FutureNAV In Orbit Demonstrator - a first step towards a European LEO-PNT component

UN / Finland Workshop on Applications of Global Navigation Satellite Systems

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→ THE EUROPEAN SPACE AGENCY

Context (1/2): Evolution towards Multi-layer PNT

GNSS: 1ˢᵗ spin-off of space applications

- Presently used in most domains of global economy and society
- 6.5 billion receivers, 150 billion euros / year (Euroconsult/EUSPA), 10% annual market growth in next decade

More demanding needs:

- Resilience.
- Accuracy.
- Reliability.
- Energy efficiency.
- Ubiquity.

New applications:

- Autonomous systems (e.g. cars, UAV, train, vessels, etc.)
- Industrial IOT (e.g. logistics, machine control, asset tracking)
- Personal LBS (e.g. emergency calls indoor)

Asset tracking

Autonomous Systems

High-Accuracy, Reliable, resilient, energy efficient, ubiquitous PNT.

Industrial IOT

Emergency call location

Connected PNT

esa

Answering user needs (*e.g.* Autonomous Vehicles, Industry 4.0, …)

Multi-layer PNT architecture!

GNSS MEO Backbone + SBAS

LEO PNT

PNT-2030
Ubiquitous, Reliable (Integrity), Resilient, dm-level / ns-level PNT

Sensor fusion / Dead-reckoning

Connectivity & 5G/6G PNT

Layer 1 – MEO/IGSO/GEO
• *Global references - anchors*

Layer 2 – LEO
• *PNT diversity nodes in space*

Layer 3 – Local/Regional components
• *E.g. PNT hotspots like 5G/6G, WLAN*

PNT hotspots

Layer 4 – Dead-reckoning

PNT-2030+: Ubiquitous, reliable (integrity), resilient, dm-level
Provided by a **System-of-Systems PNT** and advanced **Key Enablers**

LEO PNT fully complementary & boosting MEO GNSS backbone

LEO-PNT : opportunities and enablers

Opportunities

Lower Propagation Losses:

- Potentially higher received power (but limited by ITU)
- Lower EIRP requirements for given received power
- Use of higher frequency bands (higher BW)
- Enable uplink for small user terminals

Faster satellites:

- Geometry change rate (measurement diversity)
- Higher Doppler

GNSS-enabled ODTS on board:

- Simplifies onboard clocks and ground segment

Investigation on the use of new frequency bands

Augmentation of GNSS:

- ✓ Increased resilience.
- ✓ Faster convergence of high-accuracy positioning
- ✓ Enhanced PNT services in challenging environment (*e.g.,* urban, canopy, indoor,…).
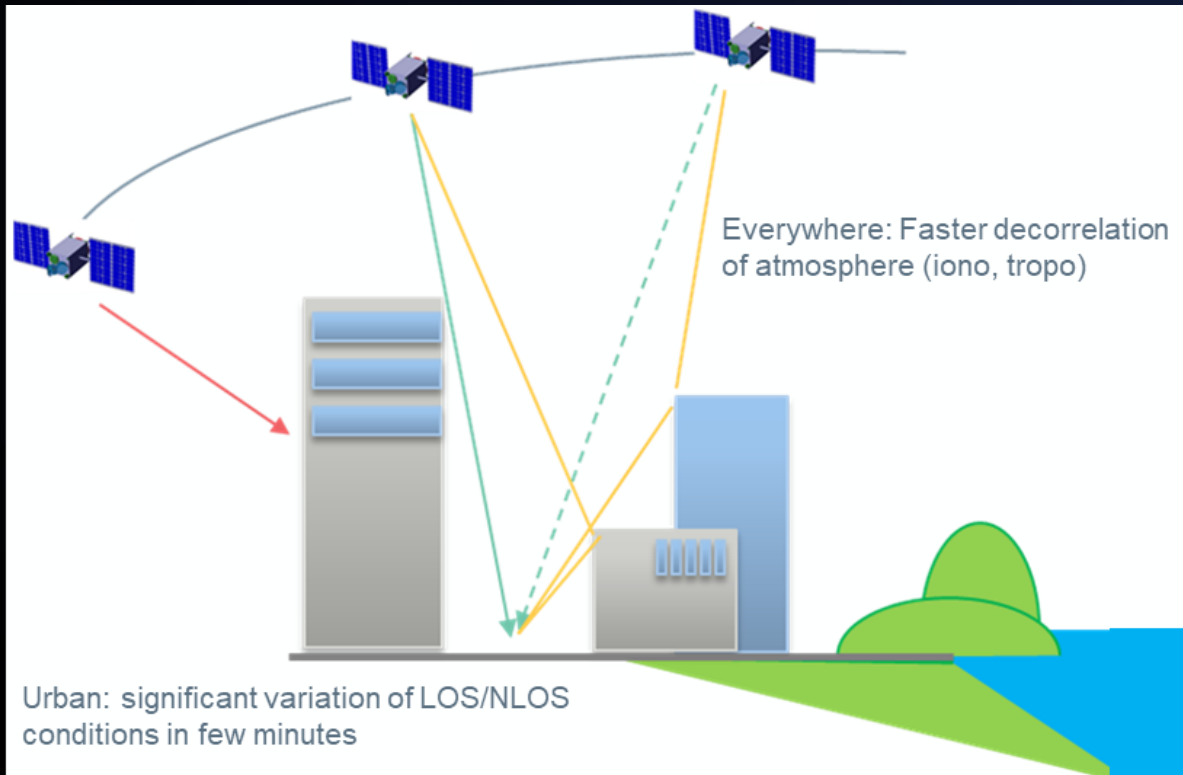- ✓ Additional PNT data channel.

Specific features:

- ✓ Connected PNT and 2-way PNT links
- ✓ Lower user terminal energy consumption
- ✓ Solutions combined with satcom standards
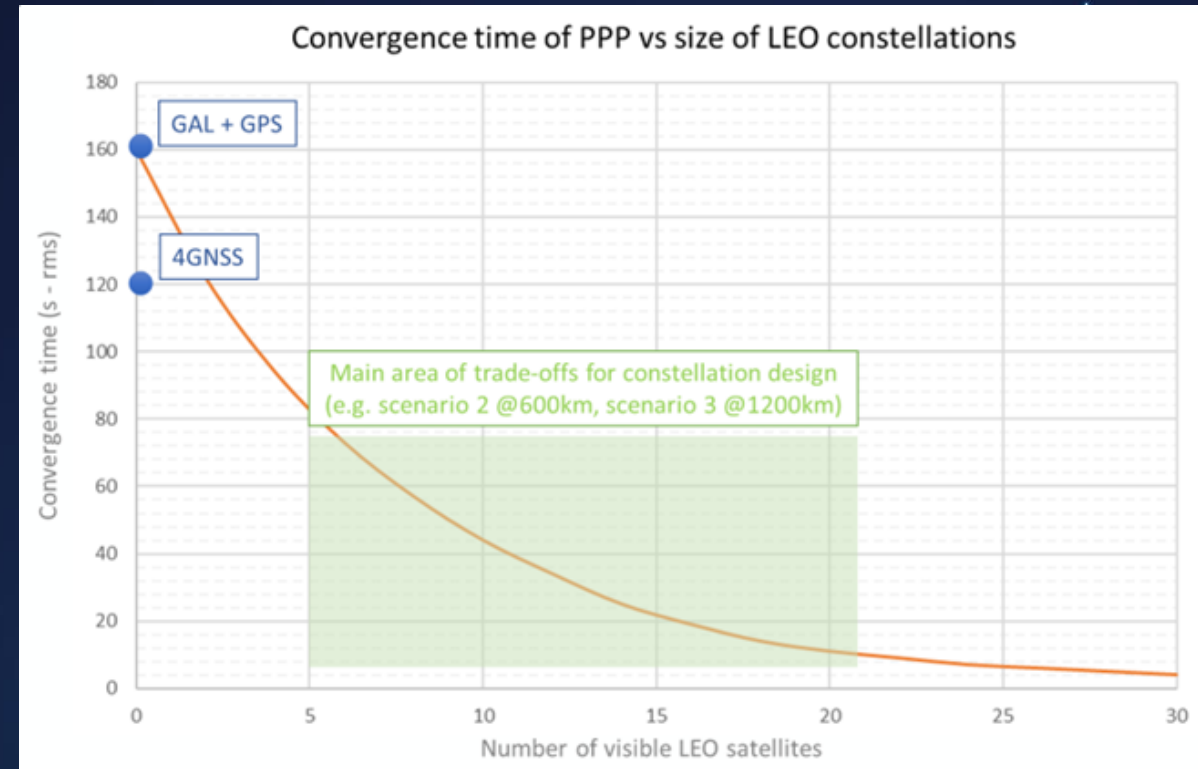- ✓ Monitoring of MEO signals.

Spatial/measurement Diversity

Enhanced spatial/measurements diversity enabled by faster SV motion

- Measurement decorrelation: reduced convergence time for PPP algorithms (GNSS + LEO)

- Doppler-based positioning (1-3 satellites): improved availability, but lower accuracy (3m–100m)

- Shorter outages in case of NLOS: improved coasting with drifting sensors (e.g. IMU, MAC or equivalent)
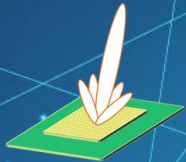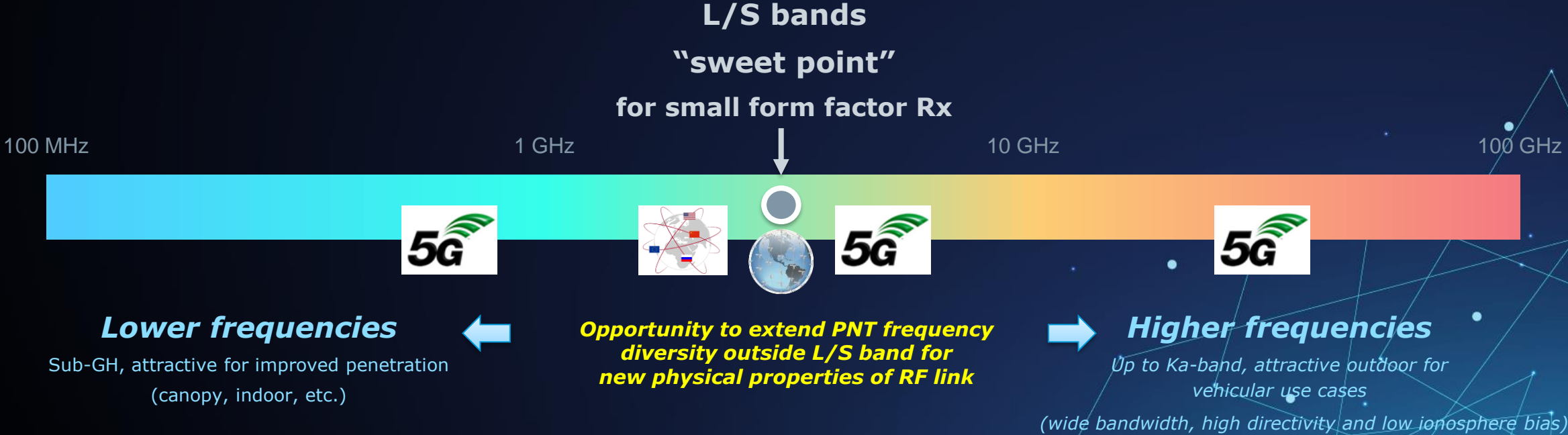
Example: Faster convergence of PPP algorithms

Everywhere: Faster decorrelation of atmosphere (iono, tropo)

Urban: significant variation of LOS/NLOS conditions in few minutes

Convergence time of PPP vs size of LEO constellations

GAL + GPS

4GNSS

Main area of trade-offs for constellation design (e.g. scenario 2 @600km, scenario 3 @1200km)

Convergence time (s - rms)
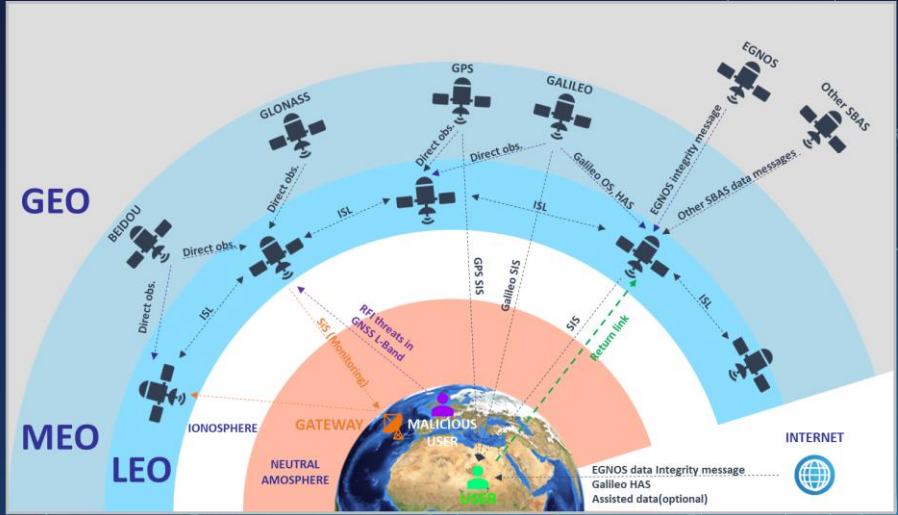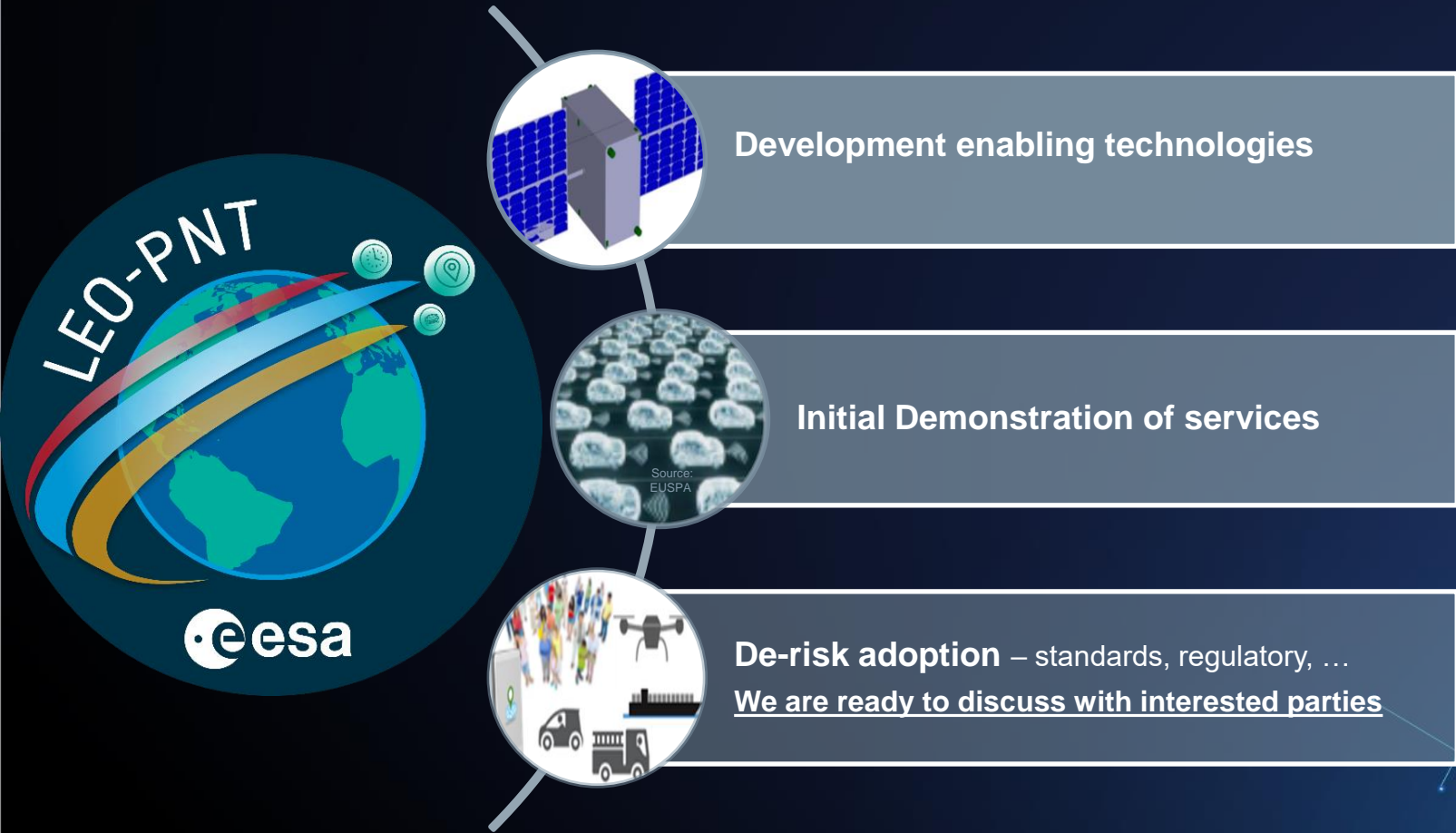
Number of visible LEO satellites

Frequency Diversity

Low Size-Weight-Power payload and low Time-To-Market facilitates the introduction of additional frequencies for improved frequency diversity
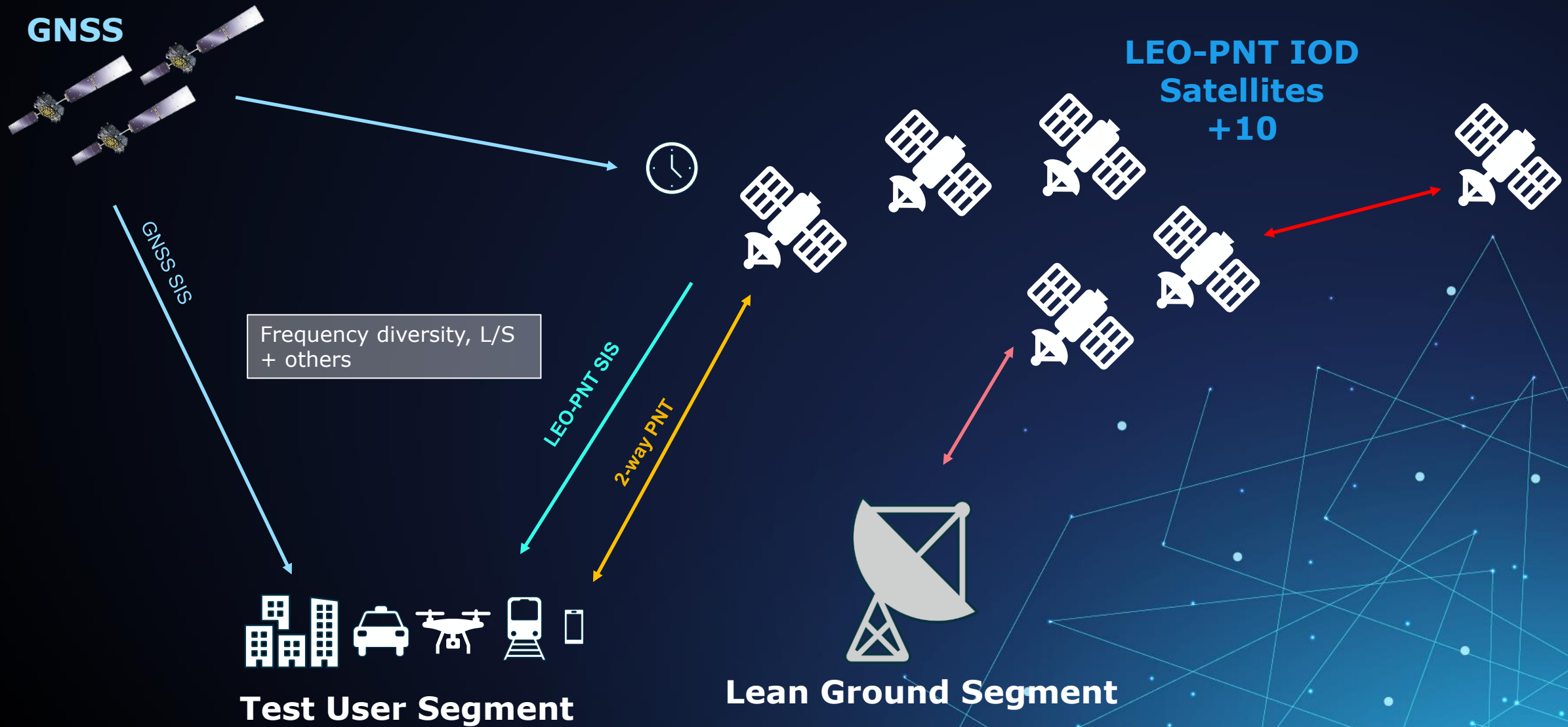
L/S bands

"sweet point"

for small form factor Rx

| 100 MHz | 1 GHz | 10 GHz | 100 GHz |

Lower frequencies

Sub-GH, attractive for improved penetration

(canopy, indoor, etc.)

Opportunity to extend PNT frequency diversity outside L/S band for new physical properties of RF link

Higher frequencies

Up to Ka-band, attractive outdoor for vehicular use cases

(wide bandwidth, high directivity and low ionosphere bias)

ESA's FutureNAV LEO-PNT IoD synthesis

Accelerate **LEO PNT** from concepts to demonstration through **Fast-Track In-Orbit Demonstration**, and **prepare the future of SatNav** by anticipating PNT market trends and more demanding needs.
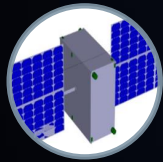

Development enabling technologies

Initial Demonstration of services

Source: EUSPA

De-risk adoption – standards, regulatory, …
We are ready to discuss with interested parties

ESA's FutureNAV LEO-PNT IoD System overview

Take away

Need to accelerate from concept to demonstration of LEO PNT

- ✓ match fast-growing market demands and lead private commercial initiatives
- ✓ prepare for future European LEO-PNT operational institutional programmes
- ✓ drive LEO PNT standardisation, new frequency filings

With fast track In-Orbit Demonstrations

Develop and demonstrate enabling technologies in-orbit

Demonstrate system and services

Source: EUSPA

De-risk uptake / adoption

Targeted features:
Fast convergence PPP, additional data channel, two way communication for IOT, in-door positioning, robustness increase, frequency diversity (UHF, L, S, Ku/Ka)

Medium/High TRL, New space dual source approach for payload / satellites

FutureNAV

LEO PNT component

Accelerate service, system and technologies of PNT in LEO

We are looking forward to collaborate with you!

If interested, contact me!

Thank you for your attention

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