Current Status and Plan of Korean SLR System for Space Geodesy and Space Debris

2012. 9. 27

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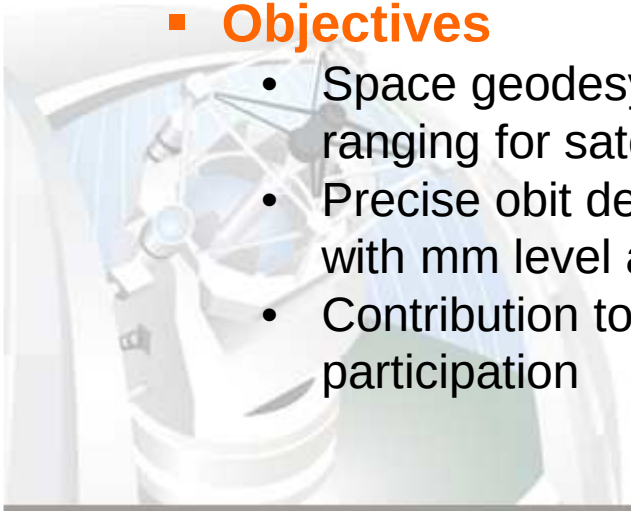
Outline

1. Overview of ARGO Project
2. Introduction of ARGO-M and ARGO-F
3. Current Status of ARGO-M Development
4. Future Plan of Fundamental Station
5. Future Plan of Laser Tracking System of Space Debris
6. Summary

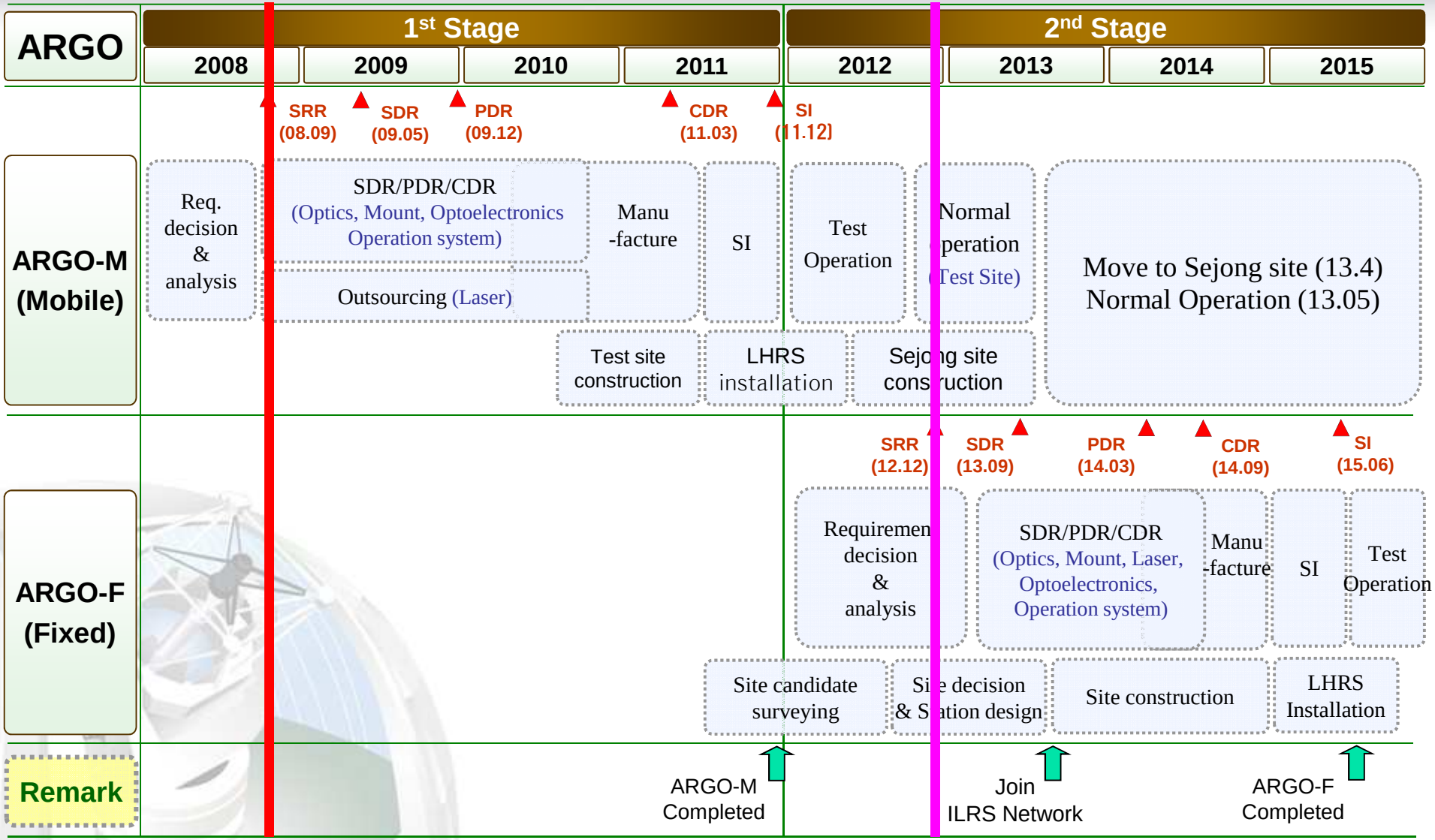
Overview of Korean SLR Project

- **ARGO**
  - Name of Korean SLR project
  - **A**ccurate **R**anging system for **G**eodetic **O**bservation
- **Development Period**
  - 2008 - 2015 (8 years)
- **Final Goal**
  - One mobile system(40cm/10cm) : ARGO-M
  - One fixed system(1m) : ARGO-F

- **Objectives**
  - Space geodesy research and GEOSS/GGOS contribution by laser ranging for satellites with LRA
  - Precise obit determination(POD) through laser ranging measurement with mm level accuracy
  - Contribution to international SLR societies and ILRS network participation



Milestone of ARGO Project



Major Characteristics of ARGO-M

- **Tracking Capability**
  - Capable of tracking satellites between 300km and 25,000km altitude
    - STSAT-2(300x1,500km), KOMPSAT-5, GPS, Galileo
  - KHz laser ranging
  - Daylight and night tracking

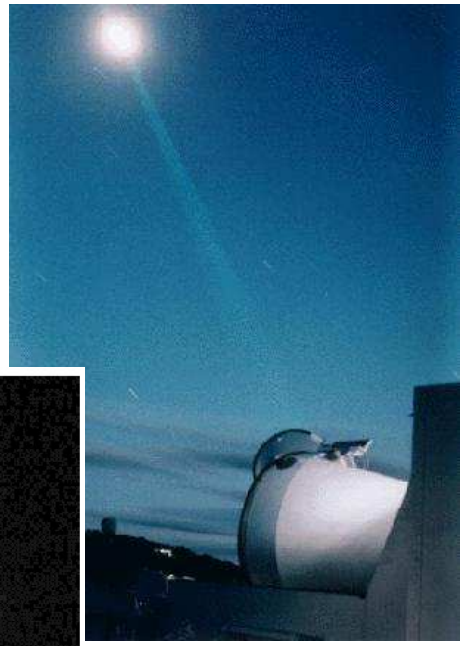
- **Ranging Accuracy**
  - Lageos : 10mm(SS), 5mm(NP)
  - Ground Target : 5mm(SS)
- **Operational Functions**
  - Controlled from the remote site
  - Automated scheduling, planning and orbit prediction capability
  - Automatic ranging based on schedule and aircraft detection(using radar)
  - Automated diagnostic warning to monitoring system
- **Etc**
  - Container and central locking dome (move by using a trailer)

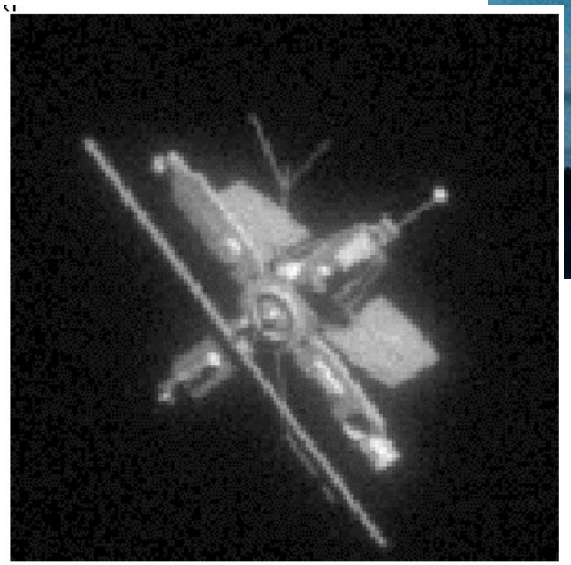
Major Characteristics of ARGO-F

- **Tracking Capability**
  - Capable of tracking satellites between 300km and 36,000km altitude
    - STSAT-2(300x1,500km), KOMPSAT-5, GPS, GEO satellites
  - Daylight and night tracking
  - **Satellite imaging using adaptive optics**

- **Ranging Accuracy**
  - Lageos : 4~6mm(SS), 1~2mm(NP)
  - Ground Target : 2~4mm(SS)

- **Operational Functions**
  - Fully automatic remote operation





Comparisons between ARGO-M and ARGO-F

Item	Parameter	ARGO-M	ARGO-F
Telescope	Optical path	Bistatic	Common Coude
	Rx and Tx telescope	40/10 cm	> 120 cm
	Primary mirror F-ratio	1.5	-
	Transmit beam divergence	5 ~ 200 arcsec	3 ~ 25 arcsec
	Max slew rate	20 deg/sec (Az) 10 deg/sec (El)	10 deg/sec (Az) 10 deg/sec (El)
	Tracking & Pointing accuracy	< 5 arcsec	< 1 arcsec
Detector	Type	C-SPAD	MCP-PMT or C-SPAD
	Quantum efficiency	20%	-
Laser	Wavelength	532 nm	532 nm
	Pulse energy	2.5mJ @2 kHz	> 2mJ @2 kHz
	Pulse width	50 ps	10 ~ 30 ps
	Repetition rate of Operation	2 kHz	-
	Beam diameter @ Tx telescope	7.5 cm	> 80 cm
Etc	Timing system	Event timer	Event Timer
	Aircraft detection type	Radar	-

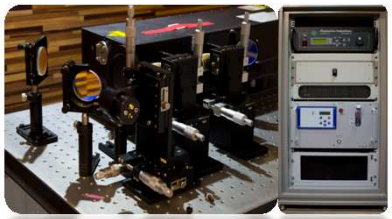
Configuration of ARGO-M

Telescope/Mount

Operation System

Radar

Ground Target



Laser

Electronics

External Image of ARGO-M

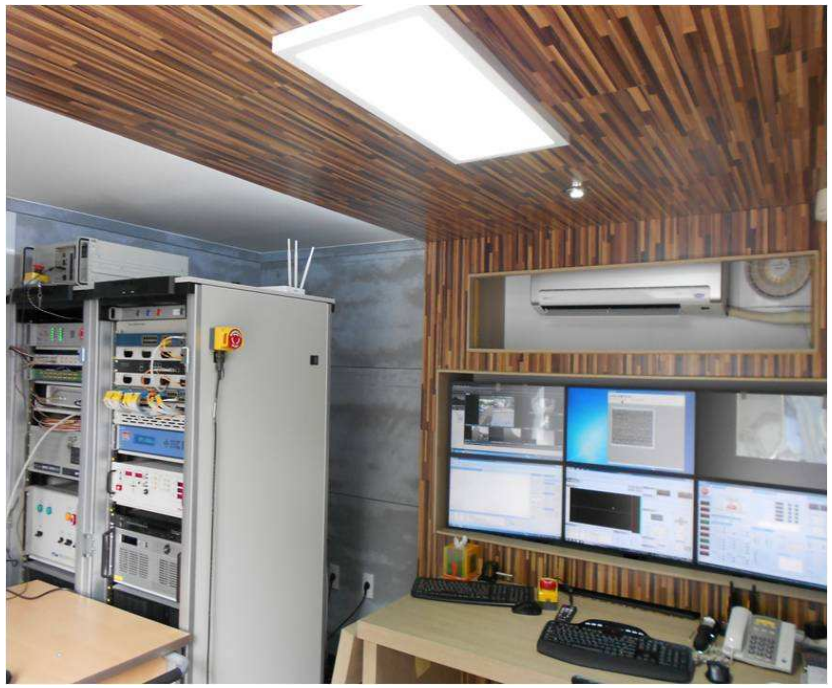
Test site at KASI HQ

Internal Structure of ARGO-M

Laser room

- Tracking mount
- Laser
- Optical table
- Ground target pillar

Operation room



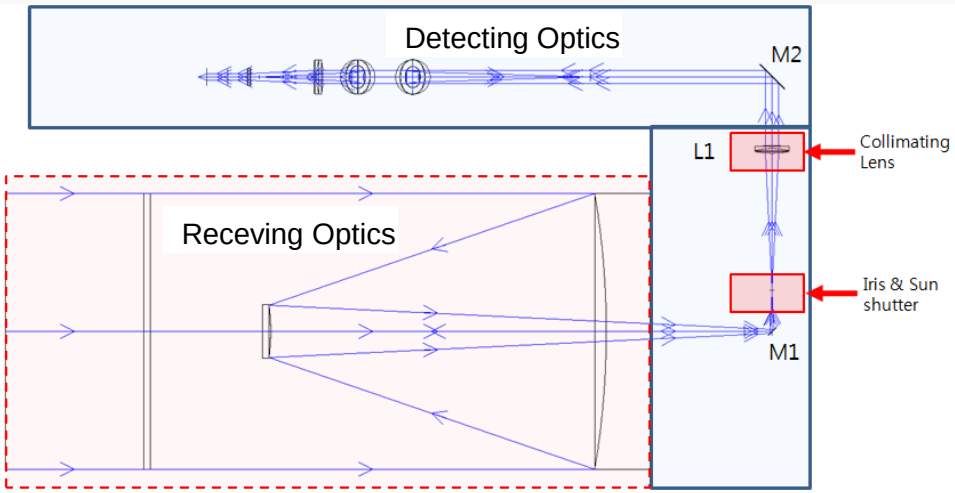
- Electronics : Event timer, GPS and etc
- Tracking mount servo system
- Operation system
- Radar controller(LCU)
- Firewall and network system

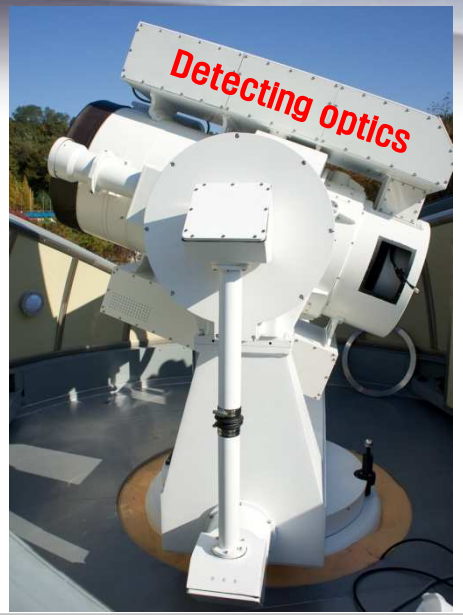
Accessory room

- UPS
- Power distribution unit
- Surge protection device

Status of ARGO-M System Integration (OPS)

▪ Design of Receiving Optics

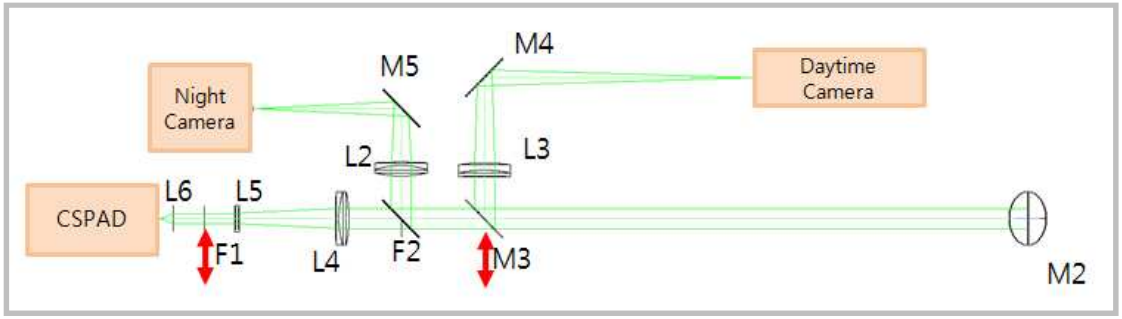




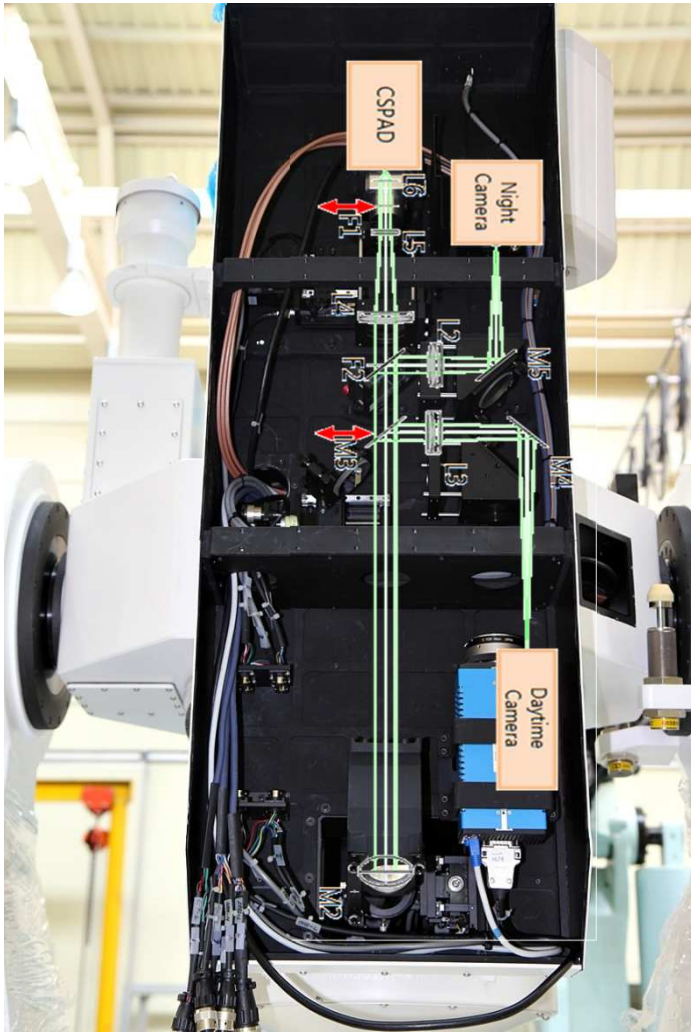
- Separate path(Tx/Rx telescope) to reduce back scattering
  - Aperture : 40cm Rx telescope & 10cm Tx telescope
  - FoV of Rx telescope : 5 arcmin
  - Reflectivity of primary and secondary mirror : >90% @532nm
- Iris
  - 3 holes and one blocked hole
  - the spatial filters(day, night and twilight) and the sun shutter
  - controlled by the operation system for hole choice
- Collimating Lens
  - controlled by the operation system for focusing of C-SPAD and camera

Status of ARGO-M System Integration (OPS)

Design of Detecting Optics

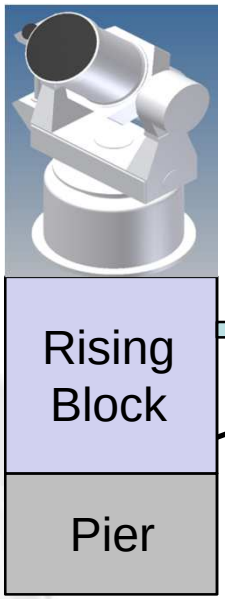


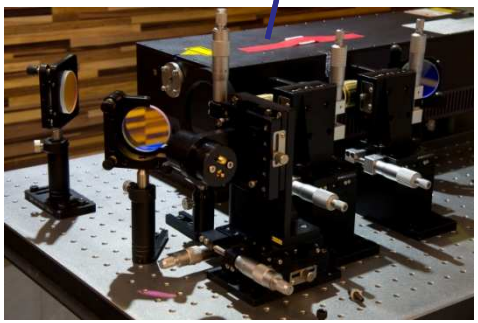
- Bandpass filter(F1) : 0.3nm for daytime tracking
- Switching mirror(M3) :
  - change the beam path for daytime camera and C-SPAD
  - On : the daytime camera is activated
  - Off : C-SPAD and the nighttime camera are activated
- C-SPAD : Peso Consulting(Austria)
- Daytime camera : PCO1600
  - Resolution pixel : 1600 x 1200
  - Data interface : IEEE1394a, camera link, GigE Vision
- Nighttime camera : Watec WAT-120N
  - CCD size : 0.5 inch



Status of ARGO-M System Integration (LAS)

- **RGL-532 Model (Photonics Industry, USA)**
  - Nd:YAG(laser material) and 532nm wavelength
  - Pulse energy : 2.5mJ@2KHz
  - Pulse width : 30ps
  - Beam diameter : 1.9mm at the exit of laser head,
    - It is expanded to 25mm on the optical table using two beam expanders
  - Head size : 600 × 192 × 127mm
  - M^2 : < 1.2

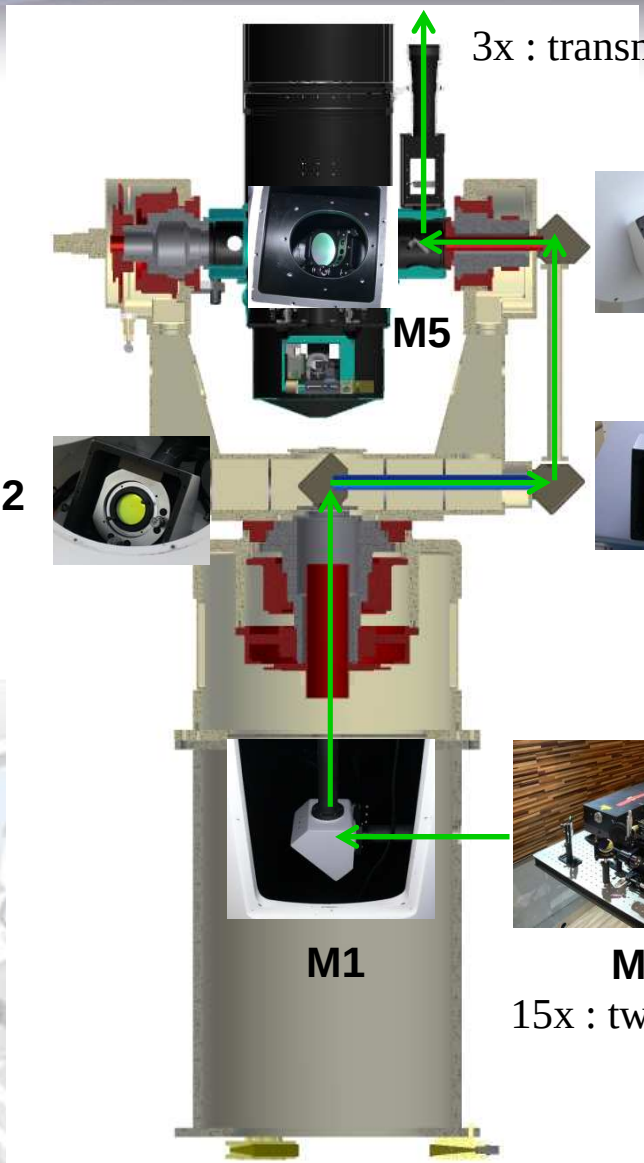


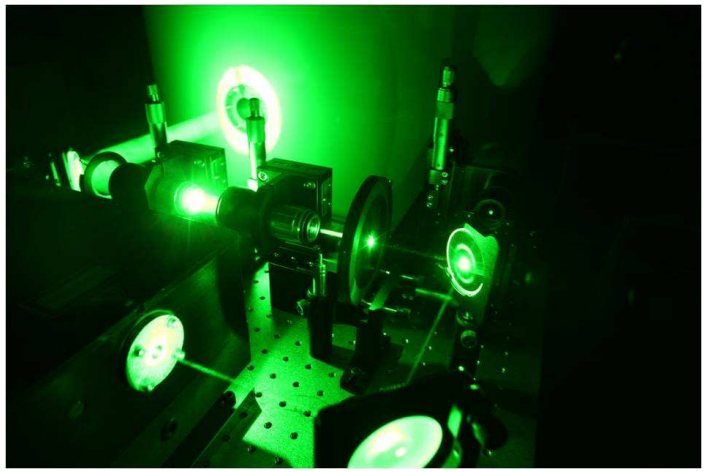


Status of ARGO-M System Integration (LHRS)

- **LHRS (Laser Hazard Reduction System)**
  - Provides a means of detecting aircraft before they intersect a transmitted laser beam
  - Laser beam is disable when aircraft is detected
  - Made by Honeywell(USA)
- **Specification**
  - Max. detection range : 40 km
  - Beamwidth : 2.8 deg
  - Position resolution : 0.09 deg for Az/El
  - Max. slew rate : 15 deg/sec for Az/El
- **Current Status**
  - System installation and test : 2012.01
  - Helicopter and fighter detection test : 2012.06

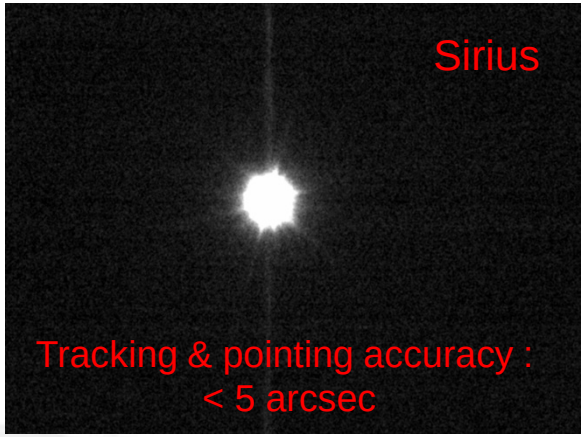
Optical Coude Path & Ground Target of ARGO-M

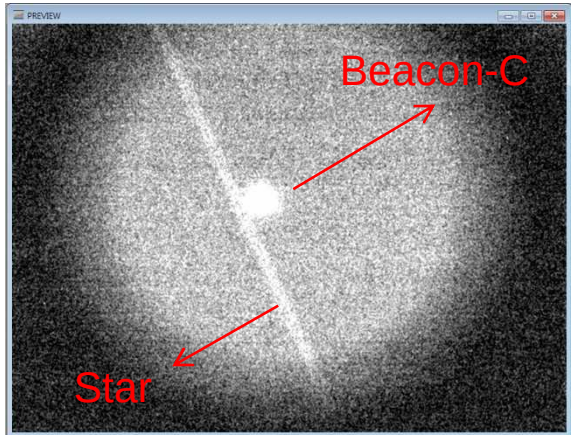




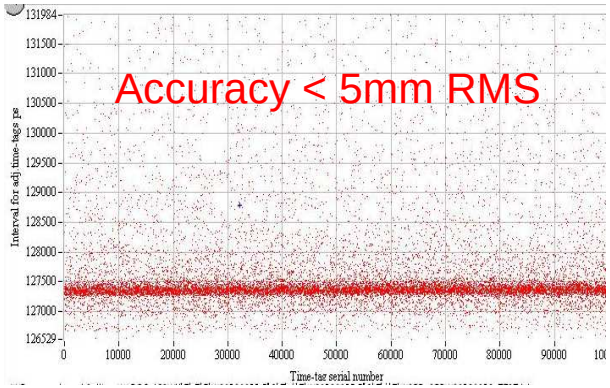
Current Status of ARGO-M Development

- Satellite optical tracking experiment for tracking performance verification
- Laser ranging experiment of ground target
- Waiting for an approval from Korean government to fire laser into the sky





Optical tracking Experiment



GT laser ranging Experiment

Future Plan – Fundamental Station

- **Composition**
  - VLBI, GNSS : NGII (National Geographic Information Institute)
  - SLR, DORISS : KASI (Korea Astronomy & Space Science Institute)
- **Location**
  - Sejong city
  - ARGO-M will be moved to Sejong site in March 2013
- **Normal operation :** April 2013

Future Plan – Laser Tracking System of Space Debris (1)

- **Earth Orbiting Space Debris**
  - Object > 10 cm : 15,000
  - Object > 1 cm : 350,000
- **Damage from Space Debris Collision**
  - 5 ~ 15 mm : will damage or impair a spacecraft
  - > 15 mm : will destroy a spacecraft
- **Korean Satellites**
  - Several satellites in LEO (Low Earth Orbit)
  - In the face of collision risk against space debris

Laser tracking system for space debris monitoring

Future Plan – Laser Tracking System of Space Debris (2)

- **Development Strategies**
  - Development period : 2016 ~ 2018 (3 years)
  - ARGO-F(Fixed SLR system) upgrade
    - New high power laser system installation
    - Operation system modification

- **Laser Tracking System of Space Debris**
  - Performance
    - Capable of tracking space debris > 10 cm
    - Tracking coverage : < 1,000 km
  - Tracking accuracy : < 0.2 arcsec
  - Laser Spec.
    - > 20 Hz repetition rate, > 5 J/pulse energy
    - < 5 ns pulse width, M^2 < 1.5

Summary

- **Three SLR Systems**
  - ARGO-M for space geodesy
  - ARGO-F and laser tracking system of space debris for space surveillance
- **ARGO-M**
  - Develop period : 2008 ~ 2012
  - System integration & optical alignment was finished
  - It will be moved to Sejong site in March 2013 for the fundamental station
- **ARGO-F**
  - Development period : 2012 ~ 2015
  - Capable of tracking satellites up to geostationary orbits
  - Satellite imaging using adaptive optics
- **Laser tracking system of space debris**
  - Development period : 2016 ~ 2018
  - Capable of tracking space debris > 10 cm within 1,000 km altitude
  - ARGO-F upgrade

Thanks for your attention !!!