

ILRS: What's New?

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ILRS Central Bureau

2019 ILRS Technical Workshop
October 21, 2019
Stuttgart, Germany

Outline

- Intro
- News
- Recent developments/ future plans
 - ◆ General
 - ◆ Network
 - ◆ Mission support
 - ◆ Operations
 - ◆ Analysis
- Challenges

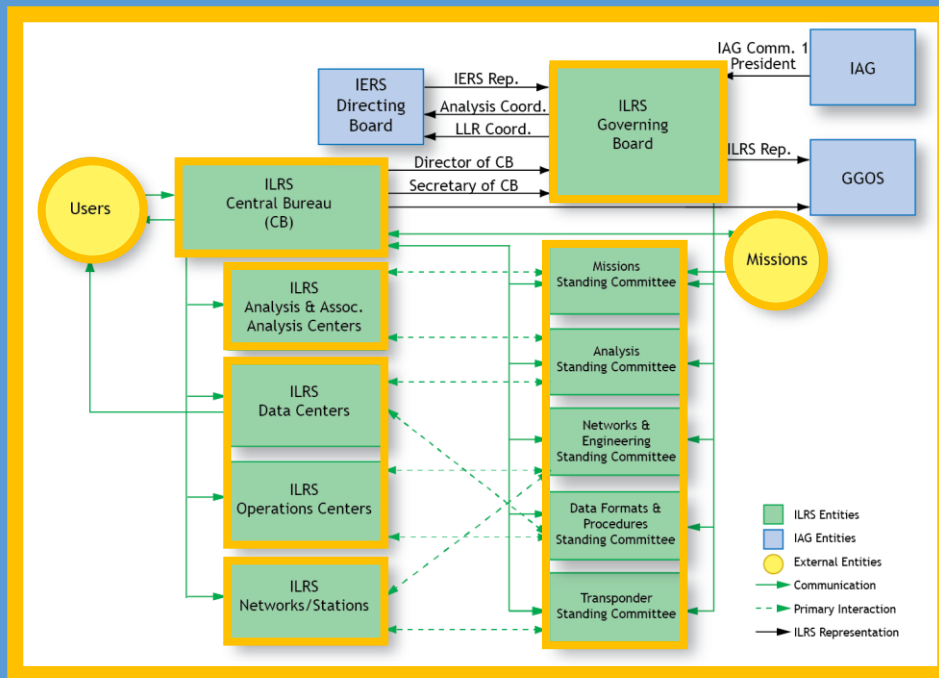
ILRS: large community participation



- Operation through cooperation of organizations leveraging resources to all levels of service functionality

- Components:

- ◆ Network: 40+ stations
- ◆ Data Centers:
 - 2 Operations Centers
 - 2 Data Archive Centers
- ◆ Analysis Centers:
 - 7 Analysis Centers
 - 2 Combination Centers
 - 21 Associate Analysis Centers
 - 6 Lunar Analysis Centers
- ◆ Standing Committees: 5
- ◆ Central Bureau: 25+ members
- ◆ Governing Board: 18 members
- ◆ Membership
 - Associates: 400+
 - Organizations: 110+
 - Countries: 30+
 - Correspondents: 200+
- ◆ Supporting:
 - Users: 1000's
 - Missions: 110+



<https://ilrs.gsfc.nasa.gov/about/organization/index.html>

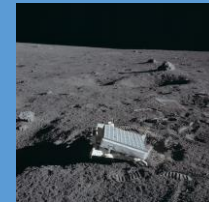
ILRS Governing Board: 2019-2020 term



- Elected positions:
 - ◆ EURDLAS Network Representatives:
Pippo Bianco, Georg Kirchner
 - ◆ NASA Network Representatives:
Jan McGarry, Stephen Merkwitz
 - ◆ 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 (Chair), Matt Wilkinson
- Ex-officio/appointed positions:
 - ◆ Director of the Central Bureau:
Mike Pearlman
 - ◆ Secretary of the Central Bureau:
Carey Noll
 - ◆ Representative of IAG Commission I:
Urs Hugentobler
 - ◆ IERS Representative:
Daniela Thaller
- Appointed by the Governing Board:
 - ◆ **Ulli Schreiber**
 - ◆ **Krzysztof Sośnica**



- Proceedings, presentations, posters, and summary information from 21st International Workshop in Canberra (November 2018) available on workshop website: <https://cddis.nasa.gov/lw21>
- First “SLR School” held before this workshop
 - ◆ Feedback welcome
 - ◆ Video to be made available
- NASA celebrated the 50th anniversary of the Apollo 11 moon landing and the start of LLR
- Finalizing Journal of Geodesy Special Issue on Laser Ranging
- Collecting input and editing 2016-2018 ILRS report



International Workshops on Laser Ranging



- International Workshops on Laser Ranging typically held every two years
 - ◆ Program includes sessions on science, infrastructure, operations, technology, software, and mission design
 - ◆ Presentations, proceedings, summaries available on ILRS website
 - ◆ Clinics focus on small group interactions with station personnel
 - ◆ 21st International Workshop on Laser Ranging held in Canberra, Australia, November 2018
 - ◆ Theme: “Laser Ranging for Sustainable Millimeter Geoscience”

Number	Year	Location
1 st	1973	Lagonissi, Greece
2 nd	1975	Prague, Czechoslovakia
3 rd	1978	Lagonissi, Greece
4 th	1981	Austin, TX, USA
5 th	1984	Herstmonceux, UK
6 th	1986	Antibes, France
7 th	1989	Matera, Italy
8 th	1992	Annapolis, MD, USA
9 th	1994	Canberra, Australia
10 th	1996	Shanghai, China
11 th	1998	Deggendorf, Germany
12 th	2000	Matera, Italy
13 th	2002	Washington, D.C., USA
14 th	2004	San Fernando, Spain
15 th	2006	Canberra, Australia
16 th	2008	Poznan, Poland
17 th	2011	Bad Koetzing, Germany
18 th	2013	Fujiyoshida, Japan
19 th	2014	Annapolis, MD, USA
20 th	2016	Potsdam, Germany
21 st	2018	Canberra, Australia
22 nd	2020	Kunming, China



Over 150 participants in the 21st International Workshop on Laser Ranging, Canberra Australia
<https://cdis.nasa.gov/lw21/>

- ILRS also organizes smaller, focused workshops in years between the International Workshops on Laser Ranging
 - ◆ *"Laser ranging: To improve economy, performance, and adoption for new applications"*
 - ◆ Included one-day "SLR School" providing tutorials on SLR and the ILRS



Topic	Year	Location
SLR System Calibration Issues	September 1999	Florence, Italy
Working Toward the Full Potential of the SLR Capability	October 2003	Kötzing, Germany
Observations Toward mm Accuracy	October 2005	Eastbourne, UK
Challenges for Laser Ranging in the 21st Century	September 2007	Grasse, France
SLR Tracking of GNSS Constellations	September 2009	Metsovo, Greece
Satellite, Lunar and Planetary Laser Ranging: Characterizing the Space Segment	November 2012	Frascati, Italy
Network Performance and Future Expectations for ILRS Support of GNSS, Time Transfer, and Space Debris Tracking	October 2015	Matera, Italy
Improving ILRS Performance to Meet Future GGOS Requirements	October 2017	Riga, Latvia
Laser ranging: To improve economy, performance, and adoption for new applications	October 2019	Stuttgart, Germany

<https://ilrs.gsfc.nasa.gov/about/reports/workshop/index.html>

Journal of Geodesy Special Issue on Laser Ranging



The ILRS: Approaching twenty years and planning for the future

Geodetic Satellites: A High Accuracy Positioning Tool

Satellite Laser Ranging to Low Earth Orbiters - Orbit and Network Validation

Version of a glass retroreflector satellite with a sub-millimeter "target error"

Laser and Radio Tracking for Planetary Science Missions - A Comparison

Assessment of the impact of one-way laser ranging on orbit determination of the Lunar Reconnaissance Orbiter

Overview of Applications of Satellite Laser Ranging and Laser Time Transfer in BeiDou Navigation Satellite System

Lunar Laser Ranging - A Tool for General Relativity, Lunar Geophysics and Earth Science

NASA's Satellite Laser Ranging Systems for the 21st Century

Time and laser ranging: A window of opportunity for geodesy, navigation and metrology

The Next Generation of Satellite Laser Ranging Systems

Rapid Response Quality Control Service for the Laser Ranging Tracking Network

Solar orbital thermo-optical characterization of an innovative GNSS retroreflector array

Operating two SLR Systems at the Geodetic Observatory Wettzell - from local survey to space ties

Future SLR station networks in the framework of simulated multi-technique terrestrial reference frames

Information Resources Supporting Scientific Research for the International Laser Ranging Service

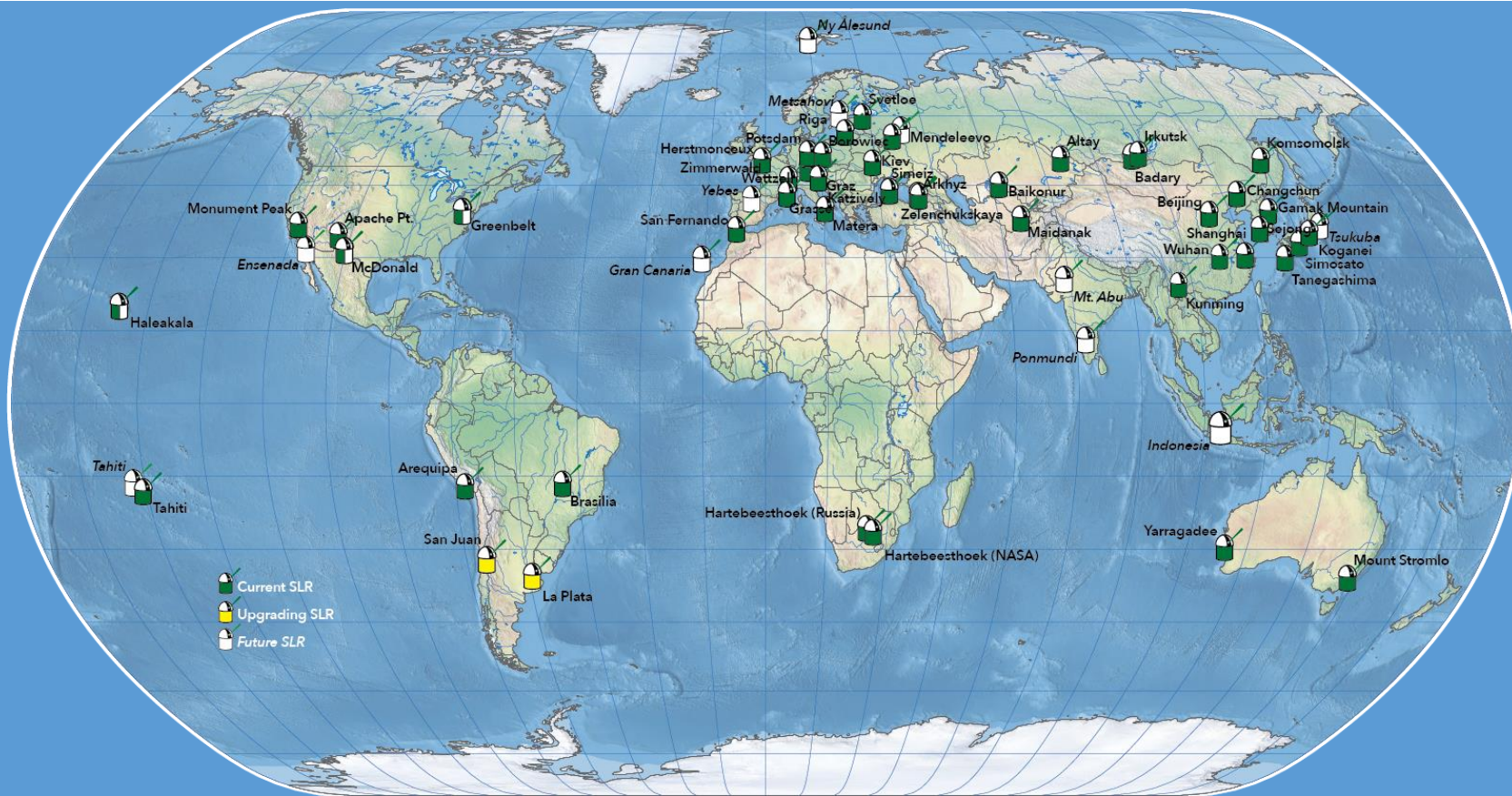
Modernizing and Expanding the NASA Space Geodesy Network to Meet Future Geodetic Requirements

Time Bias Service: Analysis and Monitoring of Satellite Orbit Prediction Quality

*30+ papers submitted;
18 papers published online;
4 papers in final review stage.*



ILRS network



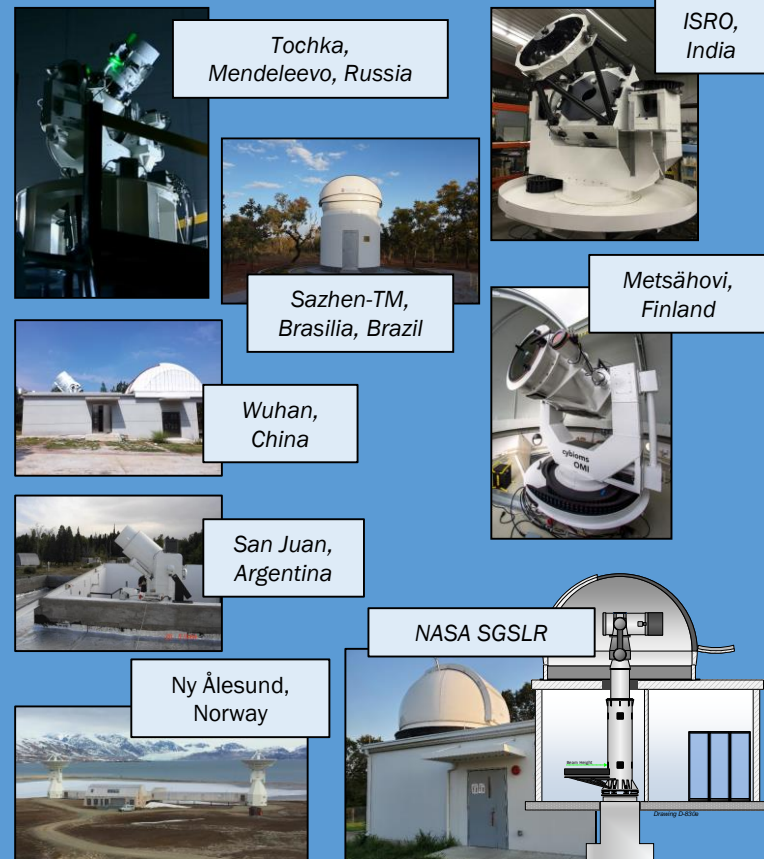
Recent developments: network



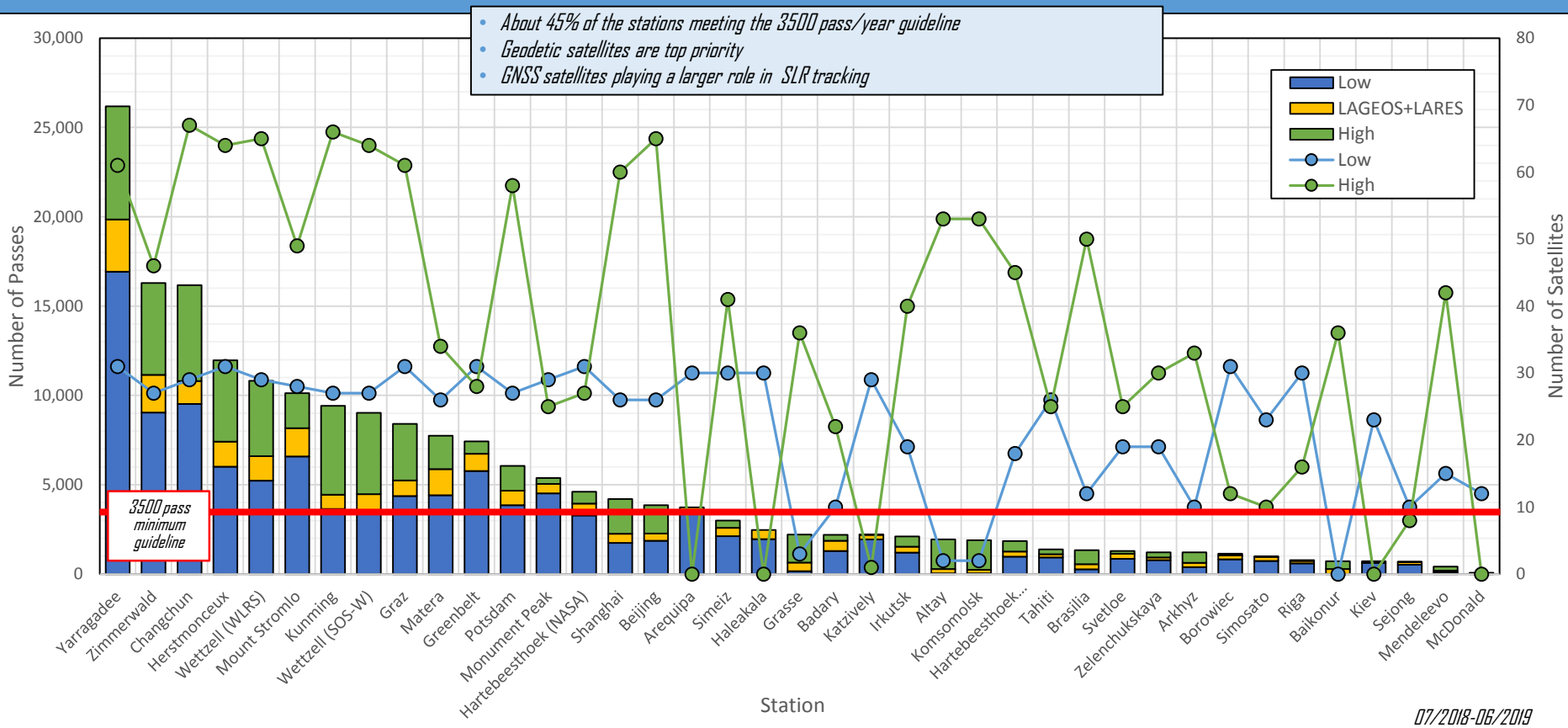
- Station closings:
 - ◆ MLRS, McDonald, TX: lightning strike; to be replaced by SGSLR
- Upgraded stations:
 - ◆ Simosato (Japan): kHz operations late 2018
 - ◆ Wuhan (China): submitting data (in quarantine)
 - ◆ BKG AGGO: continuing setup La Plata Observatory (Argentina); TIGO relocation
 - ◆ San Juan (Argentina): kHz, operations planned for 2020
- Co-locating stations:
 - ◆ Russia implementing co-location concept at select stations to expand temporal coverage of satellites
 - ◆ Hartebeesthoek (South Africa) operational; Mendeleev (Russia) soon; Tahiti (French Polynesia) future
- New station installations underway/planned

Future developments: network

Site	Type	Agency	Timeframe
La Plata, Argentina	Upgraded core site	BKG, Germany	2019 -
San Juan, Argentina	Upgraded SLR system	NAOC, China	2019 -
Metsähovi, Finland	New SLR system	FGRI, Finland	2019 -
Greenbelt, MD, USA	Replacement core site	NASA, USA	2020 -
Haleakala, HI, USA	Replacement core site	NASA, USA	2020 -
McDonald, TX, USA	Replacement core site	NASA, USA	2020 -
Ny Ålesund, Norway	New core site	NMA, Norway/NASA, USA	2020 -
Ensenada, Mexico	New SLR site	IPIE, Russian Federation	2022 -
Java, Indonesia	New SLR site	IPIE, Russian Federation	2022 -
Gran Canaria, Spain	New SLR in core site	IPIE, Russian Federation	2022 -
Tahiti, French Polynesia	New SLR system	IPIE, Russian Federation	2022 -
Mt Abu, India	New SLR site	ISRO, India	2020 -
Ponmudi, India	New SLR site	ISRO, India	2020 -
Tsukuba, Japan	New SLR site	JAXA, Japan	2021
Yebes, Spain	New SLR site	IGS, Spain	2022



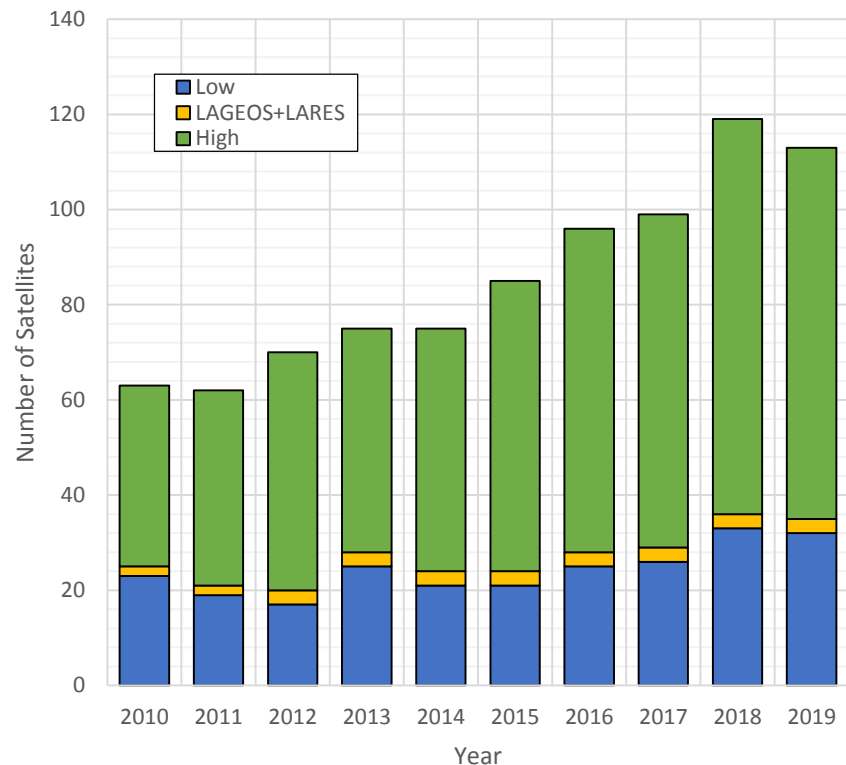
Station performance: passes



07/2018-06/2019

Recent developments: missions

- Tracked 110+ satellites in 2019
- Formulated new GNSS tracking strategy
- Completed 3-month Etalon campaign
- Updated mission support request guidelines (e.g., 6 month advance notice)
- Missions Standing Committee
 - ◆ New chair (Stephen Merkowitz) and co-chair (Toshi Otsubo)
 - ◆ MSC meeting: October 22@17:00



Number of satellites tracked over the years

Recent developments: missions

- Recent additions to the ILRS priority list:
 - ◆ PAZ (SAR mission)
 - ◆ ICESat-2 (laser altimetry mission/restricted tracking)
 - ◆ Beidou-3M (4 GNSS satellites)
 - ◆ Galileo (4 GNSS satellites)
 - ◆ HY-2B (altimetry mission)
 - ◆ LightSail-2 (solar sail)
- Future missions requesting ILRS support:
 - ◆ Astrocast Precursor (2 cubesats/engineering testing)
 - ◆ Additional GNSS: BeiDou/Compass, Galileo, etc.
 - ◆ COSMIC-2, HY-2C, SWOT, NISAR
- More requests for restricted tracking, which is time consuming to implement



PAZ



ICESat-2



HY-2B



LightSail-2

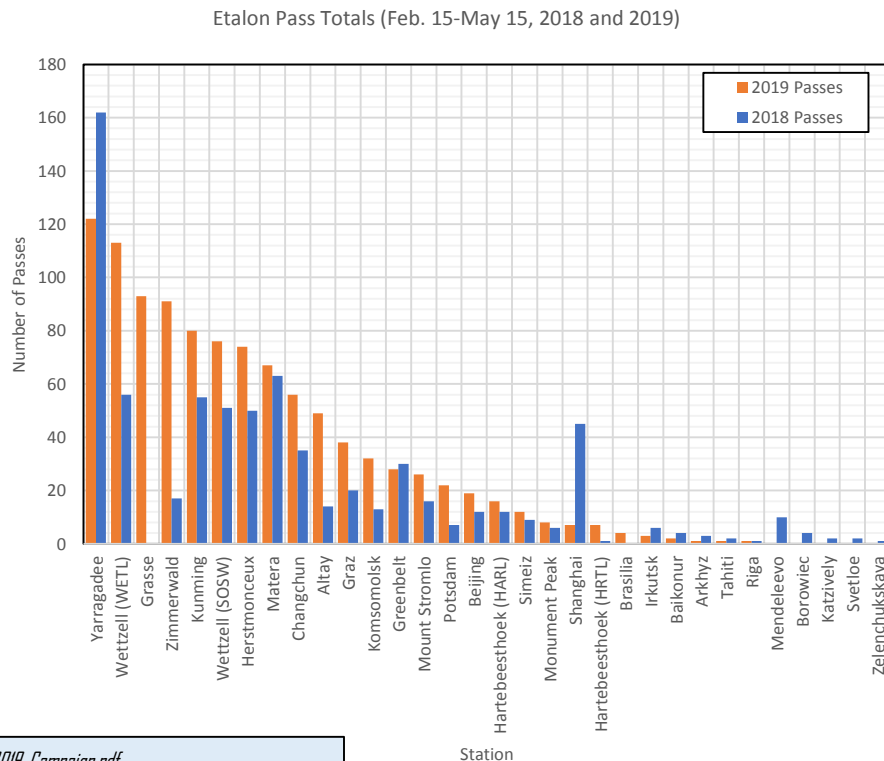


Astrocast

Etalon campaign: results



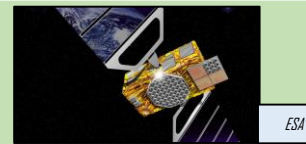
- February 15 through May 15, 2019
- Evaluate increased role of Etalon data in computation of ILRS products contributing to the ITRF, particularly EOP
- Successful campaign: in general, stations collected more Etalon data overall and added geometry to data yield
- Summary report available on ILRS website



https://ilrs.gsfc.nasa.gov/docs/2019/Etalon_land2_2019_Campaign.pdf

GNSS tracking strategy

- Large number of GNSS satellites
 - ◆ GNSS agencies have different requirements for ILRS tracking support
 - ◆ More satellites coming with GPS-III
 - ◆ GNSS tracking strategy put in place after consultation with missions, IGS, and the ICG
- Strategy:
 - ◆ Each constellation selects 4 satellites for higher priority tracking (3 segments of tracking requested per pass)
 - ◆ All of the remaining GNSS satellites are tracked at lower priority on a non-interference basis with all of the other ILRS requirements (sampling approach)
- Concentrated tracking in special campaigns (e.g., eclipsing)



Galileo



GLONASS



BeiDou



GPS-III

ESA

ROSCOSMOS

Chinese Academy of Sciences

USAF

Recent developments: operations

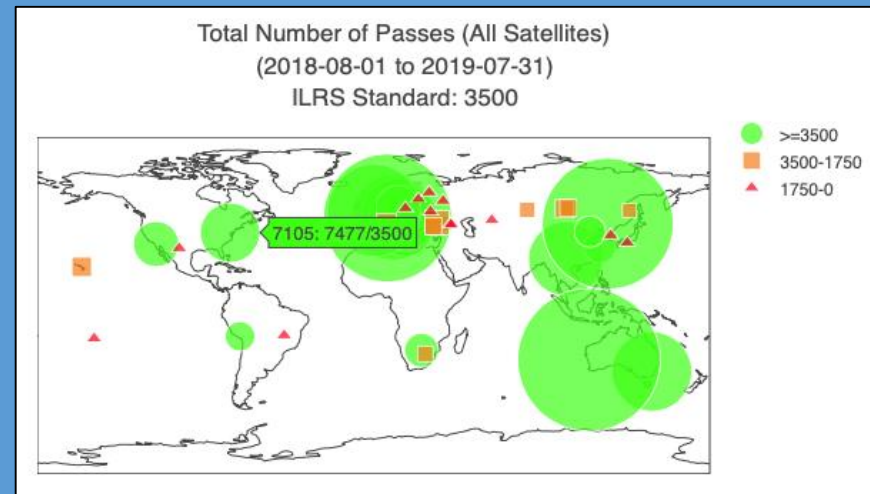


- Site log format and submission/update process
 - ◆ Added more information about station configuration and operations
 - ◆ Implemented improved procedures (web-based) for submitting/updating station site logs
 - ◆ New procedure should help stations keep site logs current
- CRD and CPF formats
 - ◆ Issued version 2 of both formats; testing underway
 - ◆ Updated versions will facilitate support of future missions and applications (e.g., ELT, space debris)
- Data screening/QC at operations centers
 - ◆ Implemented more thorough QC procedures to improve ILRS data product for the user community
 - ◆ Harmonized process between EDC and NASA OCs

Station performance assessment tool



- Allows station personnel, analysts to view network capabilities (e.g., #passes, #normal points, adherence to ILRS guidelines, etc.) by category
 - ◆ Overall
 - ◆ Satellite type (geodetic, altimetry, GNSS)
 - ◆ Adherence to priority list
- Report features
 - ◆ Emphasize value of station performance to the user community and to the creation of science products
 - ◆ Show areas of improvement to support ILRS goals
- Generated monthly, reflects data assessed over the previous 12 months



Size of the bubble reflects the extent the parameter is met, not the geographical coverage tracked

https://ilrs.gsfc.nasa.gov/network/system_performance/monthly_station_performance_maps/index.html

Recent developments: analysis (ASC)



- Working on development of ITRF2020 series; production starts late 2019
- Currently testing new models for gravity, tides, TVG, and target signature (CoM) models, and the inclusion of LARES data
- New operational approach to handling error sources in our current modeling standards
 - ◆ Allowance for estimation of systematic errors simultaneously with all other parameters to eliminate biases in station positions (mainly height)
 - ◆ Improved corrections in the current model for the CoM target signatures; such errors can affect the SLR-VLBI scale difference at the 0.25 ppb level
- Next steps:
 - ◆ Low degree/low order gravity field terms (data product)
 - ◆ Include LARES satellite to the operational data products and ITRF2020
 - ◆ Add atmospheric loading to the operational data products (at observation level)

Issues and challenges

- Many geographic gaps, primarily in Latin America, Africa, and Oceania
- Mix of new and old technologies, levels of financial support, weather
- Lack of standardization in system hardware and operations
- Marginal operation at many stations, making little or no contribution to the ILRS data products
- Addressing data quality issues; still some systematics
- Continued increase in number of target satellites as new missions use SLR for orbit determination and other applications (110+ satellites)

