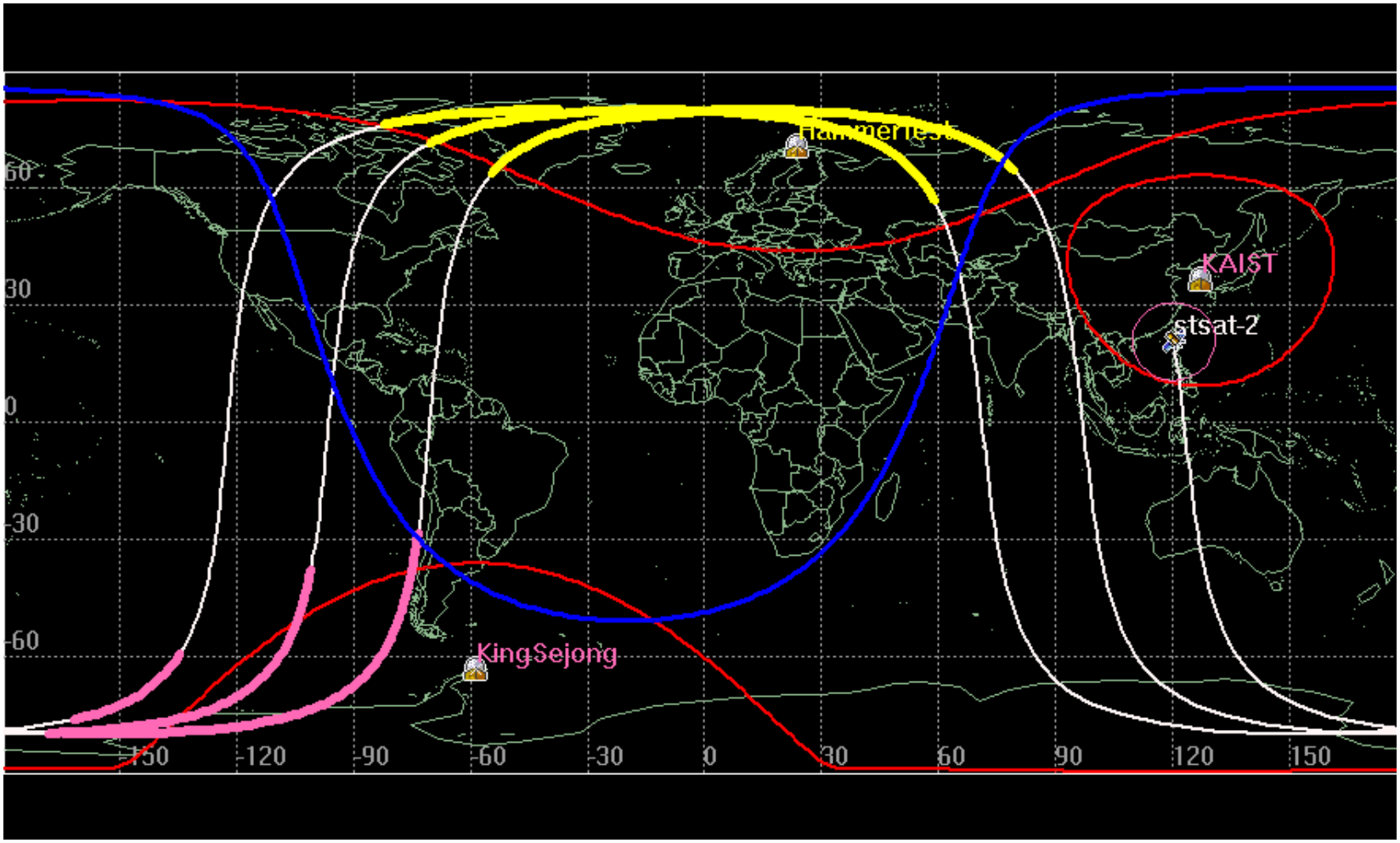
- We performed eclipse time analysis of elliptical orbit
  - Perigee :300km, Apogee :1500km, Inclination : 80^{o}
- Some period among one year, partially sunlight period without eclipse
- Maximum eclipse time have about 35% and minimum eclipse time is 0%



Eclipse time analysis during 2007

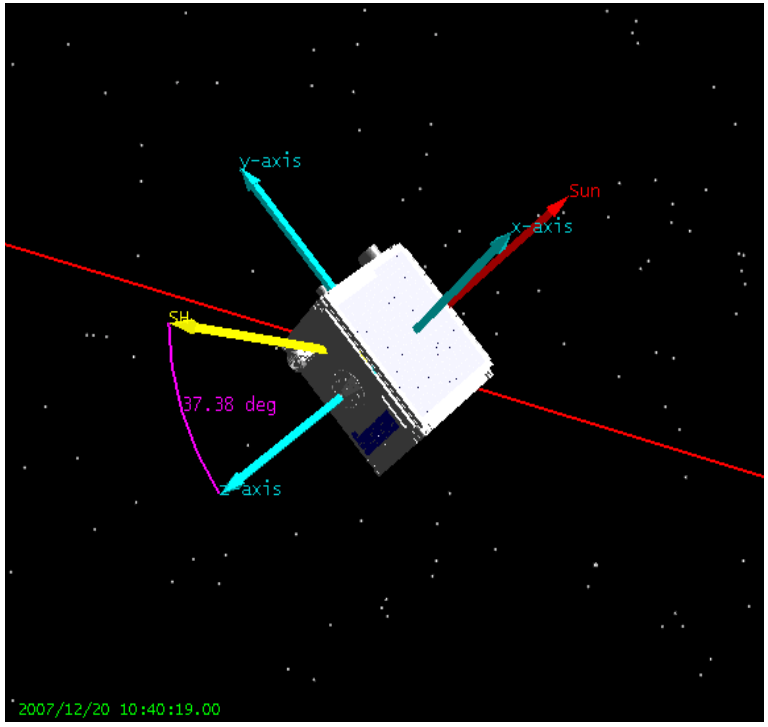
Contact Analysis of Ground Station♪

- Red line is contact area of STSAT-2 when passing through KAIST ground station



Coverage Analysis

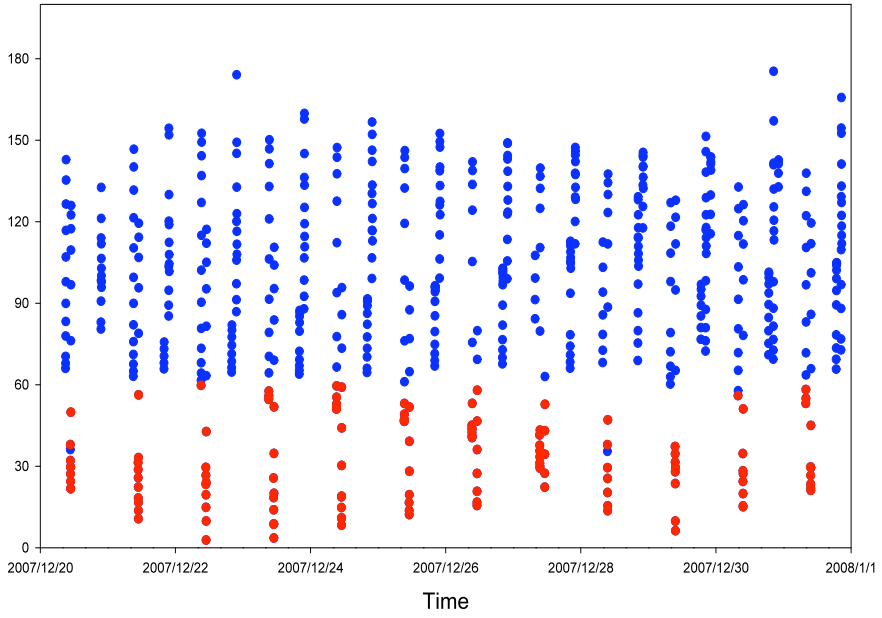
- Field of view analysis from the STSAT-2 to Shanghai SLR station and Herstmonceux SLR station was performed for three operational modes
  - the solar panel is toward the sun, the +Z axis is toward the nadir of the earth, and the +Z axis is toward the KAIST ground station



Paper : SLR Coverage Analysis of STSAT-2

Kyunghee Kim, Sang-Hyun Lee, Jun Ho Lee, Jonghan Jin, Noh Hoon Myung

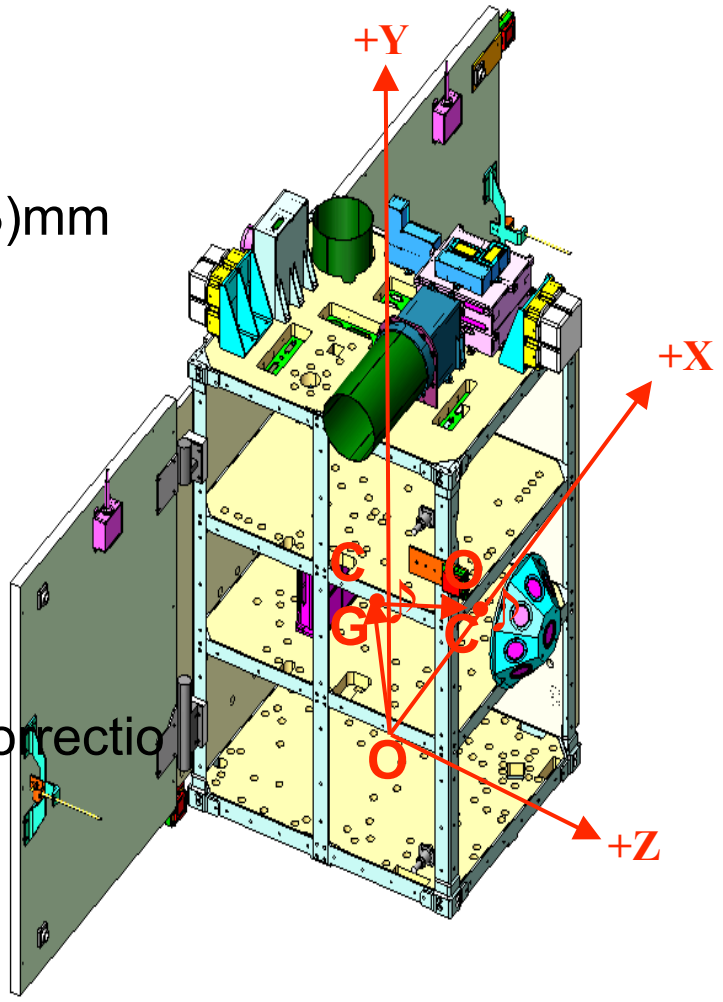
View angle of SLR of STSAT-2 with the sun pointing mode during the contact at the shanghai, Chaina for 10 days, 2007, 12.



LRA Location♪

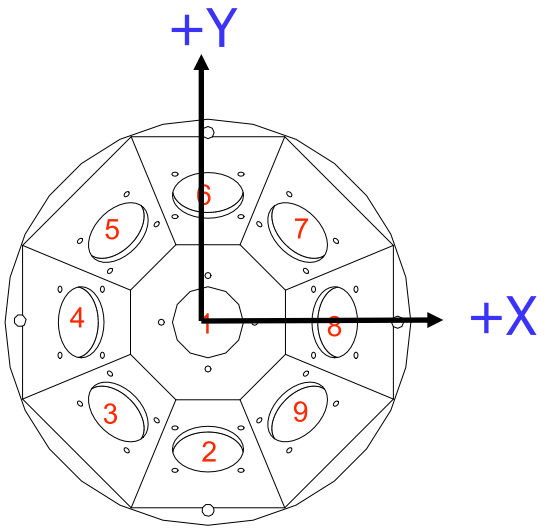
- Satellite coordinator
  - O : Origin (0,0,0)
  - CG : Center of Gravity
    - STSAT-2A (-7.6,381.4,1.9)mm
    - STSAT-2B (-0.18,412.16,-0.03)mm
  - OC : Optical Center
    - (-0.5,382,269.5)mm
  - Distance between CG and OC
    - STSAT-2A : 267.7mm
    - STSAT-2B : 271.2mm

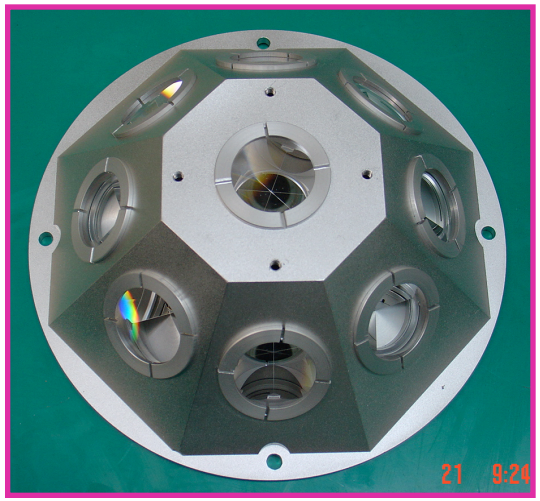
- STSAT-2 must be performed range correction



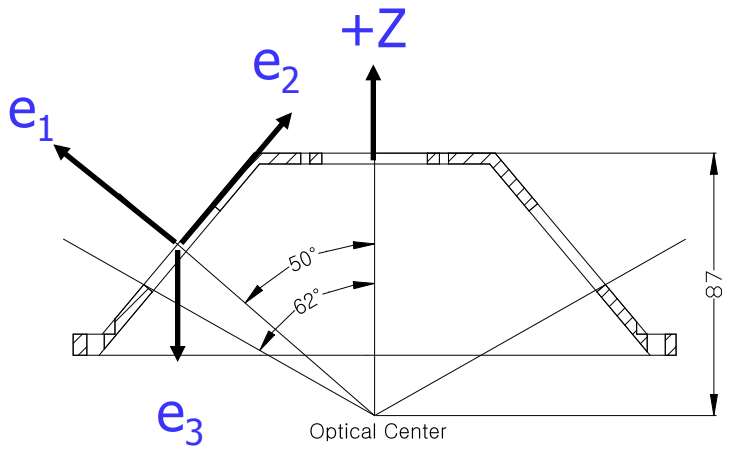
LRA Configuration♪

- LRA consists of 9 corner cubes and symmetrically mounted on a hemispherical surface with one nadir-looking corner cube in the center and surrounded by an angled ring of eight corner cubes like ERS-1 &2, Envisat.
- LRA dimensions are ϕ200×67(Height)mm
- LRA beam divergence is 15 acrsec and FOV is ±60º
- STSAT-2A & 2B LRA are the same
- STSAT-2 LRA is almost the same configuration as Shu nzhou IV



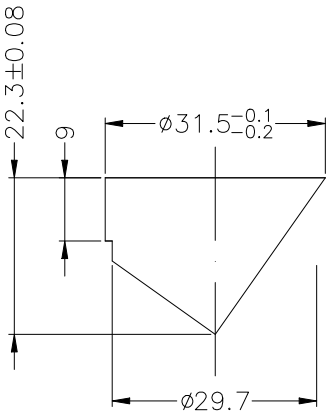


Retroreflector



Corner Cube Reflector Assembly

- Corner cube diameter is 31.5mm and the height of corner cube is 22.3 mm
- Optical Characteristics
  - Material : Fused Silica, Al
  - Coating : no coating for reflection surface
  - Dihedral angle offset is 1.5 arcsec more than 90 degree
  - Mass : 815g



Corner Cube Housing

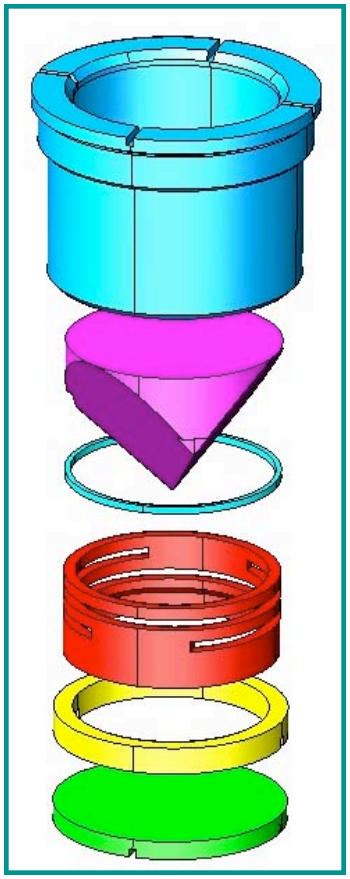
Corner Cube reflector (Fused Silica)

PTFE (PolyTetraFluoroEthylene)

Flexure

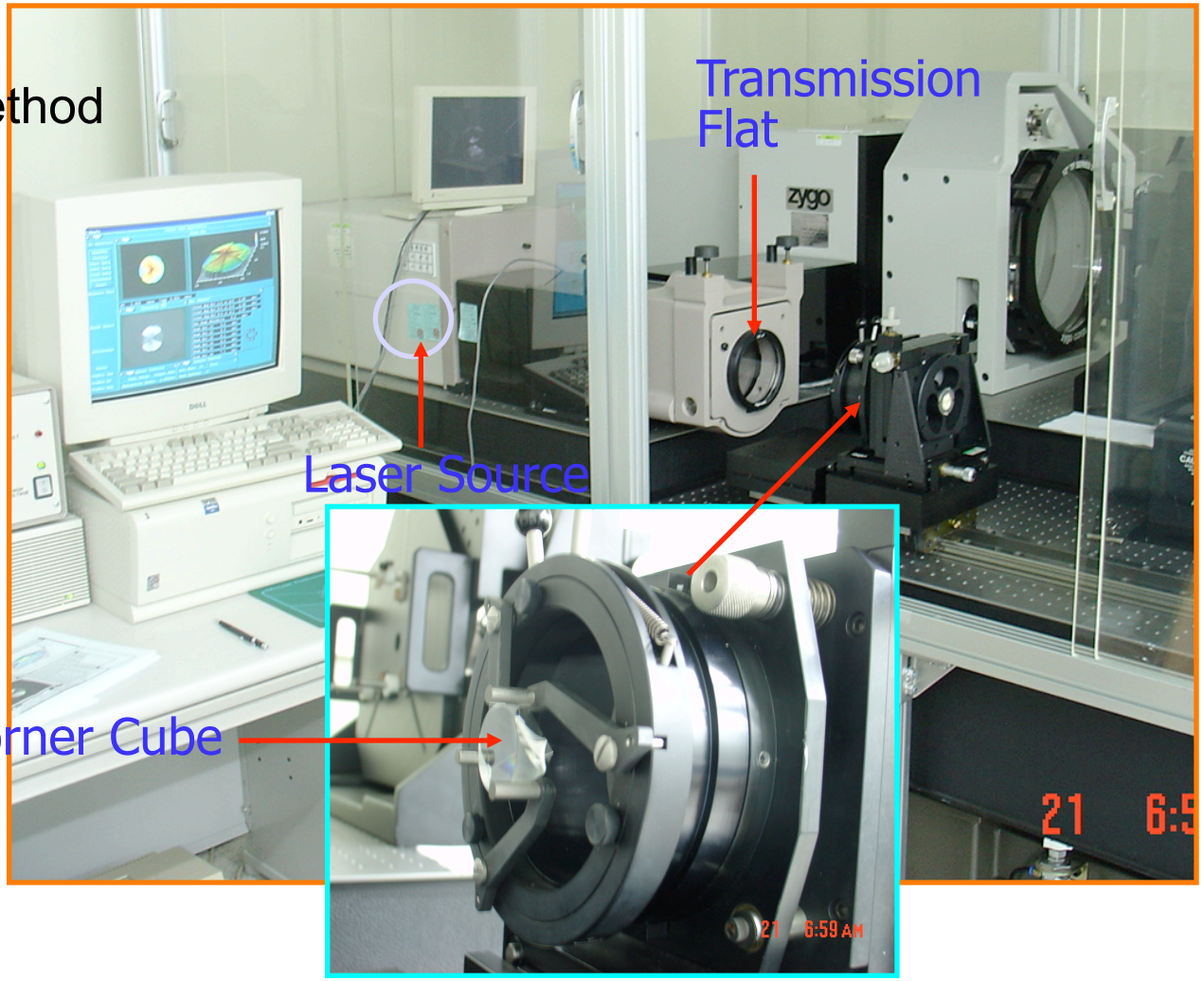
Flexture Supporter

Cover



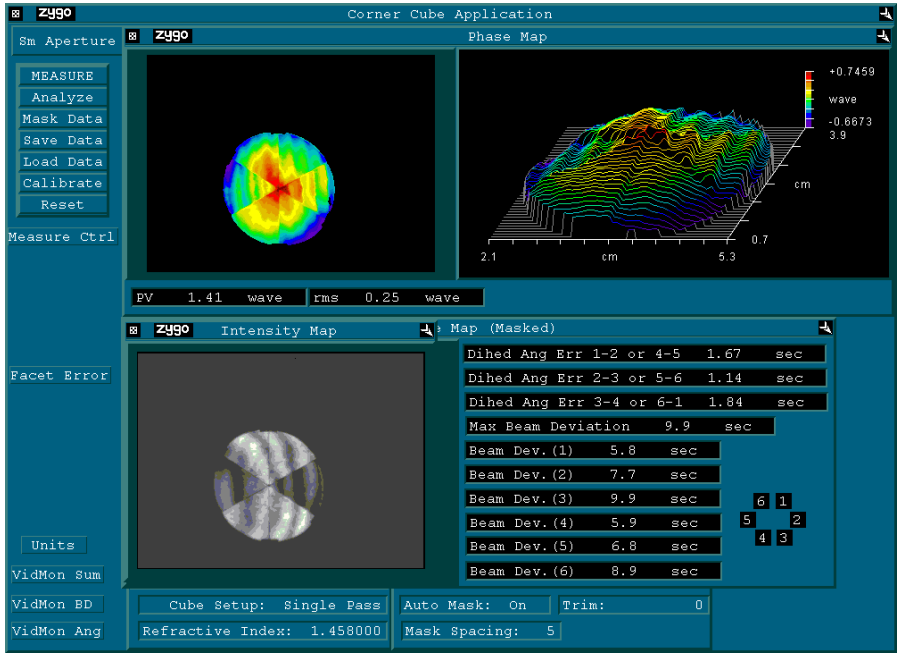
Test Setup for Beam Divergence

- Beam divergence test was performed by Zygo interferometer
  - Laser : He-Ne
  - Wavelength : 632.8nm(He-Ne)
- Test was performed using single pass method



Beam Divergence Results

- Average beam divergences is 14.5 arcsec
- Dihedral angle offsets are computed from beam divergence

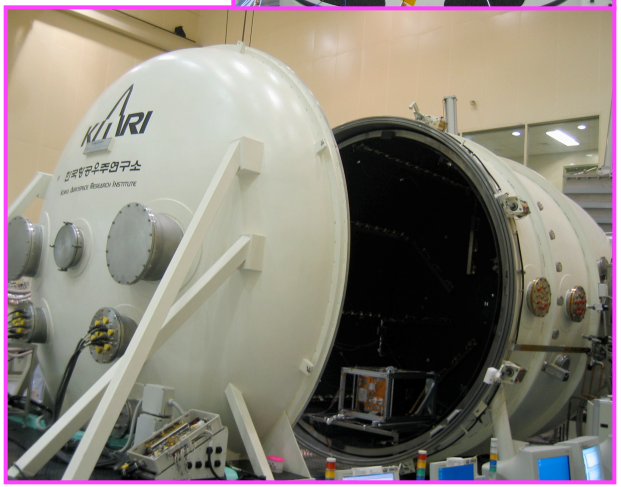


No♪	BD♪	δ_1	δ_2	δ_3
1♪	14.8”♪	1.78”♪	1.56”♪	1.30”♪
2♪	14.2”♪	1.08”♪	1.09”♪	2.11”♪
3♪	14.2”♪	1.29”♪	1.42”♪	1.74”♪
4♪	14.5”♪	1.54”♪	1.47”♪	1.54”♪
5♪	13.7”♪	1.90”♪	1.25”♪	1.11”♪
6♪	15.1”♪	1.65”♪	1.73”♪	1.38”♪
7♪	14.3”♪	1.76”♪	1.13”♪	1.55”♪
8♪	14.4”♪	2.03”♪	1.57”♪	0.83”♪
9	**15”**	**1.67”**	**1.14”**	**1.84”**
Average BD : 14.5”♪				

Environmental Test

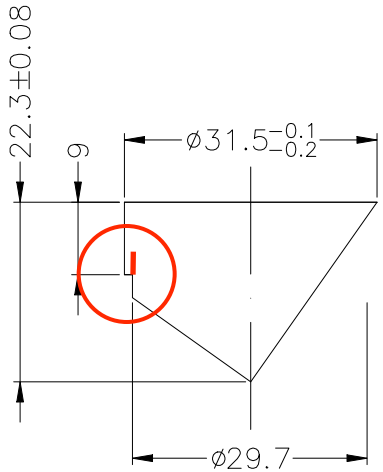
- Vibration test was performed by acceptance level
  - Random level is 9.5grms
  - Sine level is 2g for lateral and 3g for vertical

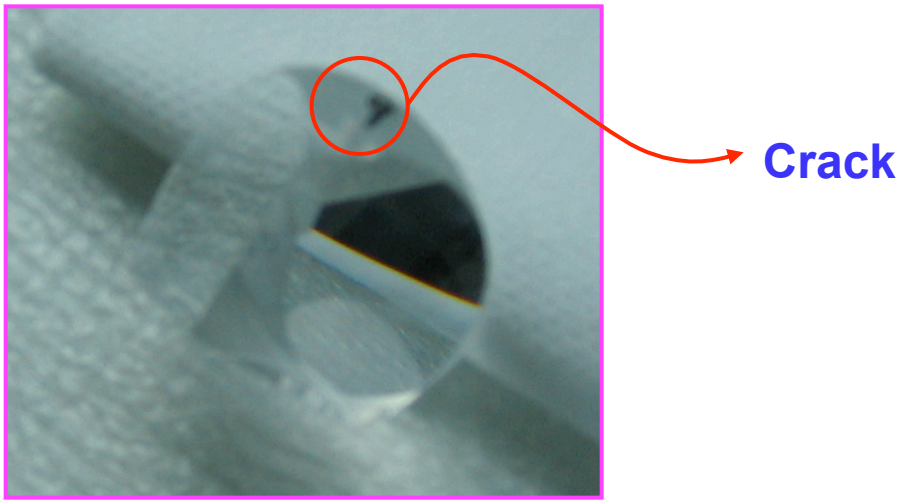
- Thermal vacuum Test
  - In order to measure temperature difference between cor ner cube (Fused silica) and housing (Al), two thermocou ples were attached on the center of corner cube and hou sing♪
  - Pressure : 7 x 10^{-6} Torr
  - Shroud Temperature : -162.5˚C (fixed)



Vibration Test Results

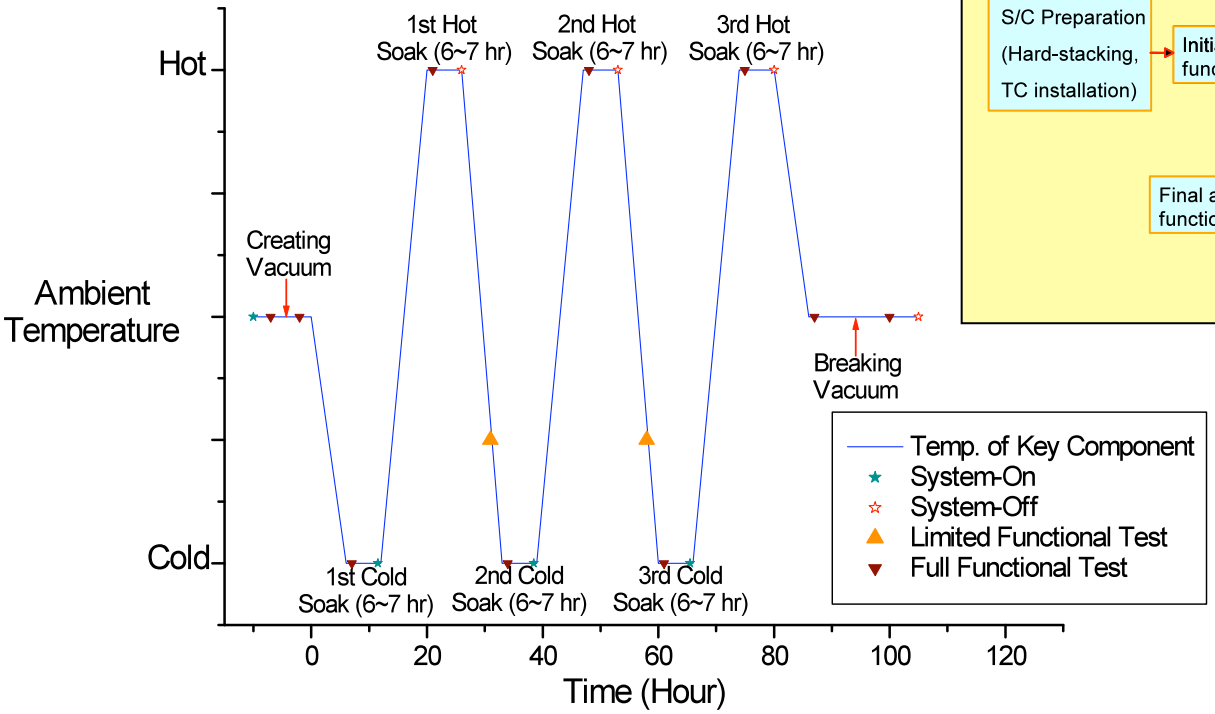
- After testing by qualification level, small crack occurred at the edge of c orner cubes.
- Cause is due to high vibration test level.
- So, antivibration material (PTFE ring) was inserted between corner cube and flexure.
- And then performed vibration test again.
- Corner cubes was tested successfully without damage and crack.

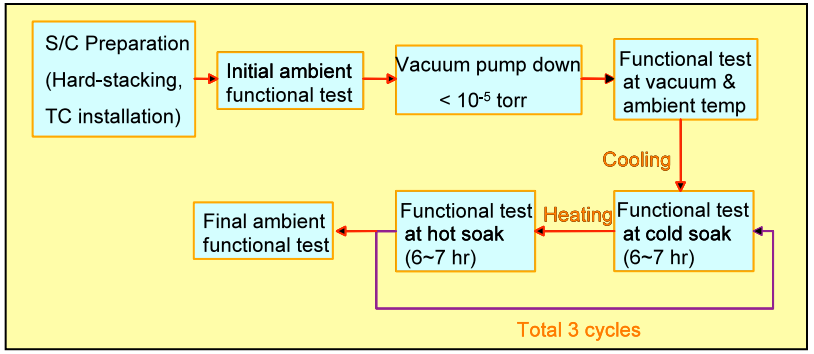




Thermal Vacuum Test

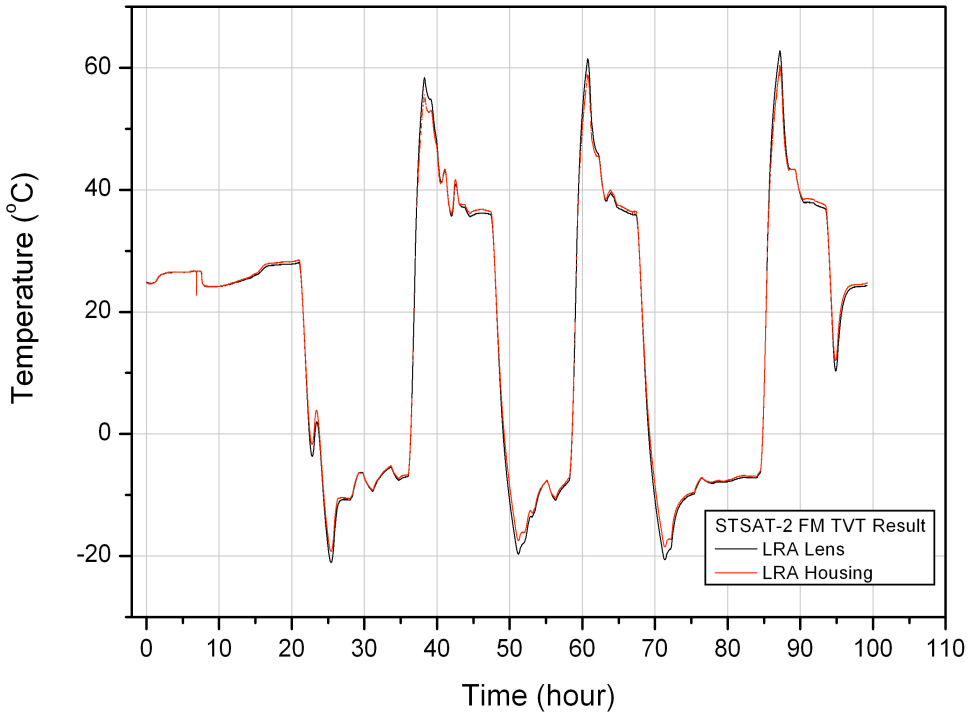
- Test conditions
  - Number of cycle : 3
  - Dwell time : 6 ~ 7 hours
  - Shroud temperature : -120°C ~ 100°C





Thermal Vacuum Test Result♪

- Temperature between corner cube center and holder housing were mea sured.
  - Temperature difference between corner cube and holder housing is 2.7°C
  - Corner cube minimum temperature is -21.1°C and corner cube maximum te mperature is 62.8°C
  - Damage and crack of corner cube did not appeared because temperature di fference is low.



Tracking Plan

- Tracking plan
  - ILRS network
    - Will submit "**ILRS mission support request form**" to ILRS
    - Will start launch campaign through ILRS
    - Will track STSAT-2 through ILRS stations
  - China network
    - Shanghai Astronomical Observatory
    - Institute of Seismology
    - Institute of Geodesy and Geophysics
    - Yunnan Observatory
    - Chinese Academy of Surveying and Mapping
  - TROS
    - If possible, STSAT-2 will be tracked by TROS
  - ARGO
    - ARGO is developing by KASI (Korea)♪
    - After 2012, STSAT-2 will be tracked by ARGO system

Summary

- LRA for STSAT-2 were manufactured and tested successfully w ithout damage and crack of corner cubes.
- SLR coverage was analyzed.
- Beam divergences and dihedral angle offset measurement are performed.
  - Beam divergence for STSAT-2 is 14.5 arcsec
  - Dihedral angle offsets were computed using beam divergence res ults
- Environmental test was performed successfully.
  - After vibration test, corner cube reflector made sure safety
  - Thermal vacuum test is performed without damage and crack of c orner cube reflectors
  - Corner cube minimum temperature is -21.1°C and maximum temp erature is 62.8°C♪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Thank you!