LEO-PNT Demonstrator, Future System Perspectives and Possible Areas of Coordination

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Context (1/1): PNT market trends for Global Mobility

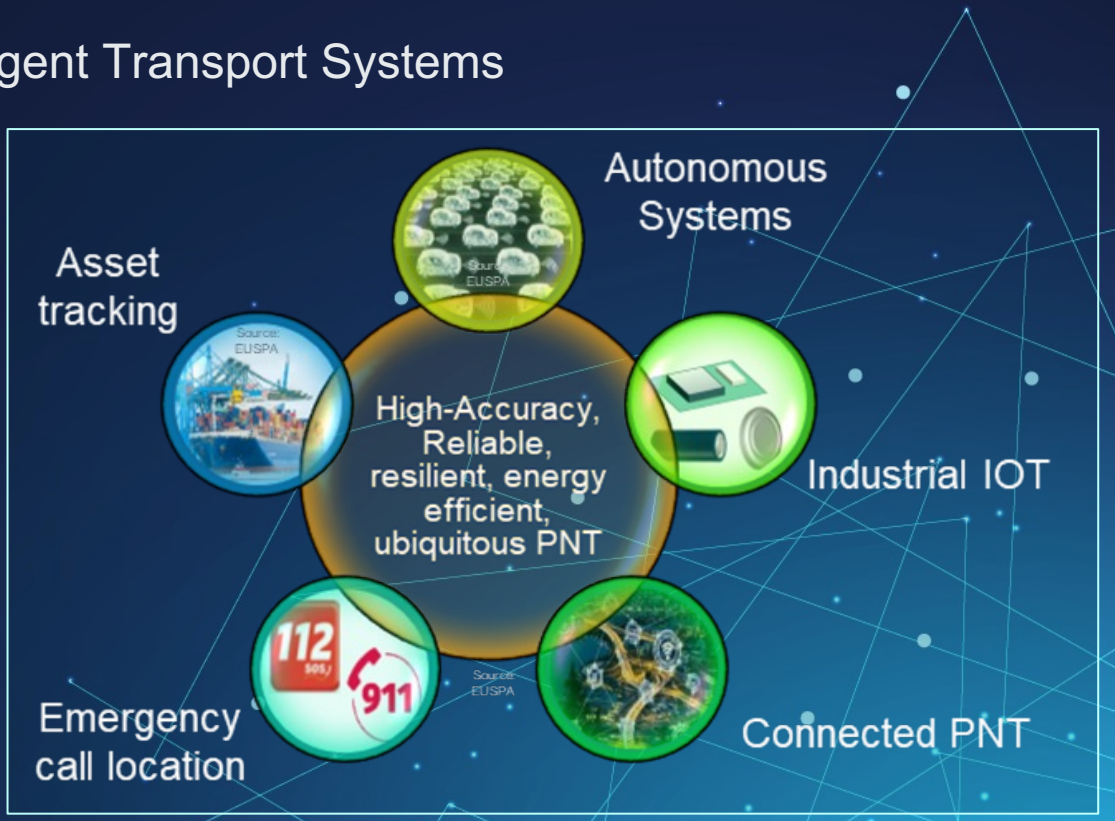
The Success of GNSS: largest spin-off of space technologies

- Present / 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

Satellite Navigation has become an essential component

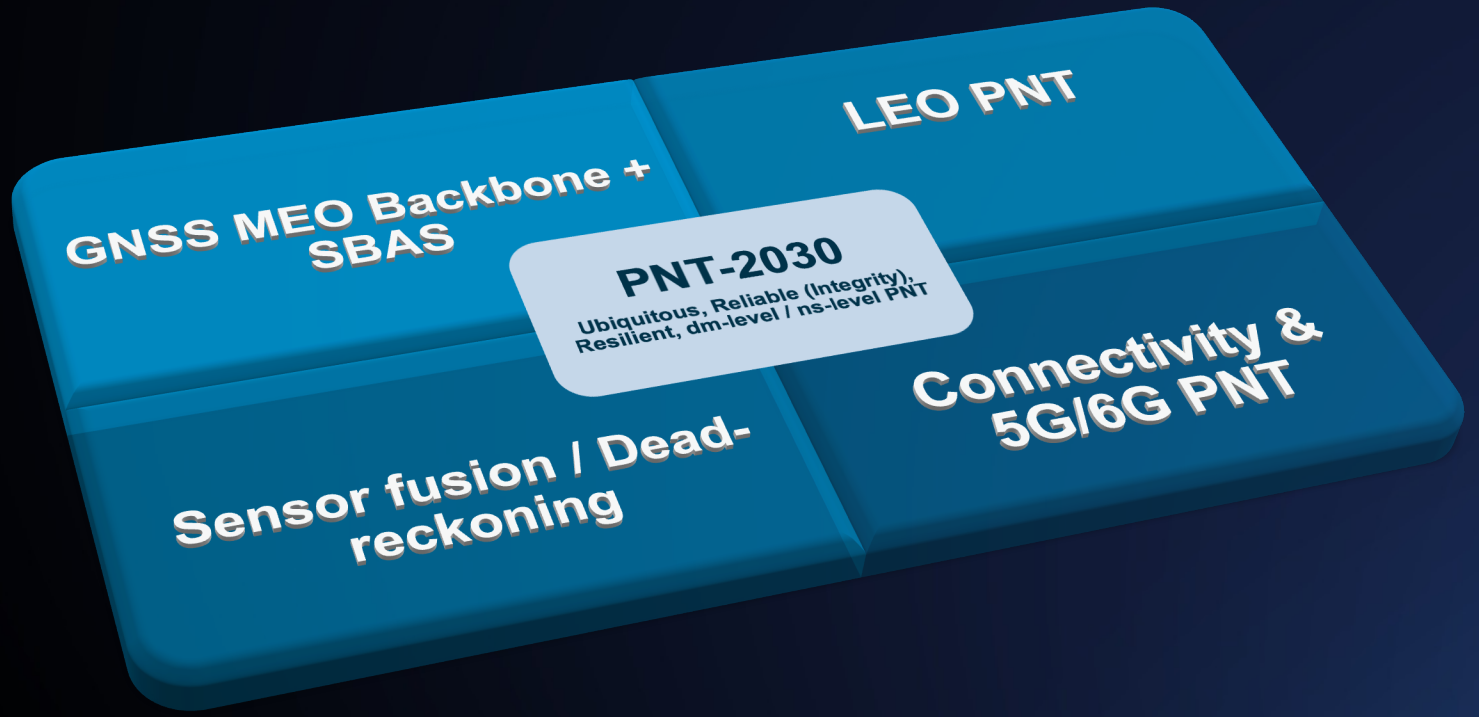
- Global Mobility, Smart cities, Autonomous Vehicles and Intelligent Transport Systems
- large public and private investments in Asia, US and Europe

GNSS huge success inspires more demanding needs



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

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



Multi-layer PNT architecture!

Layer 1 – MEO/IGSO/LEO
- *Global references - anchors*

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

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

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

Augmentation of GNSS:

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

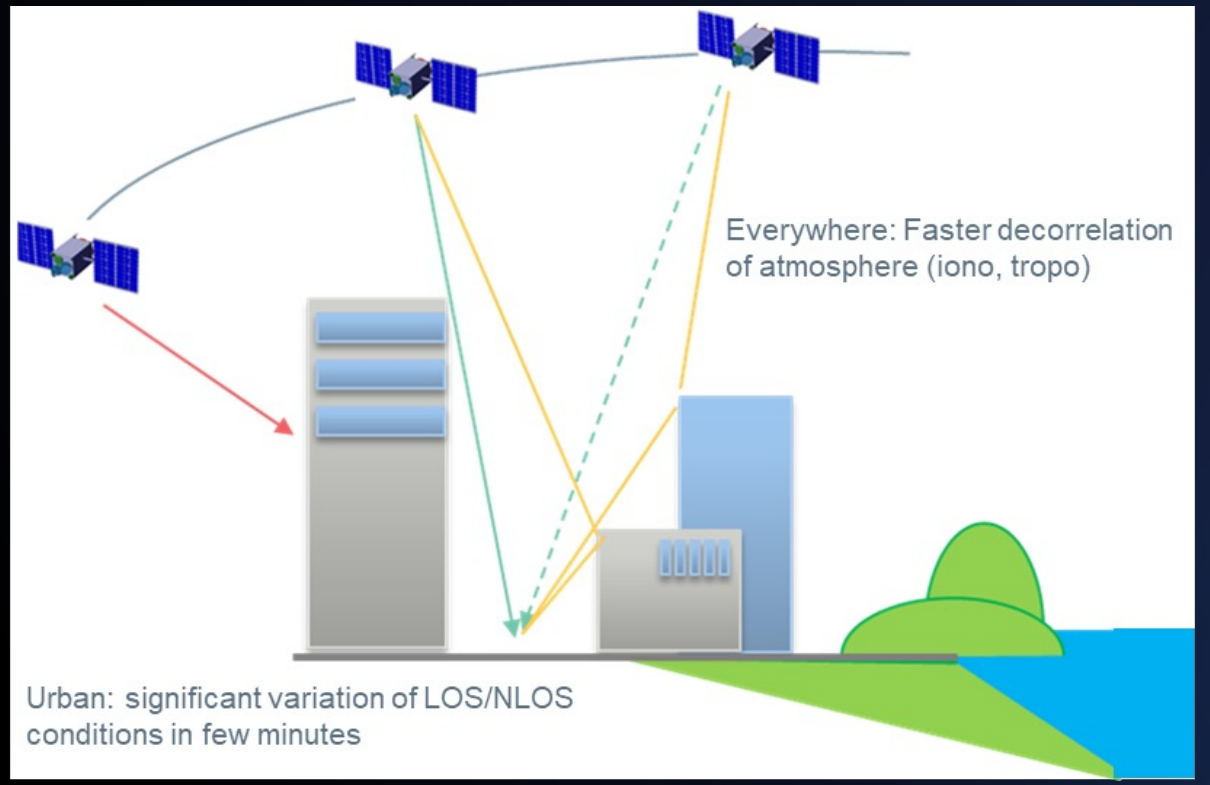
Technologically enabled by:

- **Lower free space losses**
- **GNSS-enabled ODTS**
- **Measurement diversity**
- **Frequency diversity**

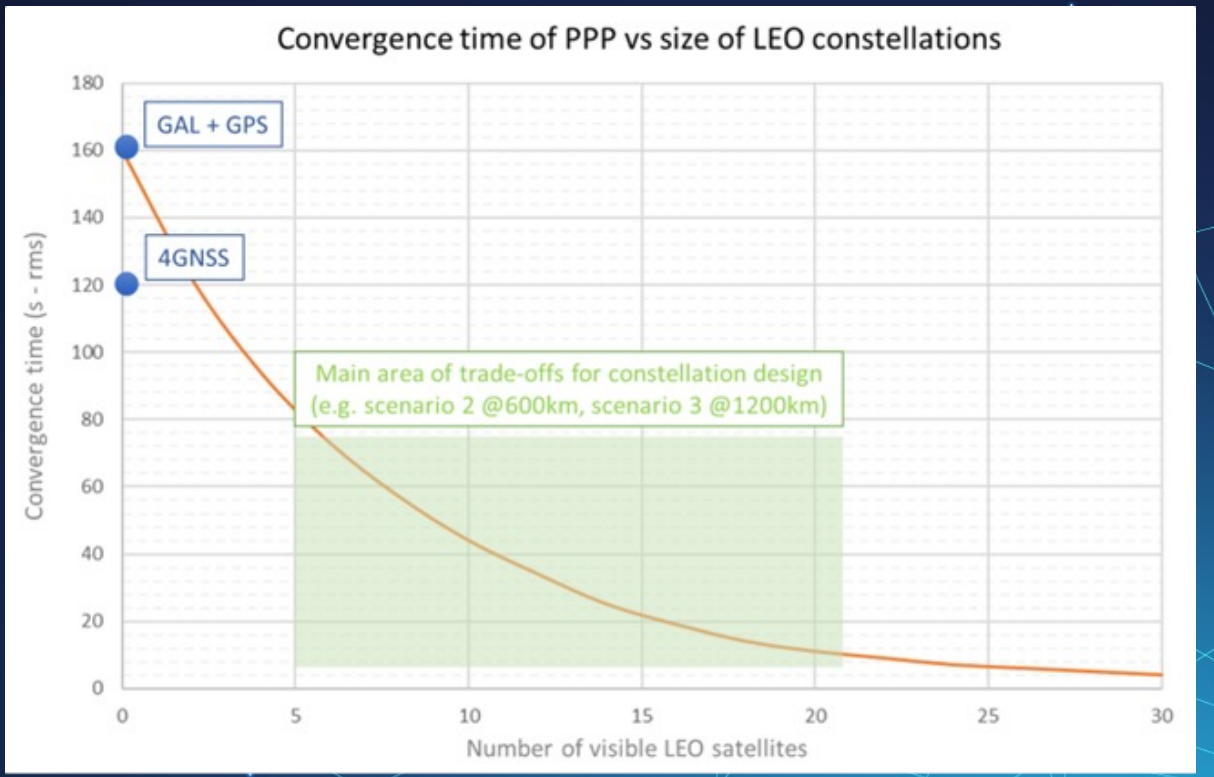
Measurement Diversity

Enhanced 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

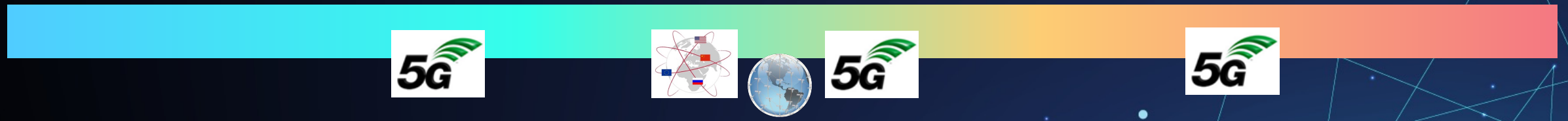


The Opportunities of Frequency Diversity

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
(GNSS, MSS, etc.)

100 MHz | 1 GHz | 10 GHz | 100 GHz



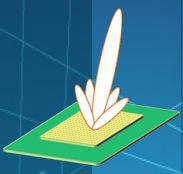
Lower frequencies
(< 1 GHz)

- ☺ Improved penetration (canopy, indoor)
- ☺ Larger wavelength (carrier ambiguity)
- ☺ Improved iono-free combination when combined to L or S
- 😐 ITU allocations

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

Higher frequencies
(> 4 GHz, up to Ka-band)

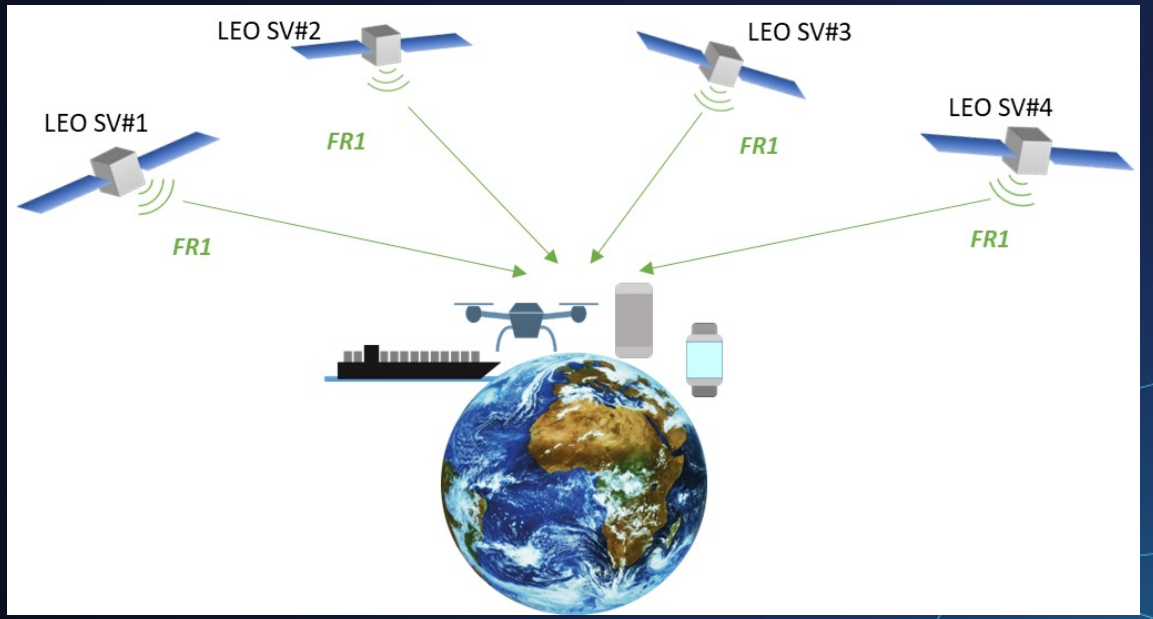
- ☺ Accuracy / Reliability
- ☺ High directivity of user antenna
- ☺ Opportunity for PNT-satcom synergies
- 😐 Form factor of UE antenna



Positioning with 5G NTN

Particularly interesting for mobile and new classes of users addressed by 3GPP

- Exploitation of Com / NAV synergies
- Devised from 3GPP SA1 "Study on Satellite Access – Phase 3" where access of devices without GNSS is being considered
- Target various use cases and waveforms, including for low complexity processing

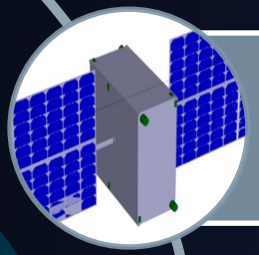


Illustrative concept: Implementation of NTN ranging signals over satellites using 3GPP radio air interface (waveform and frequency), featuring PNT-friendly geometry (e.g., GNSS-like)

FutureNAV LEO-PNT In-Orbit Demonstrator

ESA's FutureNAV LEO-PNT IoD synthesis

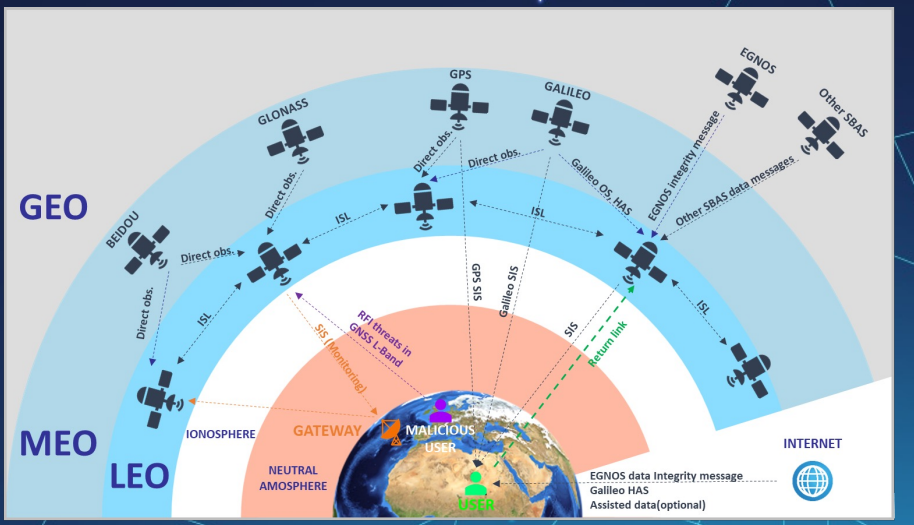
Accelerate LEO PNT from concepts to demonstration through **Fast-Track In-Orbit Demonstration**, and **prepare the future of SatNav** by anticipating PNT market trends and more demanding needs.



Develop enabling technologies

Demonstrate services

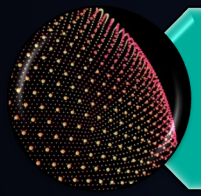
De-risk adoption – standards, regulatory, …



LEO-PNT In Orbit Demonstrator

Accelerate LEO PNT from concepts to demonstration

Prepare the future of SatNav



Constellation with more than 10 satellites by 2027

End-to-end demonstration

Pursue systems interoperability based on open standards

Possible Areas of Coordination

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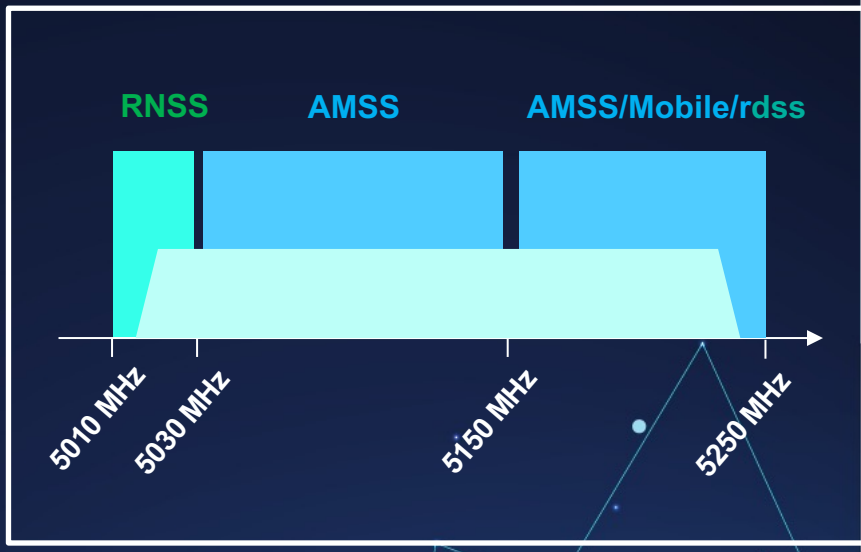
The following aspects may be subject of coordination among current and future LEO-PNT systems:

- **Spectrum aspects** (frequency coordination, protection of spectrum, usage of new bands for radionavigation)
- **Space debris mitigation**
- **Compatibility / interoperability** among LEO-PNT systems and with GNSS/SBAS
- **Adoption of standards**

Example: extension of RNSS C-band

Opportunity for additional RNSS allocation – extended C-band (5030 – 5250 MHz)

- Wideband signal with low ionosphere - improved accuracy, robustness in challenging environments, compatibility with incumbent systems
- Compatibility AMSS/Mobile Services: Transmission below the existing EPFD limits can provide enough power on ground for RNSS services



European Common Proposal

- At CEPT, ESA presented a proposal for the allocation of the bands 5030 – 5150 MHz and 5150 MHz – 5250 MHz to RNSS (Space-to-Earth) with Co-primary status

➔ Support from several European administrations obtained, item submitted to WRC-23 as **European Common Proposal for WRC-27/31**.

Interest and support from the RNSS community and other frequency administrations is fundamental, starting at WRC-23

Summary

- **Opportunities** are identified for **PNT from LEO orbit to complement / augment existing GNSS systems** in response to current, future, diverse and challenging user needs

  ➔ LEO-PNT has the potential to be a major contributor to GNSS and PNT in general

- **ESA's FutureNAV LEO-PNT In-Orbit Demonstration** established to demonstrate services and enabling technologies in preparation of future operational systems
- A number of areas have been identified for possible follow-up **coordination** including **spectrum, space debris, compatibility and interoperability, and usage of standards**

Thank you for your attention