Technical Aspects and Progress of
Korean SLR System

November 15, 2013
Hyung-Chul Lim
Korea Astronomy and Space Science Institute
Outline

1. Overview of ARGO Project
2. Introduction of ARGO-M and ARGO-F
3. Star Calibration Results of ARGO-M
4. Laser Ranging Results of ARGO-M
5. Future Plan of Fundamental Station
Overview of Korean SLR Project

- **ARGO**
  - Name of Korean SLR project
  - Accurate Ranging system for Geodetic Observation

- **Development Period**
  - 2008 - 2016 (9 years)

- **Final Goal**
  - One mobile system(40cm/10cm) : ARGO-M (2008 ~ 2013)
  - One fixed system(1m) : ARGO-F (2013 ~ 2016)

- **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

- **Mobile SLR System (ARGO-M)**
  - Development History
    - Development was completed: Oct. 2012
    - Participation in ILRS network: Nov. 2012
      - Station name: Daedeok
    - Date uploading to ILRS DC: 29th Oct. 2013
  - Status and Plan
    - Moving to Sejong site: December 2014
    - Permanent normal operation in Sejong site: Jan. 2015

- **Fixed SLR System (ARGO-F)**
  - Status and Plan
    - System requirements and specification: July 2013
    - PDR(July 2014), CDR(Jan. 2015), FAT(Nov. 2015), SAT(March 2016)
    - Permanent normal operation in Gamak Mt.: April 2016
  - Development Strategy: Joint development with foreign institute
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
  - Daytime and nighttime tracking
  - 2KHz laser ranging

- **Target 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)

- **Future Plan**
  - Upgrading to 10KHz laser ranging (Oct. 2014)
  - Developed RG generator by KASI
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
  - Daytime and nighttime tracking
  - *Satellite imaging using adaptive optics*

- **Target Ranging Accuracy**
  - Lageos: <10mm (SS), <3mm (NP)
  - Ground Target: <5mm (SS)

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

- **Future Plan**
  - Space debris laser ranging (Dec. 2017)
  - High power laser + Adaptive optics
<table>
<thead>
<tr>
<th>Item</th>
<th>Parameter</th>
<th>ARGO-M</th>
<th>ARGO-F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telescope</td>
<td>Optical path</td>
<td>Bistatic</td>
<td>Common Coude</td>
</tr>
<tr>
<td></td>
<td>Rx and Tx telescope</td>
<td>40/10 cm</td>
<td>&gt; 100 cm</td>
</tr>
<tr>
<td></td>
<td>Primary mirror F-ratio</td>
<td>1.5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Transmit beam divergence</td>
<td>5 ~ 200 arcsec</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Max slew rate</td>
<td>20 deg/sec (Az)</td>
<td>30 deg/sec (Az)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 deg/sec (El)</td>
<td>15 deg/sec (El)</td>
</tr>
<tr>
<td></td>
<td>Tracking &amp; Pointing accuracy</td>
<td>&lt; 5 arcsec</td>
<td>&lt; 1 arcsec</td>
</tr>
<tr>
<td>Detector</td>
<td>Type</td>
<td>C-SPAD</td>
<td>MCP-PMT or C-SPAD</td>
</tr>
<tr>
<td></td>
<td>Quantum efficiency</td>
<td>20%</td>
<td>-</td>
</tr>
<tr>
<td>Laser</td>
<td>Wavelength</td>
<td>532 nm</td>
<td>532 nm</td>
</tr>
<tr>
<td></td>
<td>Pulse energy or Power</td>
<td>2.5mJ @2 kHz</td>
<td>&gt; 1W</td>
</tr>
<tr>
<td></td>
<td>Pulse width</td>
<td>50 ps</td>
<td>&lt; 20 ps</td>
</tr>
<tr>
<td></td>
<td>Repetition rate of Operation</td>
<td>2 kHz</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Beam diameter @ Tx telescope</td>
<td>7.5 cm</td>
<td>&gt; 50 cm</td>
</tr>
<tr>
<td>Etc</td>
<td>Timing system</td>
<td>Event timer</td>
<td>Event Timer</td>
</tr>
<tr>
<td></td>
<td>Aircraft detection type</td>
<td>Radar</td>
<td>Radar</td>
</tr>
</tbody>
</table>
Configuration of ARGO-M

Telescope/Mount

Operation System

Ground Target

Radar

Laser

Electronics
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
Star Calibration Results of ARGO-M

- Mount model: 7-parameter model
  \[ \Delta A = C_0 + C_3 \tan E + C_4 \sec E + C_5 \cos A \tan E + C_6 \sin A \tan E \]
  \[ \Delta E = C_1 + C_2 \cos E - C_5 \sin A + C_6 \cos A \]

- Pointing accuracy (RMS)
  - 2.8 arcsec (Az), 1.1 arcsec (El)
  - Requirement accuracy: < 5 arcsec
- **Ground Calibration**
  - Consisting of prism, diffuser and ND filter
  - Ground target in the dome
  - Average single-shot RMS
    - ARGO-M: 5.7mm (Oct 1-30, 2013)
    - ILRS stations (mean): 7.9mm (2013 Q3)
Laser Ranging Results of ARGO-M (2/3)

- **LAGEOS**
  - Launch Date: May 4, 1976
  - Altitude: 5850 km
  - Average single-shot RMS
    - **ARGO-M**: 10.3mm (Oct 1-30, 2013)
    - **ILRS stations (mean)**: 12.9mm (2013 Q3)

---

![Lageos RMS (2013 Q3)](image)

**Lageos RMS (2013 Q3)**

- **Daedeok**: October 1-30, 2013
- **Starlette**
  - Launch Date: February 06, 1975
  - Altitude: 812 km
  - Average single-shot RMS
    - ARGO-M: 9.1 mm (Oct 1-30, 2013)
    - ILRS stations (mean): 12.2 mm (2013 Q3)
Future Plan – Fundamental Station

- **Composition**
  - VLBI, GNSS, Gravity meter : NGII (National Geographic Information Institute)
  - SLR, DORISS : KASI (Korea Astronomy & Space Science Institute)

- **Site**
  - Sejong city (altitude : 250m)
  - ARGO-M will be moved to Sejong site in December 2014
    - Can be delayed due to Korean government approval for the use of land
Thanks for your attention !!!