Networks & Engineering Standing Committee - Report

Matthew Wilkinson, Clément Courde, You Zhao

NESC

The NESC has remained active over the last two years through regular online meetings using Microsoft Teams.

These meetings usually attract between 30-45 participants from different time zones.

The meetings are scheduled for 2 hours and usually include 3-5 presentations or items for discussion.

NESC

Presentations to the NESC meetings have included:

- Jullian Rivera described the methods used to accurately survey to 1mm the local ties at McDonald Observatory. The survey network included baselines of about 1 km with 120m elevation change.

- Radosław Zajdel presented his study of SLR tracking to the Beidou-3 satellites, following the ILRS adopting the policy of tracking the whole constellation. This included a comparison with the Galileo constellation, which showed that Beidou-3 satellites were tracked less.

NESC

- Eva Terradillos and Marc Fernández Usón from GMV summarised the annual Sentinel-3 and Sentinel-6 report. Many stations have range biases of more than 5mm and for some this value was not constant from month to month.

- Eléonore Saquet showed how SLR ranges are used to validate the radial component of Earth observation satellite orbits generated using GNSS and DORIS. In the resulting range residuals it is possible to determine station range biases.

- Alexandre Couhert presented orbit validation results using SLR ranges to the Surface Water /Ocean Topography (SWOT) satellite.

NESC

Stations have provided updates to the NESC meetings, including:

- Manuel Angel Sánchez Piedra presented the work at the San Fernando SLR station. The new teescope mount will have an accuracy of < 1 arcsec and is capable of high speeds and accelerations. The invariant point is defined to < 1mm.

- Toshimich Otsubo showed the first returns from Omni-SLR taken on the rooftop of the National Institute of Polar Research, Tachikawa, Tokyo. Omni-SLR is designed to be transported by car and made at low cost with commercially available components

- Julien Barnéoud presented the recent work of his team in Grasse to determine the reference invariant point at the intersection of the telescope axes using an automated total station.

NESC

- Thomas Schildknecht presented the problems faced at the Zimmerwald SLR station that began with the changing of the dome from an open all-sky dome to a slit dome.

- Shinichi Nakamura introduced the new Tsukuba SLR station, which is operated by JAXA and was manufactured by DiGOS.

- Mykhaylo Medvedskyy provided an update on the significant renovations at the Golosiiv SLR station in Ukraine. The team developed a novel approach of mounting two receiving 305mm aperture telescopes and a guide 250mm aperture telescope on to the original telescope body.

NESC

Invited guest speakers from outside commercial organisations:

- Fabio Signorelli from Micro Photon Devices presented their single SPAD chip and multi-chip CMOS array detectors. Detectors are available for visible wavelengths using silicon and also for longer infrared wavelengths using InGaAs.

- Vincent Kumar and Saulius Frankinas from QS Lasers in Lithuania presented their expertise in compact DPSS lasers for scientific and industrial application.

- Robert Aldrich from Rockwell Laser Industries presented their laser hazard analysis software for airspace applications - the SKYZAN.

- Antoine Courjaud from Amplitude and he presented an overview the ultrashort pulse laser technology available.

NESC

Discussions were also held in the NESC meetings, including:

- The design, practical implementation and results of the Galileo 4 Science campaign.

- The tracking of the legacy WESTPAC satellite, including the difficulty in identifying the correct NORAD number target.

- Meteorological readings at stations, including a new barometer at Greenbelt and the design and manufacture, by Nils Raymond at OCA, of a travelling barometer system.

NESC

Finally, the NESC discussed how there are stations in the network that are not reaching the required minimum productivity levels and are therefore not contributing very much to the products from the ILRS.

A Station Survey & Plan document was drafted and designed to find out more about the status of these station and the limitations to greater SLR tracking and ask them to produce a plan of action.

This was passed to the ILRS CB and has been sent to a select group of stations and the responses will be reviewed by a panel.

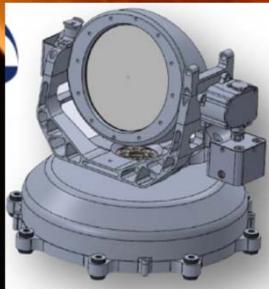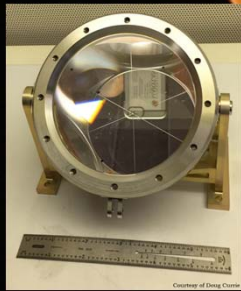# Lunar Laser Ranging (LLR) & Time Transfer

Science with LLR

- *Fundamental Physics Tests*
- *Selenophysics / Selenodesy*
- *Planetary ephemeris*

And maybe in a near future :
Gravitational waves detection with LLR&SLR

Beyond the General relativity
- constrain of new theories of relativistic gravity
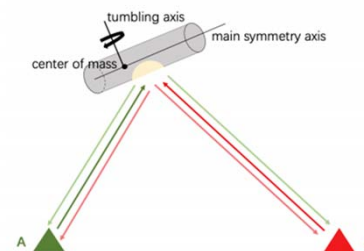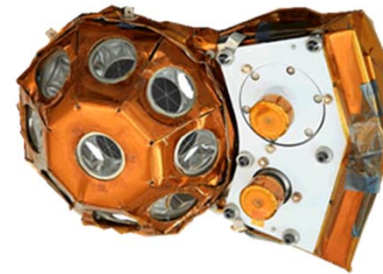- open window for dark energy/matter understanding

LLR Network

Apollo (USA), Grasse (France), Matera (Italy), Wettzell (Germany), + Chinese/Russian/South Africa stations in progress

LLR Analysis centers

- Goddard Lunar Data Analysis Center (GLD AC), Greenbelt, MD, USA
- *the Paris Observatory Lunar Analysis Center (*POLAC*), Paris,* France*;*
- the Institute of Geodesy (IfE), University of Hannover, Germany;
- the National Institute for Nuclear Physics (INFN), Frascati, Italy;
- The Jet Propulsion Laboratory (JPL), Pasadena, USA
- the Institute of Applied Astronomy Russian Academy of Sciences (IAARAS), Saint Petersburg (Russia).

Science and application with Transponder

- *Time & frequency transfer and clock synchronization between ground & space*
- *Interplanetary laser ranging*
- *Fundamental physics*
- *Chronometric geodesy*
- *Atmospheric propagation delay*
- *Laser communication*
- *Navigation*

On-going :
- CSS-LTT (2022, underway) 2way asynchronous

Up-coming :
- ACES-ELT : launch in early 2025
- LTT on CAS-1

5 reflectors on the Moon and new reflectors in a near future (2024-2025) on the Moon & on orbiter :

- NASA-NGLR-1&2
- ESA-MoonLIGHT & Lunar Pathfinder
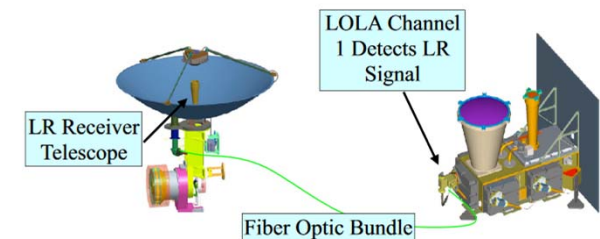- CNSA-Tiandu-1 & CAS-1

tumbling axis
main symmetry axis
center of mass
A
B

LOLA Channel 1 Detects LR Signal
LR Receiver Telescope
Fiber Optic Bundle

1

LLR & TT standing committee report
News

- **_LLR space segment =>_** new LRR soon (NGLR should be launched in Q4 2024)

- **_LLR stations_**
  - Matera => upgrade of the station => see the presentation of Vincenza Luceri Session 3
  - Wettzell => upgrade of the laser amplification stage => see the presentation of Johann Eckl Session 4
  - Apache Point => data release in february 2024 : a reprocessing of all pre-NASA data
  - Sun Yat-SEN UniversCity => LLR on all the 5 LRR in 2019 ; 2023 LLR of A15 @full Moon conditions

- **_LLR analysis centers_**
  - IAA RAS => Ephemeris of the Moon EPM2023 => see presentation of Eleonora Yagudina Session 4 part 2
  - IfE => ERPs + DLLR simulations + testing the general relativity => see presentation of Zhang Mingyue Session 4 part 2
  - POLAC => looking for gravitational waves => see presentation of Diego Blas Session 6

- **+ Institutional discussions on Lunar Reference & Time Frame** 2

LLR & TT standing committee report

General remark for LLR

The ILRS database for LLR measurement is weak w.r.t SLR measurement

=> Each quality LLR data is very precious !

, I encourage all the new LLR observations to be shared as soon as possible through the ILRS database.

LLR & TT standing committee report

News

- ***TT***
    - See presentations of session 7 for the chinese activities + presentation of Abdelrahim Ruby session 6
    - ESA-ACES => see the presentation of Jan Kodet Session 1
    - Experiments on passive satellites between Wettzell & Grasse

ILRS ASC REPORT

Cinzia Luceri (ASI/e-GEOS) and Mathis Bloßfeld (TUM)

ILRS Analysis Coordinators

23rd IWLR, 20-26 October 2024, Kunming, China

Operational products

A new Analysis Center, CNES (Toulouse), has joined the ILRS and is routinely submitting the official products since May 2024
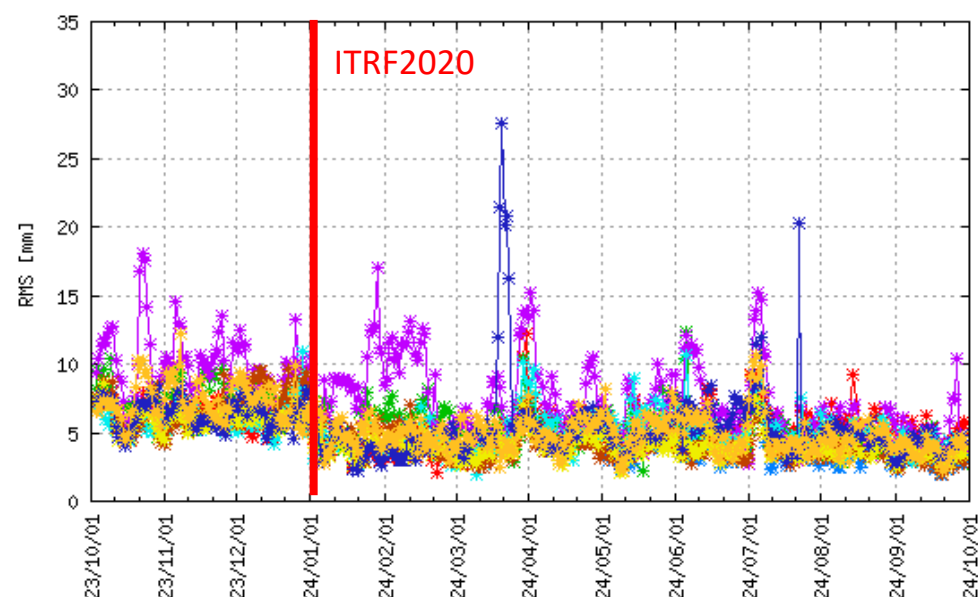
Operational products using ITRF2020 and more recent standards and model
- daily coordinates+EOP (satellites used: LA-1/-2, ET-1/-2; 1 day latency) → used for USNO Bulletin A
- weekly coordinates+EOP   (9 days latency)
- weekly orbit   (9 days latency)
- weekly station range bias (9 days latency) → used for Data Handling File updates
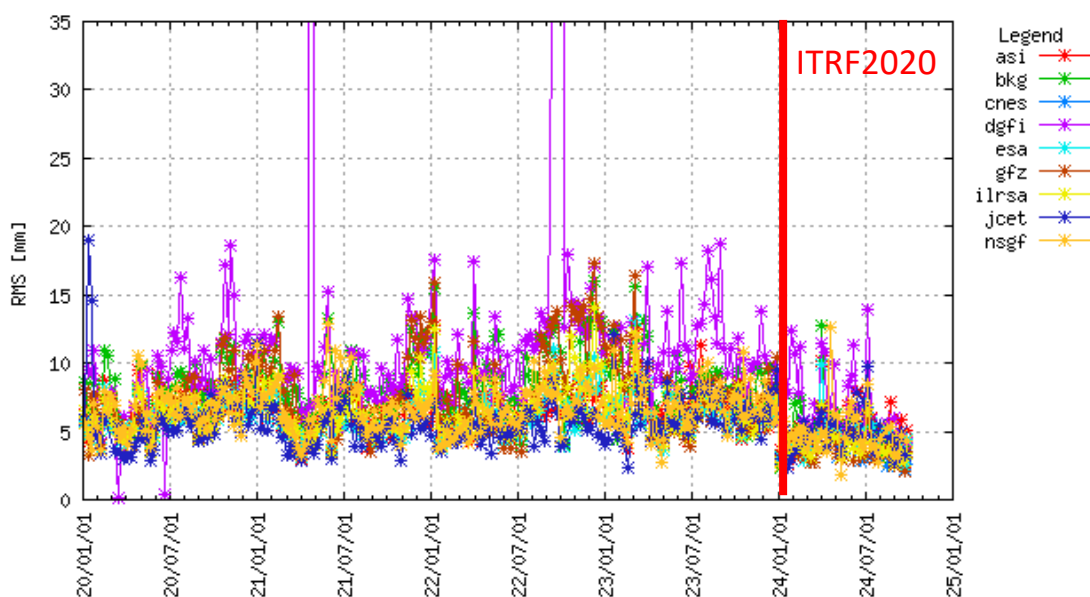
Data Handling File

- The Data Handling File summarizes information on range, time and pressure errors for all the station of the ILRS network. The range bias model is specific for LAGEOS 1/2 and ETALON 1/2

- The DHF is routinely updated. The first release was used for ITRF2020, version **210416** (yymmdd), from January 1993 to December 2020.

- The DHF was extended to the end of 2022 as a result of the SSEM-X project, version **230601.** The latest version, extended to end of 2023, is the **240213** and is available at https://ilrs.gsfc.nasa.gov/docs/2024/ILRS_Data_Handling_File_2024.02.13.snx

- All ACs are delivering WEEKLY SINEXs to extend the time series (v28* series) to the current epoch (with 9 days latency).

- A weekly production chain of SSEM-like SINEXs file to routinely extend the RB time series (v28* series) was set by the ILRSA CC to check if any update of the DH file is needed.

- ILRSA CC is testing a change-point detection (CPD) algorithm, e.g. based on Pruned Exact Linear Time to support the analysts in their search for a potential new discontinuity in range bias series. A preliminary test to set parameters was performed on v230 series.

Analysis Activities

- **ILRS contribution to ITRF2020 update**

  - mid of March 2024, the ILRS ASC provided the ILRS contribution to the ITRF2020 update (v85)

  - solutions are based on v180/v80 model setups (cf. previous slides)

  - solutions cover the time span 2021.0 until 2024.0

- **Full REPRO 1993-2020**

  - complete reprocessing of the SLR data (1993-2022; v85) based on most recent standards and models. The ASC
    agreed to provide **reprocessed orbits consistent to the reprocessing standards**, together with POS and EOPs.

- **Update of SLRF2020 and new stations**

  - the SLRF2020 will be update soon with refined and new coordinates

- **Inclusion of LARES-2 in the operational ASC products**

  - currently, long-term mean range biases to update ILRS DHF are operationally computed (v320)

  - when the DHF will be available, a test series of v180/v80 including LARES-2 as 5th satellite

LARES-2 RB

José Rodríguez, in collaboration with Graham Appleby and Toshimichi Otsubo, has modelled the most relevant effects to compute tables of CoM corrections for the geodetic satellites including the LARES satellites. The LARES-2 CoM model was included on 2023-11-28 and is available at
https://datos-geodesia.ign.es/SLR/centre_of_mass_models/models/
Using the LARES-2 CoM model the ACs and CCs are delivering WEEKLY SINEX with the RB estimates and the ILRSA CC is working to compute the RB model and update the DHF
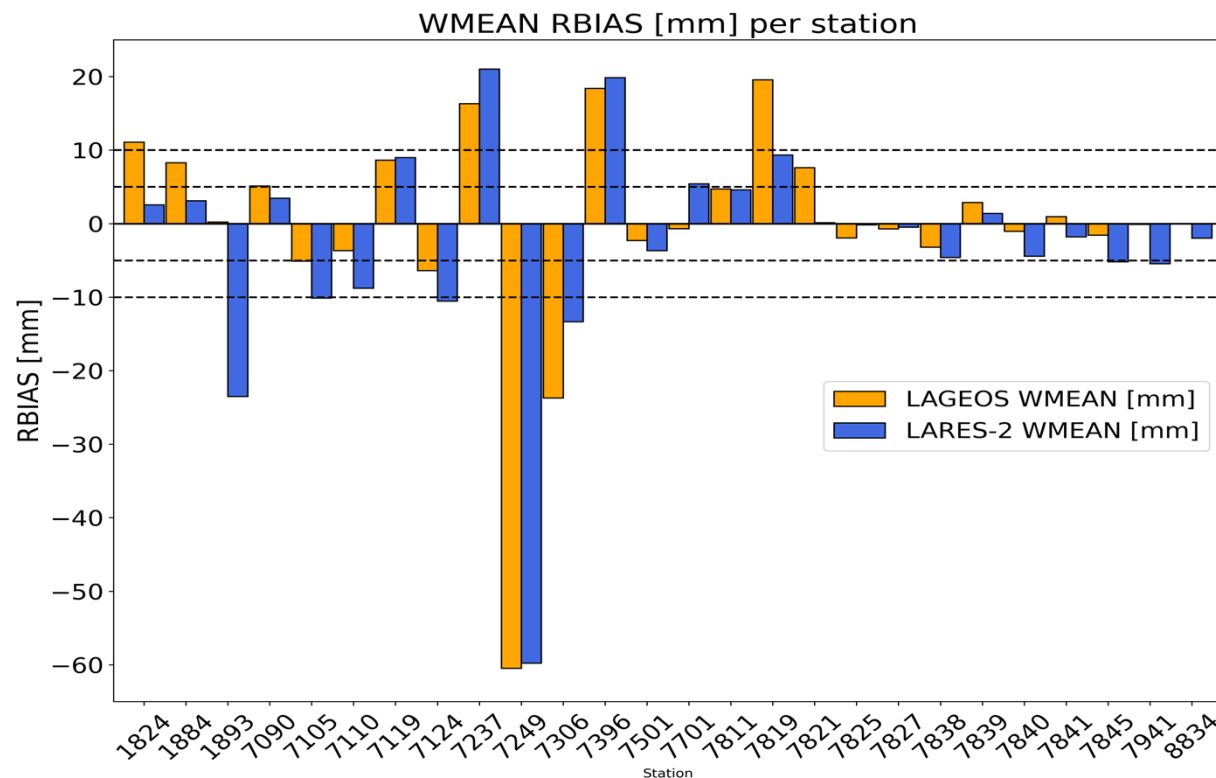
WMEAN since LARES-2 launch:
July 2022 – September 2024

ILRS ASC Product status

	daily	weekly	weekly - orb	RB	RB with LARES-2	REPRO
ASI	✅	✅	✅	✅	✅	✅
BKG	✅	✅	✅	✅	✅	✅
CNES	✅	✅	✅	✅	✅	🟡 *
DGFI	✅	✅	✅	✅	✅	✅
ESA	✅	✅	✅	✅	✅	✅
GFZ	✅	✅	✅	✅	✅	✅
JCET	✅	✅	✅	✅	✅	✅
NSGF	✅	✅	✅	✅	🟡 **	✅

✅ : Submitted, no issues.
❌ : No file.
🟡 : partial.

* Not mandatory for CNES, 2015-2023 delivered.
** NSGF uploaded a set of solutions but the contribute is not still operational.

Future projects and meetings

LARES and SH pilot project

- Inclusion of LARES data in the official ILRS products, Some ACs are investigating the feasibility of their contribution to the project

ESA's GENESIS mission

- Genesis will change also the daily work of the ILRS ASC since its task is the ILRS contribution to the ITRF; this topic will be included in all future ASC meetings.

Meetings 2023-2024

- April 2023 - 48th ASC meeting was a hybrid (online- in person) meeting at EGU 2023 in Vienna
- October 2023 - 49th ASC meeting was held virtually
- January 2024 - 50th ASC meeting was held virtually
- April 2024 - 51st ASC meeting was a hybrid (online- in person) meeting at EGU 2024 in Vienna
- **Next meeting** will be held virtually on 5 November 2024