

IGS LEO-PNT Pilot Project:

Preparing Geodetic Infrastructure and Products for future LEO-PNT Integration



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 - E.g. geoscience & remote sensing applications.
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Background information

Many emerging LEO-PNT providers (FrontierSI 2025*)

Organisation	Country	First Launch	Operational	Frequency Band	Total Planned
Iridium	USA	Block 1 – 1997-2002, NEXT – 2017-2019	66	L	66
Xona Space	USA	2022	1	L	258
TrustPoint	USA	2023	1	C	300+
JAXA	Japan	-	0	C	240
ArkEdge Space	Japan	2028-2029	0	L6, S, C	300+
Centispace	China	unknown	unknown	L	190
Geely	China	unknown	unknown	L	240
SatNet LEO	China	unknown	unknown	L	504
ESA	Europe	2026	0	L, S, C, UHF	10 demos (≤263)
Fergani Space	Türkiye	2025	2 demos	L, S, Ku, Ka	100+
NSSTC LEONAV	UAE	-	0	unknown	unknown
KASA	South Korea	-	0	unknown	unknown
VyomILC	India	-	0	L, S	240
GLONASS LEO	Russia	-	0	L, Ku	240



TRUSTPOINT



IGS LEO-PNT 'Pilot Project'



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Description

Officially approved during the IGS Governing Board 73rd meeting (01/04/26).

The primary goal of this IGS Pilot Project is

- to investigate the feasibility of integrating LEO-PNT technology in IGS components.

Co-chaired by

- Francesco Gini (ESA)
- Lotfi Massarweh (TUD)



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Interaction with ACs/ACC and

- Antenna committee
- BAR committee
- Clock Products committee
- Ionosphere committee
- Infrastructure committee
- Real-time committee
- RINEX committee
- Reference Frame committee
- SVOD committee
- Troposphere committee

IGS LEO-PNT ‘Pilot Project’

Work-plan (via a phased approach)

Exploration phase → Exploitation phase → Handover & Operations

Main objectives:

- Engage LEO-PNT providers and users.
- Assess relevance for IGS and readiness.
- Define minimum technical requirements.
- Establish interoperable data conventions.
- Develop and pre-evaluate pilot products.
- Deliver an IGS integration roadmap...

LEO Working Group, chaired by Mike Watkins in 1998

**INTERNATIONAL GPS SERVICE
CALL FOR PARTICIPATION
In support of
LOW EARTH ORBITING MISSIONS**

TABLE OF CONTENTS

- Letter of Invitation to Participate from Professor Christoph Reigber, Chair IGS Governing Board
- Executive Summary
- Call for Participation Details
 - IGS Mission and Objectives
 - LEO Recommendations
 - Call for GPS Network Stations
 - Call for High Performance IGS Subnetwork
 - Data Formats



(Jan 2000)

First LEO-PNT Splinter Meeting

Overview and highlights

It took place during IGS Workshop 2026 in Santiago de Chile, with more than 120 participants (in hybrid format) and a few invited speakers:

Some key points:

- New modulations means new biases, thus leading to potential interoperability issues.
- Signals not limited to L-band, along with other possible ISL and SLR capabilities.
- An extension of IGS formats is necessary.

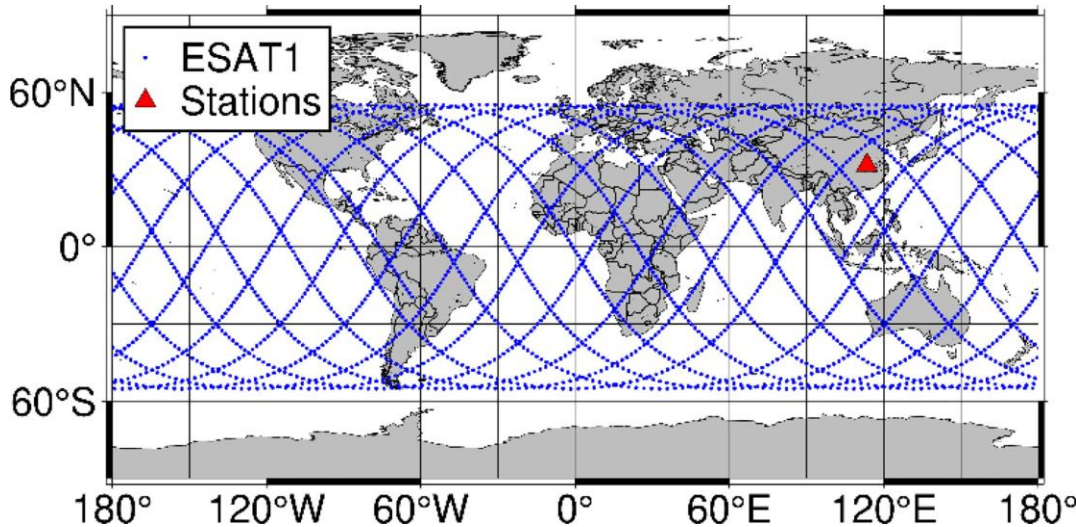
- **Commercial Xona Receiver**
(J.M. Sleewagen/Septentrio)
- **Provider: ESA Celeste**
(F.C. Grec/ESA)
- **Provider: CENTISPACE**
(W. Li/Wuhan)
- **RINEX & future formats**
(O. Montenbruck/DLR)

CENTISPACE real world dataset

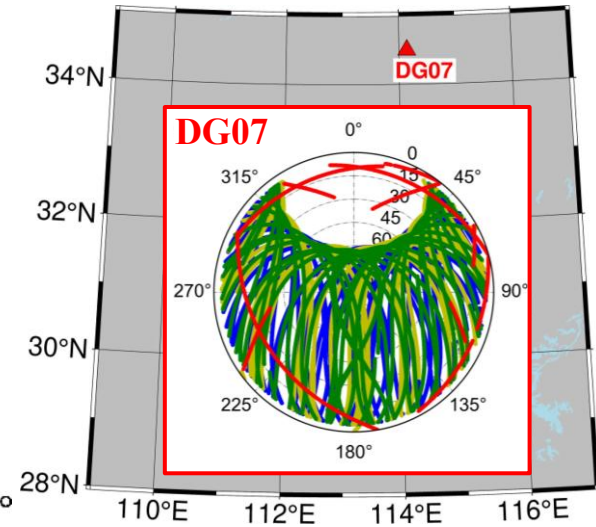
700km
~54°

ESAT1 satellite observation data

Collected by 7 stations ($\triangle$) at 2 seconds over 24 hours on January 1, 2023.



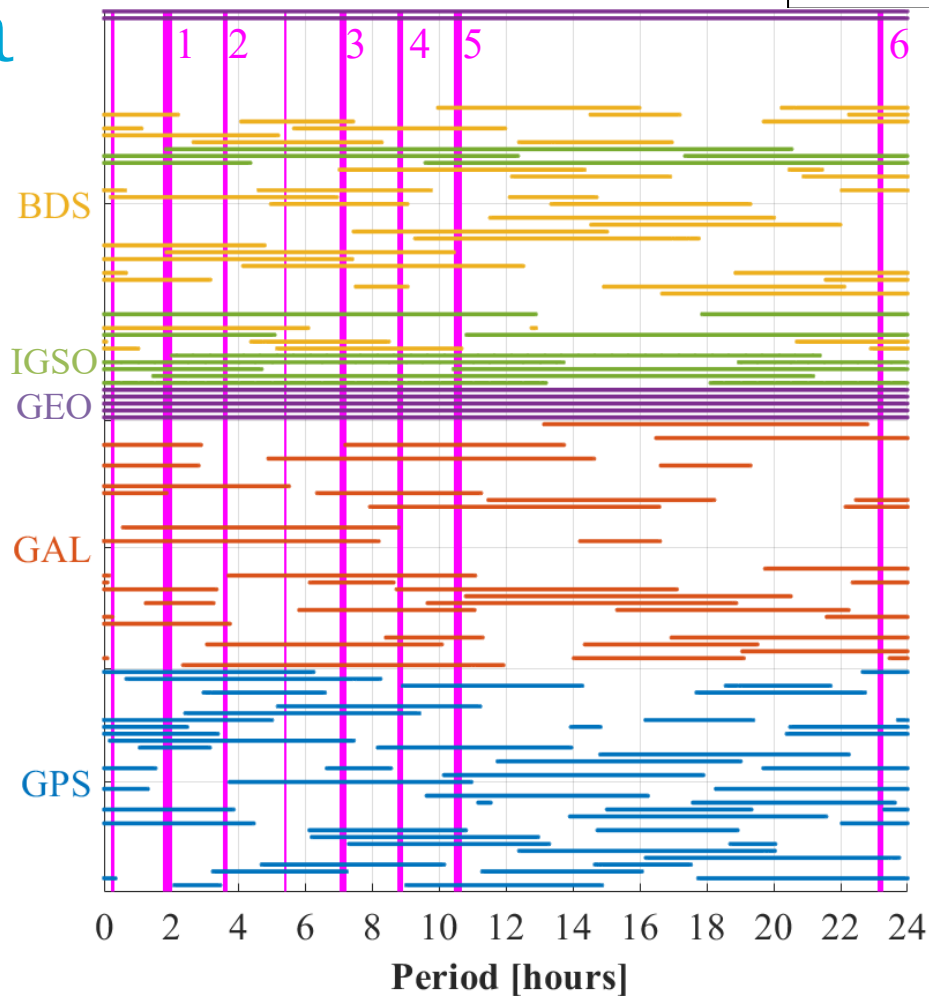
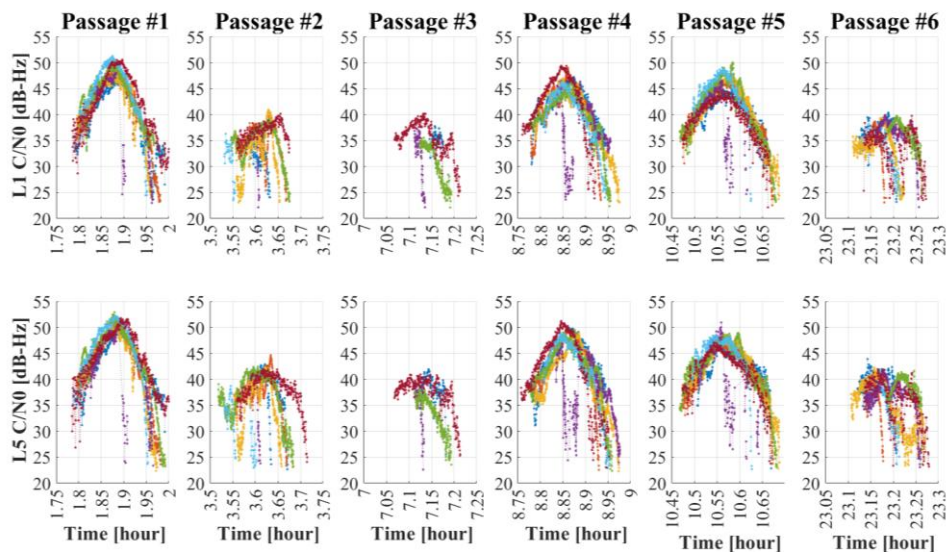
Source: Xu et al. (2024)



CENTISPACE data

ESAT1 signal strength (L1/L5)

Different passages below 15 minutes.

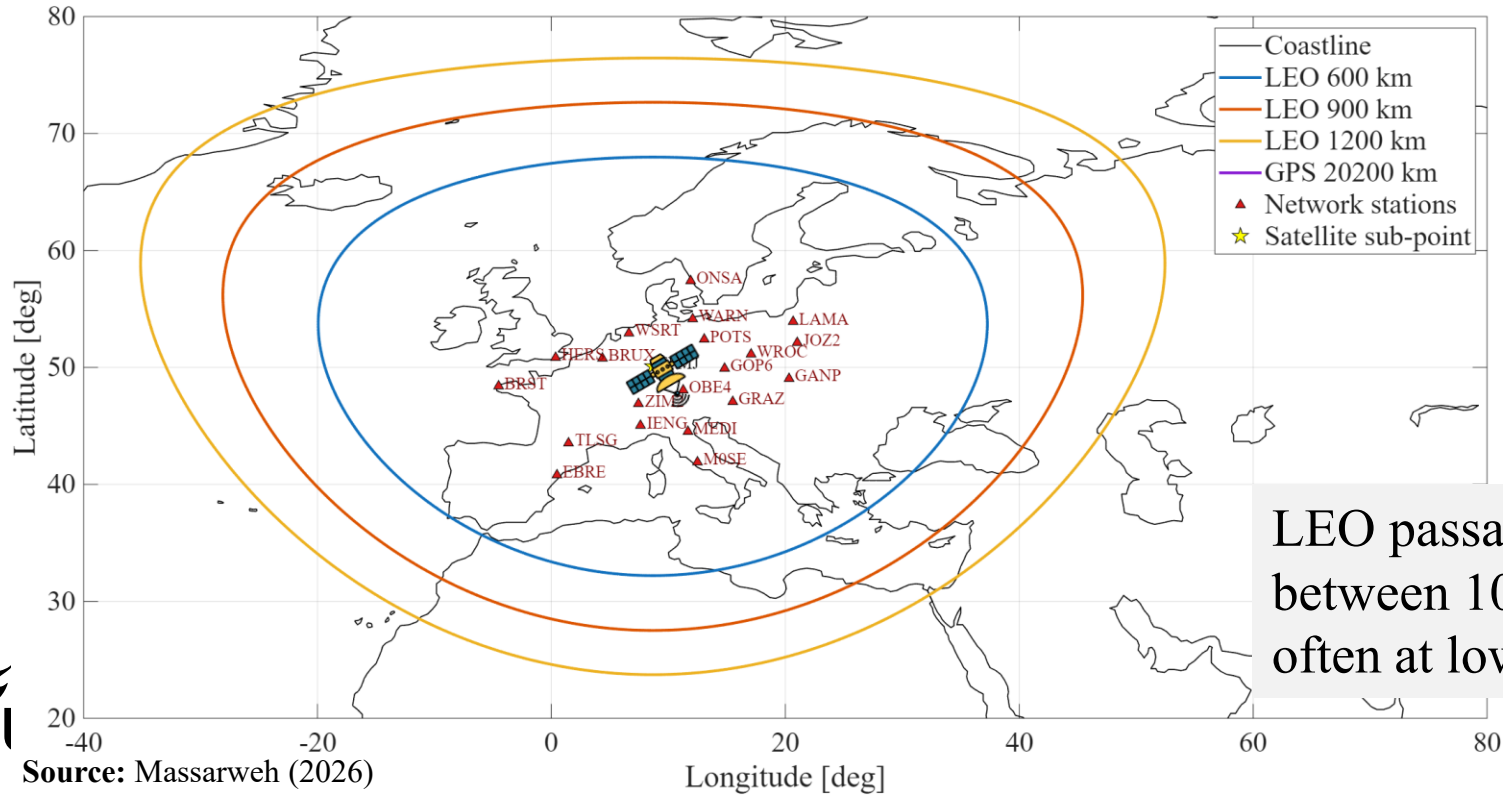


Source: Massarweh (2024)

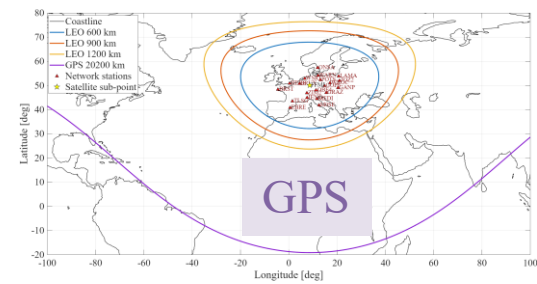
Overview of challenges & opportunities

Remarks on LEO altitude

Example: satellite visibility over Frankfurt



LEO passages generally
between 10-12 min and
often at low elevation...



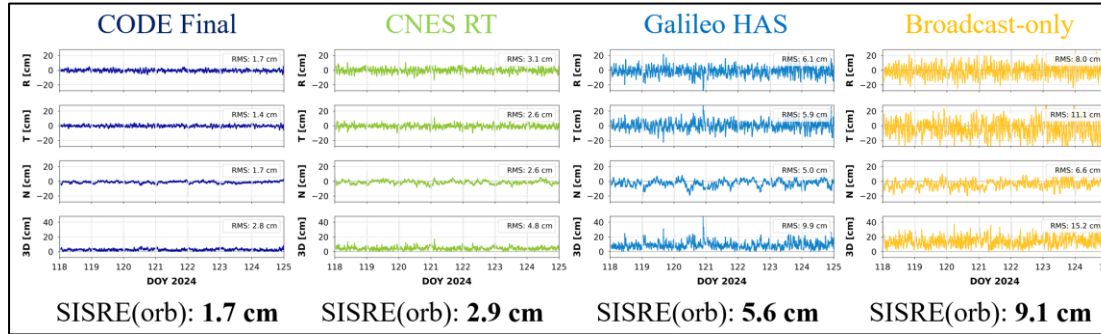
Some foreseen challenges

Limitations for 'on-board' estimation

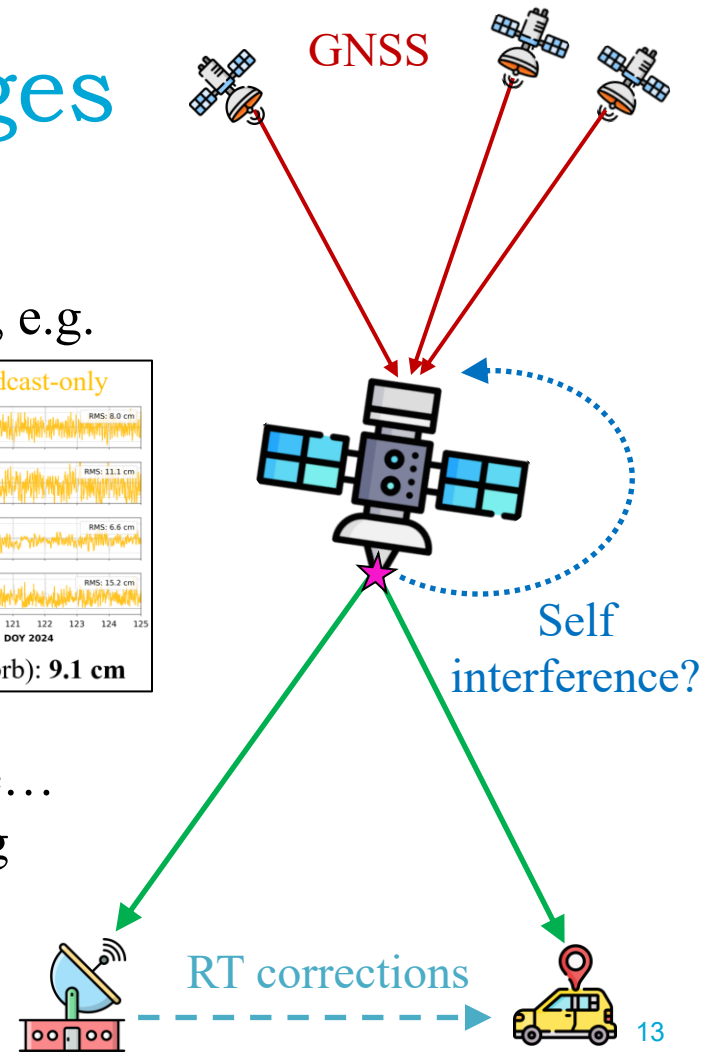
A real-time POD solution could be made available, e.g.



Oduber
(MSc 2025)



But satellite **transmitter biases** are less likely stable...
and a ground network estimation is still demanding
due to very short tracking passes (i.e., 10-12 min).



Infrastructure-related remarks

EUREF/EPN as a regional LEO-PNT testbed?

Some existing strengths are

- Well-documented (dense and stable) infrastructure across European region.
- Well-established procedure for data quality control and data dissemination.

However, this might require to

- Update existing hardware infrastructure, e.g. LEO-PNT enabled receivers.
- Increase of current storage capabilities, e.g. higher rate observations.
- Have a clear understanding of ‘worthy’ LEO-PNT providers. **But how?**

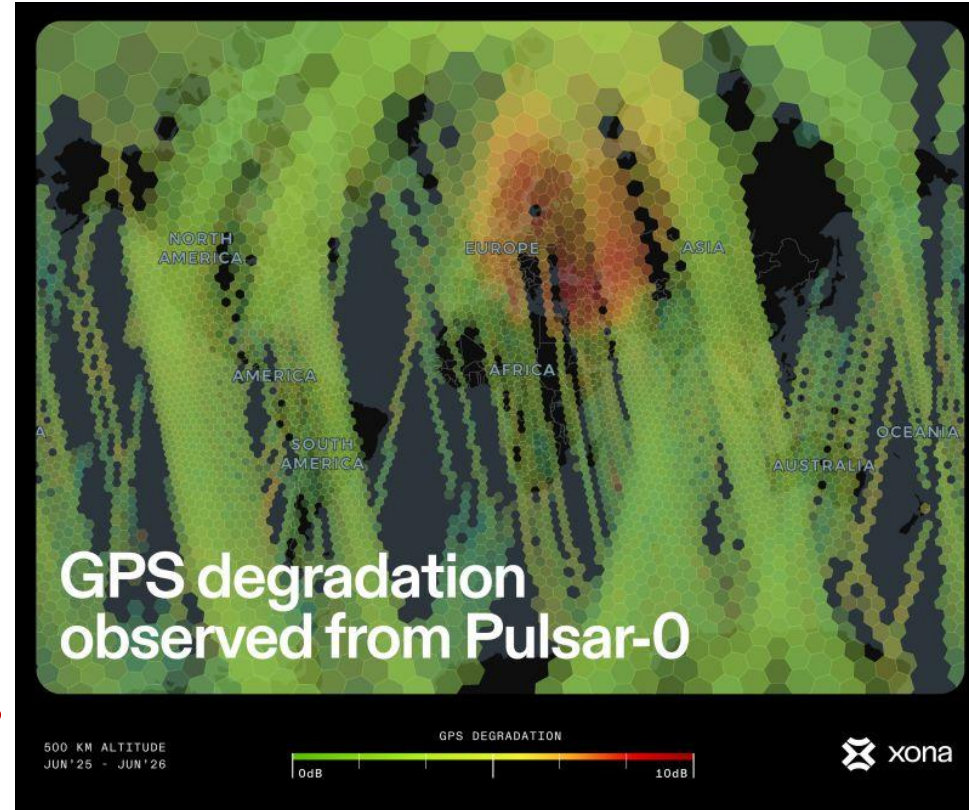
Monitoring from space capabilities

Xona example: 'Pulsar-0'

Launched in June 2025, i.e. at around 520 km altitude, equipped with an on-board GPS receiver.

A *regional* degradation was observed systematically over 1-year data. Main causes could be **jamming**, even if the effects might differ for ground users.

Hazard for GNSS-related activities?



Beyond PNT examples

Atmospheric remote sensing

A rapid change of geometry can benefit

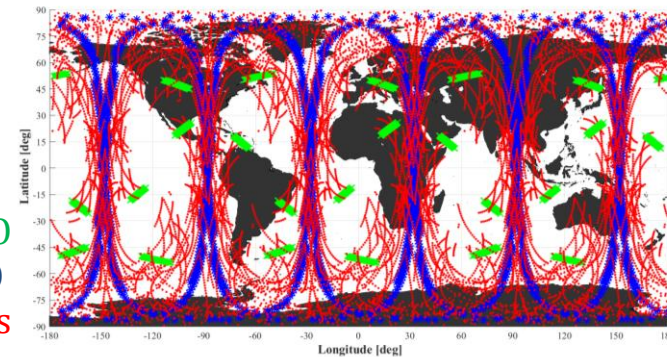
- Troposphere real-time tomography
- Ionosphere (LEO-to-GROUND)
- Plasmasphere (MEO-to-LEO)

along with

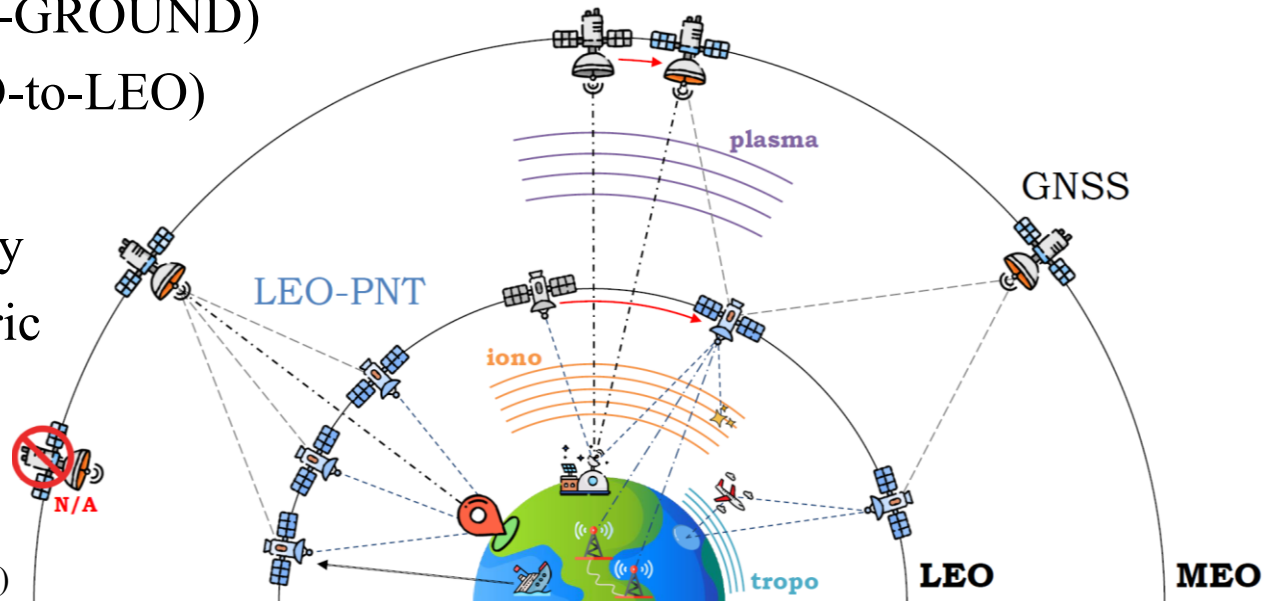
- GNSS-Reflectometry
- GNSS-Interferometric Reflectometry (IR)

• ...

× = MEO
* = LEO
• = IPPs



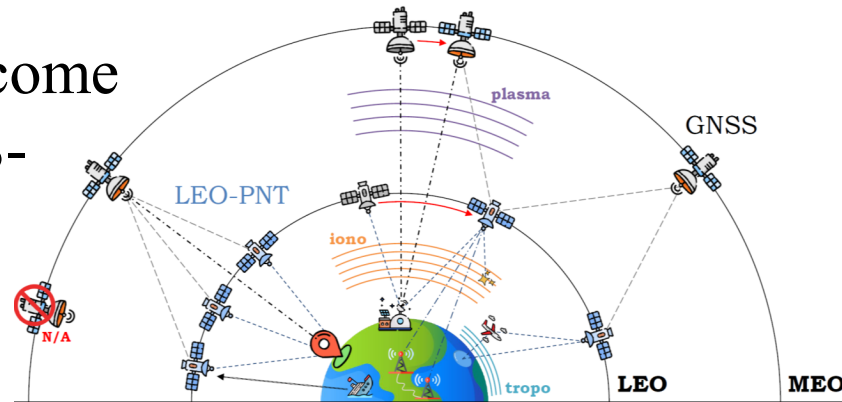
Iridium case (780 km, 86.4°) at 30s over 15 min



Conclusions

Summary

- ❑ LEO-PNT constellations will be a unique opportunity for the GNSS community. However, it is **not** free of challenges.
- ❑ This Pilot Project aims at preparing all IGS components to the potential integration of new PNT systems in low Earth orbit.
- ❑ **LEO-PNT systems** may soon become valuable layers in operational IGS- and EUREF-related activities.





Questions?

Thanks for your attention

Courtesy of ASI (Agenzia Spaziale Italiana)