ILRS:
Current Status and Future Plans

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Outline

- Introduction
- Current trends
- Network
- Mission support
- Infrastructure
- Conclusion

The ILRS mission

- Laser ranging activities are organized under the International Laser Ranging Service (ILRS) which provides global satellite and lunar laser ranging data and their derived data products to support research in geodesy, geophysics, Lunar science, and fundamental physics. This includes data products that are fundamental to the International Terrestrial Reference Frame (ITRF), which is established and maintained by the International Earth Rotation and Reference Systems Service (IERS).

- The ILRS is one of the space geodetic services of the International Association of Geodesy (IAG) and is a member of the IAG's Global Geodetic Observing System (GGOS). The Services, under the umbrella of GGOS, provide the geodetic infrastructure necessary for monitoring global change in the Earth system *(Beutler and Rummel, 2012)*.

Governing board: 2019-2020

- Ex-officio/appointed positions:
  - Director of the Central Bureau – **Mike Pearlman**
  - Secretary of the Central Bureau – **Carey Noll**
  - Representative of IAG Commission 1 – **Urs Hugentobler**
  - IERS Representative – **Daniela Thaller**
- Elected positions:
  - EUROLAS Network Representatives – **Pippo Bianco, Georg Kirchner**
  - NASA Network Representatives – **Jan McGarry, Stephen Merkowitz**
  - WPLTN Representatives – **James Bennett, Zhang Zhongping**
  - Data Center Representative – **Christian Schwatke**
  - LLR Representative – **Jean-Marie Torre**
  - Analysis Representatives – **Cinzia Luceri, Erricos Pavlis**
  - At-Large Representatives – **Toshi Otsubo, Matt Wilkinson**
- Two additional members to be appointed by the Governing Board

- *18 members on ILRS Governing Board*
- *New Board to take office on January 01, 2019*

Journal of Geodesy: special issue

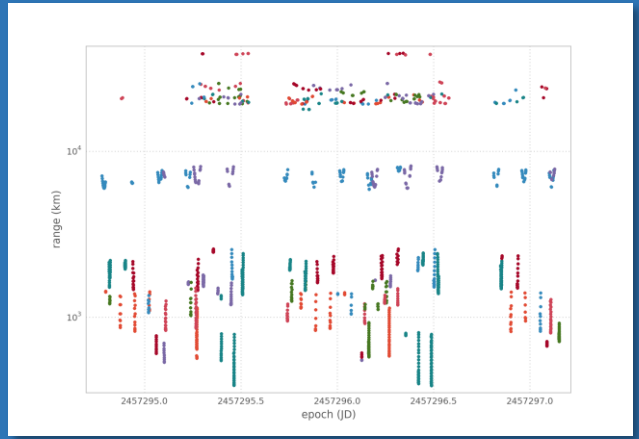
- Journal of Geodesy Special Issue on Laser Ranging
  - Publication currently in process
  - 11 papers accepted thus far (some available online):

Article Title
The SAO and the CNES contributions to the International Laser Ranging Network
Information Resources Supporting Scientific Research for the International Laser Ranging Service
Modernizing and Expanding the NASA Space Geodesy Network to Meet Future Geodetic Requirements
Assessment of the impact of one-way laser ranging on orbit determination of the Lunar Reconnaissance Orbiter
Rapid Response Quality Control Service for the Laser Ranging Tracking Network
The Next Generation of Satellite Laser Ranging Systems
NASA's Satellite Laser Ranging Systems for the 21st Century
Time and laser ranging: A window of opportunity for geodesy, navigation and metrology
Laser and Radio Tracking for Planetary Science Missions - A Comparison
The NASA Space Geodesy Network
Satellite Laser Ranging to Low Earth Orbiters - Orbit and Network Validation

**Note: 8 additional articles are currently under review and a small number are yet to be submitted*

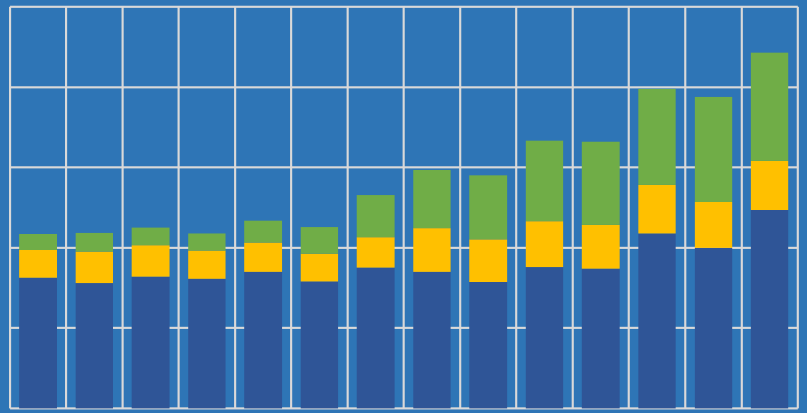
Current trends

- SLR systems: lower energy, higher repetition rates (kHz)
- Single photon sensitive detectors (geodetic satellites)
- Shorter normal point intervals (take data more quickly) and faster slewing for increased pass interleaving
- Real-time data evaluation for real-time decision making
- Automated to autonomous operation with remote access
- Stations with two SLR systems to help address the workload (e.g., Hartebeestoek)
- Environmental monitoring and awareness for instrument integrity and safety
- Real-time network communication and information sharing among stations
- Denser arrays with smaller cubes helps reduce return signal rms



Highlights: network

- On track for increased data yield in 2018 (20 additional targets)
- New sites soon (see next slide)
- NASA systems transitioning to use of the event timer
- First co-location of Russian laser system with established station (Hartebeesthoek, South Africa)
  - System comparison underway
  - Such co-locations provide for expanded tracking capabilities at unique sites
  - More co-locations under discussion

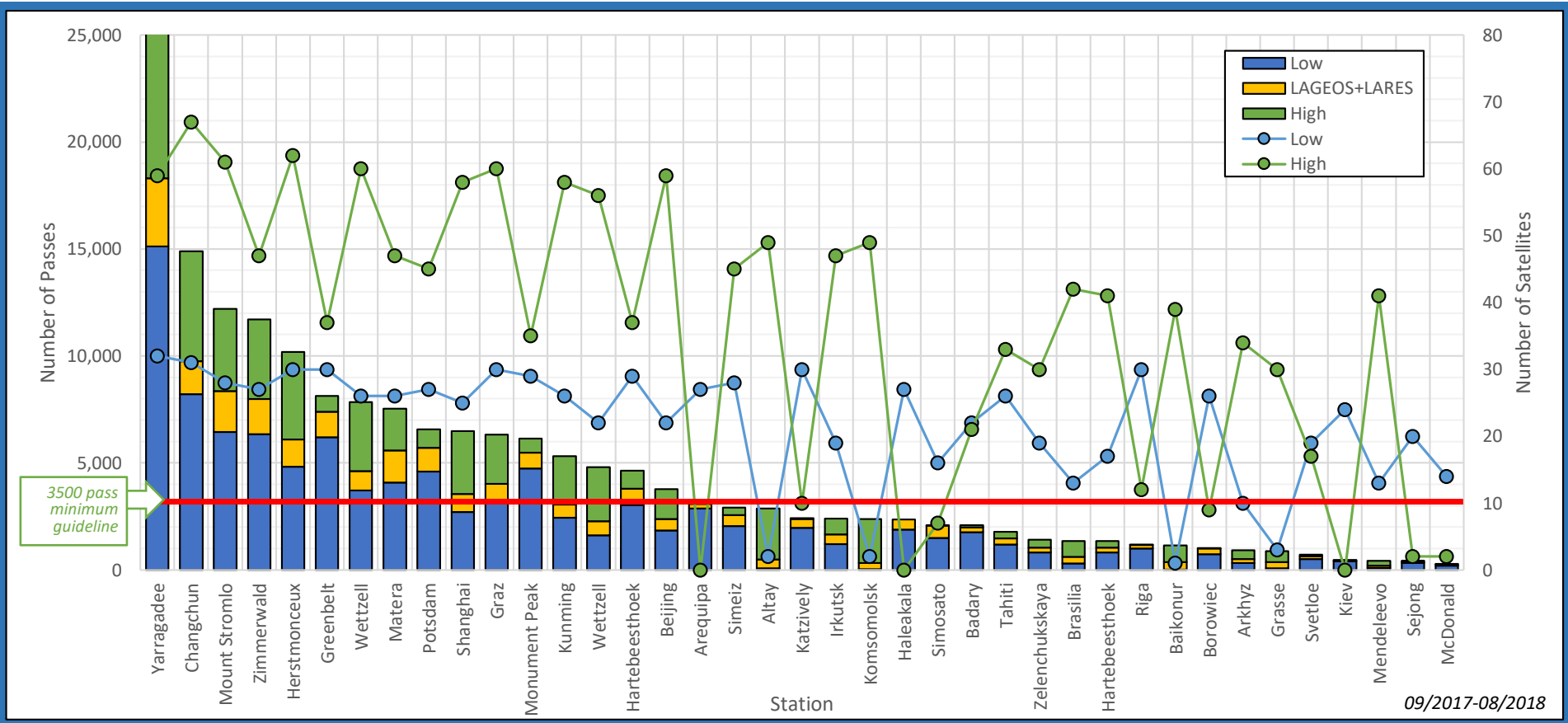


ILRS network

- BKG AGGO continuing setup at La Plata Observatory (Argentina)
- New stations underway:
  - Russia: Ensenada (Mexico), Java (Indonesia), Canary Islands (Spain)
  - NASA/NASA affiliated: McDonald, Halekala (USA), and Ny Ålesund (NMA, Norway)
  - Others: Metsahovi (Finland), Mt. Abu and Ponmundi (India), and Yebes (Spain)
- Upgrades underway at some stations

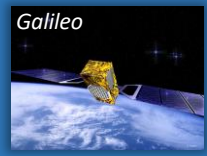
Gaps in geographic coverage remain

Station performance: passes



Highlights: missions

- Network routinely tracked 100+ satellites in 2018
- In last year, new, approved missions included:
  - S-NET (4 cubesats/testing inter-satellite communication)
  - Sentinel-3B (altimeter mission/restricted tracking)
  - GRACE-FO (2 satellites/gravity measurements)
  - Tiangong-2 (Chinese spacecraft)
  - Beidou-3M (4 GNSS satellites)
  - PAZ (SAR mission)
  - ICESat-2 (laser altimetry mission/restricted tracking)
  - Astrocast Precursor (2 cubesats/engineering testing)
  - GNSS (Galileo, GLONASS, IRNSS)
- Future missions:
  - Additional GNSS: BeiDou/Compass, Galileo, etc.
  - LightSail-2, COSMIC-2, HY-2C, SWOT, NISAR



Mission support

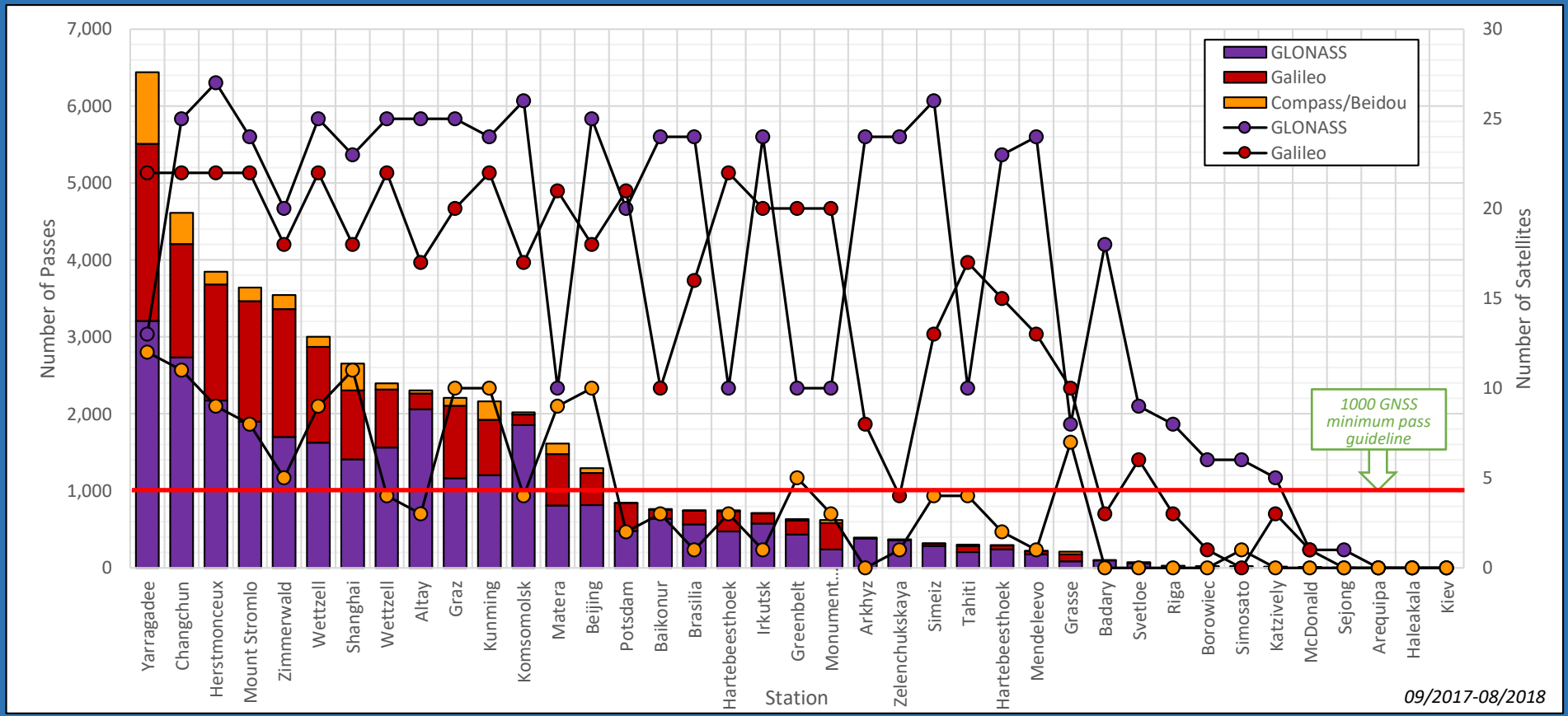
- Campaigns
  - 2018 LARGE campaigns:
    - First campaign: February 15 – May 15, 2018
    - Second campaign: August 01 – October 31, 2018
  - Proposed Etalon campaign:
    - February-April 2019
  - Possible dedicated campaigns to improve tracking on new missions
- Restricted tracking:
  - Sentinel-3
  - ICESat-2
  - Others

Designed to obtain improved temporal and spatial coverage by concentrating tracking on a subset of satellites from each of the GNSS constellations, GLONASS, Galileo, and Beidou/Compass.

Evaluate increase role of Etalon data in computation of ILRS products contributing to the ITRF.

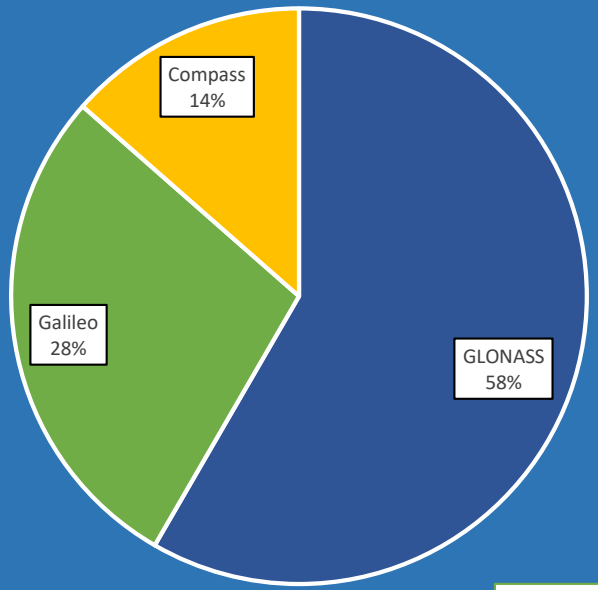
Developing mission-specific procedures for restricting SLR tracking of vulnerable satellites takes considerable time, coordination, and interaction between CB, mission, and stations.

Station performance: GNSS passes

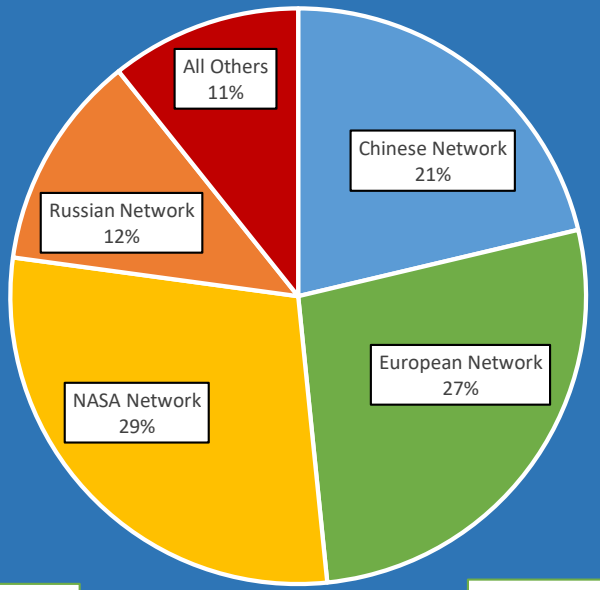


Station performance: LARGE 2018

Station Tracking Totals by Constellation (Passes)



Tracking Totals by Network (Passes)

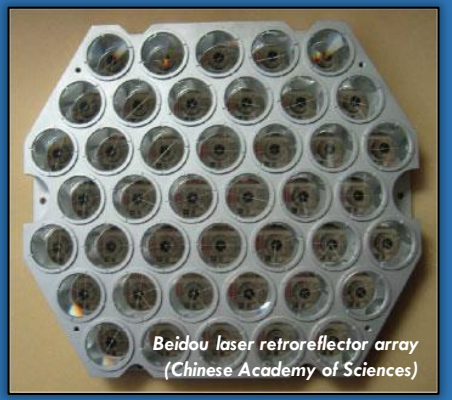


LARGE 2018 Campaign 1
February-May 2018

Chinese network:	*4 stations*
EUROLAS network:	*13 stations*
NASA network:	*8 stations*
Russian network:	*9 stations*
Other stations:	*2 stations*

Tracking GNSS: possible approach

- Large number of GNSS satellites
  - GNSS constellations have different requirements for ILRS tracking support
  - More satellites coming with GPS-III
- Constellations may select 4 – 8 GNSS satellites for higher priority with 3 segments of tracking requested per pass
  - Some number of additional GNSS satellites in each constellation remain on ILRS tracking list at lower priority
  - Tracking of lower priority satellites on non-interference basis with other requirements
- Instruct stations to take more robust sampling of the selected satellites
- Discussions underway with the IGS and the ICG


Beidou laser retroreflector array (Chinese Academy of Sciences)

Future mission support

- ILRS supports programs in geodesy, geodynamics, and space science with primary emphasis on tasks that support goals of GGOS
- Missions continue to submit support requests (10+ in 2018)
- ILRS set priorities and attempts to balance mission requests and maximize the utility of the network
- ILRS carefully reviews new mission support requests based on need and likelihood of success in meeting their tracking requirements
- To better ensure success for the mission AND the ILRS, missions must inform the ILRS well in advance of launch and in mission planning phases
- ILRS considering updated guidelines for acceptance of new missions for support

Highlights: operations/infrastructure (1/2)

- Quality Control Board (QCB) addressing laser ranging data quality issues via bi-monthly telecons
  - Data systematics Pilot Project completed and operational version is being worked on now
  - Examining consistency in NP computation
- Looking into new capabilities to assess station performance
  - Provide online tools for stations and analysts
  - Emphasize value of station performance to the users and science products
  - Show areas of improvement to support goals of the ILRS
  - Show network capabilities for altimetry, geodetic, and GNSS satellites/applications

Highlights: operations/infrastructure (2/2)

- Updates to site log format
  - Added more information about station configuration and operation
  - Implemented improved procedures (web-based) for submitting/updating station site logs
  - Helps stations keep their logs current
- CRD and CPF formats
  - Version 2 issued; testing underway
  - Version updates facilitate support of future missions and applications (e.g., ELT, space debris)
- Data screening/QC at ops centers
  - More thorough QC procedures to improve ILRS data product for the user community
  - Harmonized process between EDC and NASA OCs

Issues & challenges

- Many geographic gaps, primarily in Latin America, Africa, and Oceania
- Mix of new and old technologies and levels of financial support
- Lack of standardization in system hardware and operations
- Data quality issues (efforts underway to detect and reduce systematics)
- Number of target satellites continues to increase as new missions use SLR for orbit determination and other applications (100+ satellites)
  - Need to implement more effective tracking strategies
  - Need to be more selective on the targets
  - Need to conduct periodic community surveys to understand user requirements