I nuovi Programmi della Navigazione Europea e l'approccio New Space nella Qualità

Patrizia Secchi - European Space Agency (ESA)

esa

Definitions

LEO-PNT:

Positioning, Navigation and Timing in Low Earth Orbit

ITRF: International Terrestrial Reference Frame - The International Terrestrial Reference Frame (ITRF) is a set of points with their 3-dimensional cartesian coordinates which realize an ideal reference system, the International Terrestrial Reference System (ITRS). It is used for everything from land surveying to measuring sea level rise, including enhancing the precision of navigation systems.

ICRS: International Celestial Reference System

NEW SPACE:

New Space is generally interpreted to mean the increasing emergence of the private space industry, particularly companies that - when compared to 'traditional' space companies - tend to be less reliant on government support and focused on less well-established lines of business. It is most visible when new entrants to the sector take forward 'game changing' business models that can be either competitive or complimentary to existing commercial space services, for example, large constellations of small satellites or companies developing entirely commercial launch systems.

Future NAV: preparing the future of European GNSS

Program Objectives: secure strategic capabilities for independent European satellite navigation infrastructure and services, through support to the early development of advanced satellite navigation technology which has the potential to support operational and scientific missions, both private commercial as well as institutional programmes defined by the European Union

Future NAV comprises 2 components:

a) **The *LEO PNT Component***, which includes the definition, development, launch operations and experimentation of a LEO PNT In-Orbit Demonstration system

b) The ***GENESIS Component***, which includes the definition, development, launch and operations of the GENESIS Mission

FutureNAV - GENESIS

GENESIS Mission Objectives

Mission Objectives:

Improve ITRF accuracy and stability by in-orbit colocation of the four space-based geodetic techniques. Goal is to contribute to the achievement of the Geodetic Global Observing System (GGOS) objectives, in order to provide significant benefits in Earth modelling, and to support a wide range of societal applications (endorsed by the United Nation resolution A/RES/69/266).

Improve the link between the ITRF and the ICRF, thanks to the increased consistency of the Earth Orientation Parameters (EOP).

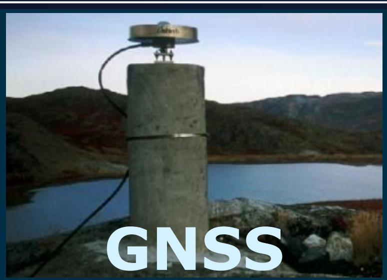
Targets

Accuracy: 1 mm

Stability: 0.1 mm per year

ITRF Elaboration

Data acquisition



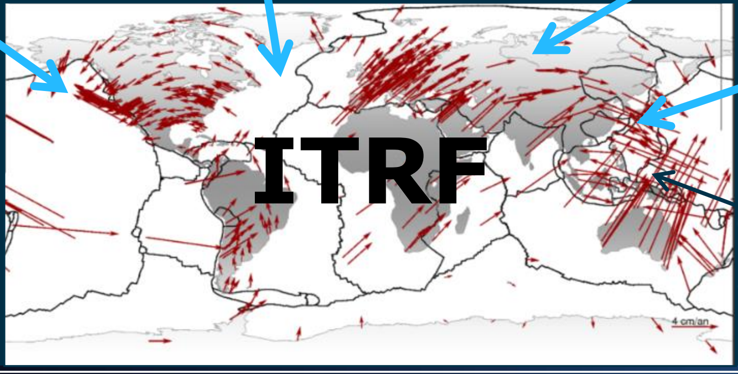
Analysis

- Session-wise VLBI solutions
- Weekly SLR solutions
- Daily GNSS solutions
- Weekly DORIS solutions

Tech. stacking

- Long-term linear VLBI solution
- Long-term linear SLR solution
- Long-term linear GNSS solution
- Long-term linear DORIS solution

Inter-technique combination



A common time reference for all on-board instruments (instrument synchronisation)

Industrial Procurement – Content

ITT for Technical Phases A/B/C/D/E

Design, Development, Qualification, Launch and Operations for 2 years

- **Satellite** Platform, Ultra-Stable Oscillator and the following instruments:
  - **VLBI** – Very Large Baseline Interferometry
  - **DORIS** – Doppler Orbitography and Radiopositioning Integrated by Satellite
  - **GNSS** – Global Navigation Satellite System
  - **SLR** – Satellite Laser Ranging
- **Ground Control Segment** for TT&C, Level 0 and Level 1 processing
- **Launcher**
- **Operations for 2 years**

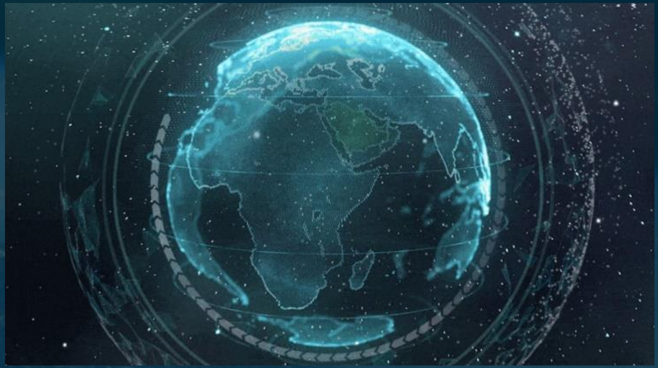
- **Option for extension of operations** for 1 year, exercisable twice

Activities outside Industrial Contract

- **Data exploitation:** Higher level data processing will be performed at **ESOC Navigation Support Facilities,** and Data archive and distribution at **ESAC** through the **GNSS Science Support Centre (GSSC)**
- **Ground campaigns** for VLBI and SLR

Industrial Procurement – Phases A/B/C/D/E

ITT open on ESA-STAR:
esa-star Publication



Launch of ITT
March 23rd 2023

ITT closing
May 31st 2023

Kick Off
Q4 2023
(indicative)

Indicative Planning	
Milestone	**Date**
PDR	2025
CDR	2026
QAR	2027
Launch	2027
Close-out Review	2029

FutureNAV LEO-PNT In Orbit Demonstrator

LEO-PNT In-Orbit Demonstration

- Until now, all navigation satellites have flown high up in medium-Earth orbit – up at 23 222 km in the case of Galileo. At such altitudes the satellites move slowly across the sky, helping ensure global availability of satellite navigation signals, albeit at relatively low power.
- ESA's LEO PNT constellation would move to a 'multilayer system of systems' approach, with medium-Earth orbit signals supplemented by those from low-Earth orbit (LEO) satellites at altitudes of less than 2000 km.
- The main objective of the LEO-PNT In-Orbit Demonstration is to mature and demonstrate in-orbit innovative LEO PNT services and technologies, as an enabler towards LEO-PNT operational programmes to be undertaken under separate commercial and/or institutional initiatives.
- Made up of approximately a dozen satellites, ESA LEO-PNT IOD will help European companies move forward at a time when worldwide commercial interest is high in LEO constellations of all kinds, especially for telecommunications and PNT.
- The satellites themselves can be stripped down compared to current navigation satellites, because they would essentially be relaying satnav signals from MEO. There will be a need for many more satellites to ensure global coverage –the lower the orbit the faster each individual satellite will pass across the sky. This fact also opens the way to a more agile 'New Space' approach to satellite construction for European firms, with smaller payloads and simplified operations from the ground.

FutureNAV: Component 1 LEO-PNT

FutureNAV Programme Declaration
The content of Component 1 LEO-PNT shall allow:

- To select the LEO PNT In orbit Demonstration project(s) to be implemented, identifying the features planned to be demonstrated by the selected project(s)
- To design and develop the satellite(s) and associated ground and test user segments
- To launch and operate the satellites
- To perform the in-orbit demonstration activities, including test user segment in the-loop
- To draw the lessons learned and conclusions, including recommendations on further actions necessary to support a transition towards an external operational system

Low Earth Orbit PNT : opportunities and enablers

Augmentation of GNSS:

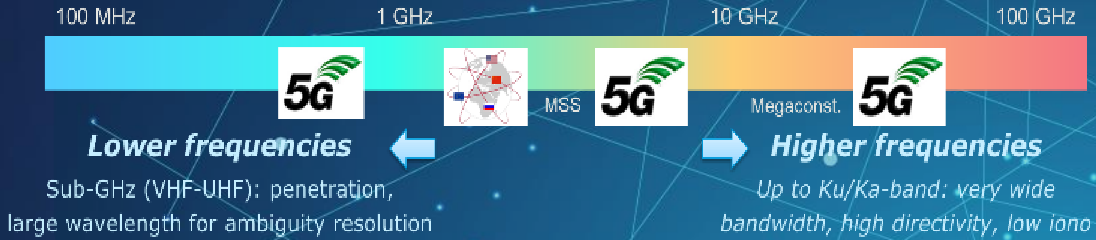
- ✓ Faster convergence of high-accuracy positioning
- ✓ Enhanced PNT services in challenging environment (*e.g.* urban canyon, under canopy, indoor, …)
- ✓ Additional PNT data channel
- ✓ Monitoring of MEO signals

Specific features:

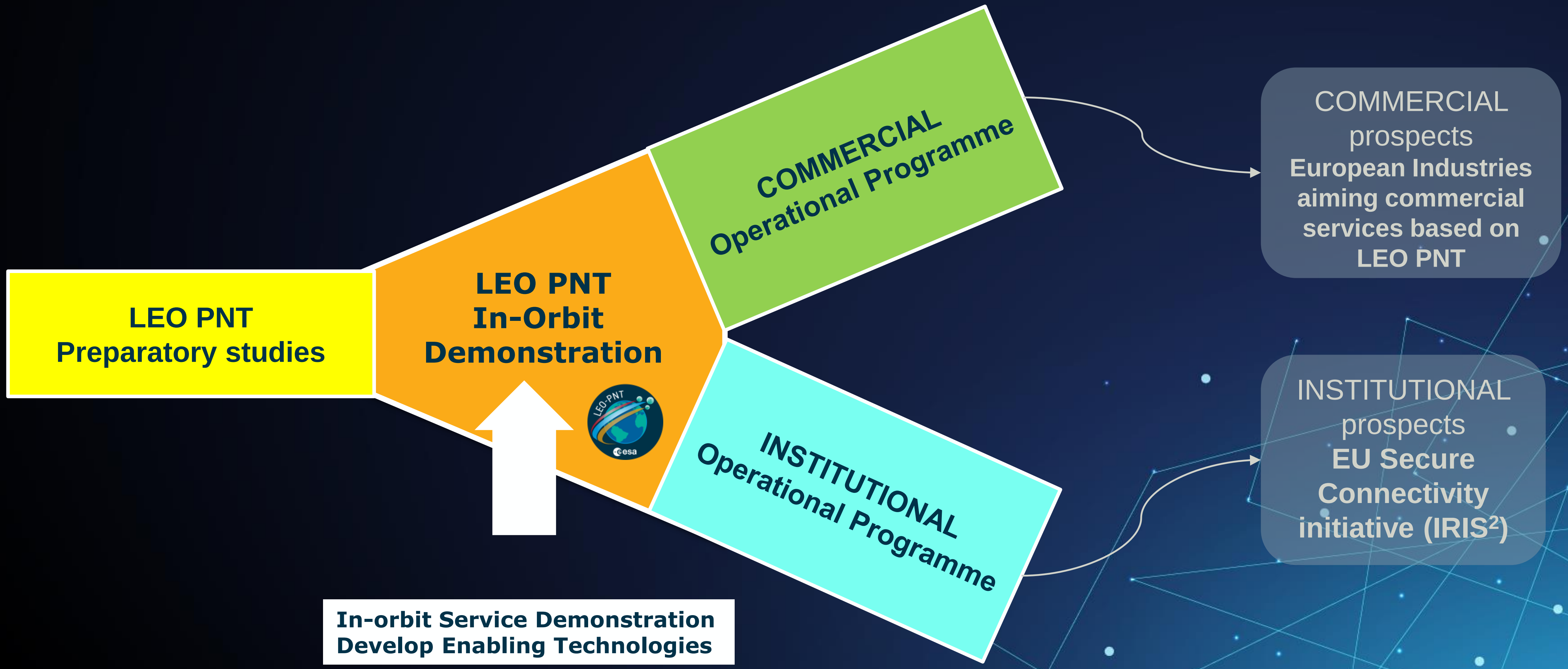
- ✓ Increased resilience of PNT solutions
- ✓ Connected PNT and 2-way PNT links
- ✓ Lower user terminal energy consumption
- ✓ Solutions combined with satcom standards

Technologically enabled by:

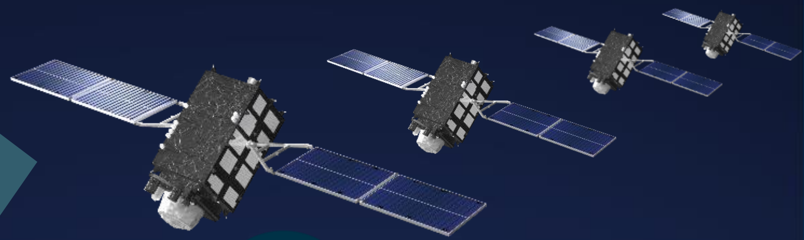
- Lower free space losses
- GNSS-enabled ODTS
- Measurement diversity
- Frequency diversity



ESA's FutureNAV LEO-PNT



Industrial Procurement Implementation



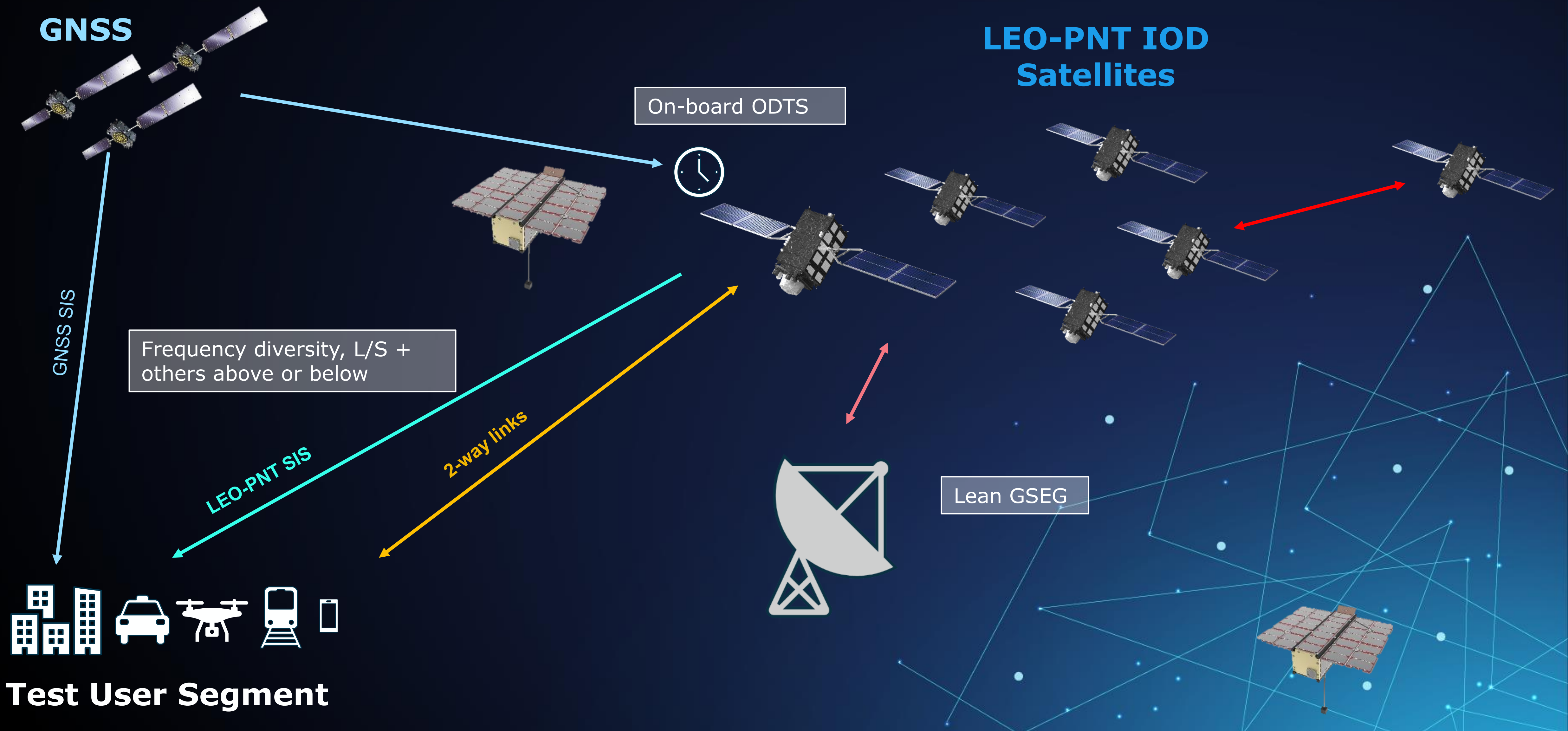
Industry Day
- 7 March 2023

Launch of ITT
- early Q2 2023

Proposal submission
- early Q3 2023

Contract Signature / KO
- Q4 2023

ESA's FutureNAV LEO-PNT IoD – System overview



ESA MISSION CLASSIFICATION: OBJECTIVES

The ESA Mission Classification provides

- ESA programme and project managers a framework to define the appropriate management, engineering and product assurance controls, tailored to the profile of the mission
- A systematic approach for optimising resources in accordance with mission objectives
- Programme and project managers a framework to develop novel implementation strategies in areas such as project management, system engineering and product assurance
- A basis for the introduction of novel elements (e.g. Commercial Off The Shelf) and working methods aiming at reducing development time and cost while balancing risk
- ESA & its Member States a new structured framework to manage the programmatic risks

ESA MISSION CLASSIFICATION TABLE

Class type	I	II	III	IV	V
Mission Criteria and Marking					
Criticality to Agency strategy (Flagship mission, Internationnal cooperation, Impact on ESA strategic goals, and image)	Extremely high Criticality	High Criticality	Medium Criticality	Low Criticality	Educational purposes
Marking					
Mission Objectives (Directorate priority and purpose, e.g in orbit demonstration, educational)	Extremely high Priority	High Priority	Medium Priority	Low Priority	Educational purposes
Marking					
Cost (Cost at Completion, Including Phase E1)	>700 M€	200 - 700M€	50 - 200M€	1- 50M€	< 1M€
Marking					
Mission Lifetime (Nominal mission life duration)	> 10 years	5-10 years	2-5 years	1-2 years	1 year
Marking					
Mission Complexity (Design interfaces unique payloads, New technology development)	High	High to Medium	Medium	Medium to Low	Low
Marking					

I. Critical strategy/safety (e.g. manned missions)

II. Performances should be met whatever it takes

III. Finding the best compromise between risk and cost to deliver the mission

IV. Mission is designed according to a hard cost limit (affordability approach)

V. Almost full delegation to industry

FutureNAV New Space approach

High Cost / Long Dev. Time (e.g. full ECSS compliance)

Class I
Critical safety issue (e.g. manned missions)

Class II
Performances to be met whatever it takes

Class III
best compromise between risk and cost

Class IV
affordability approach

Class V
Lowest Cost (e.g. educational nanosatellites)

CLASS III
Longer dev. (2026-2027)
Qualification of multiple units with small differences
Larger platforms, increased reliability and performances
Closer to operational satellites

Genesis
LEO-PNT Type 2 SVs

LEO-PNT Type 1 SVs

CLASS III-IV
Faster development (2025)
Higher risks accepted
Smaller platform (e.g.12U-16U)
Cost minimisation
More flexibility on requirements and deviation from ECSS stds

The selection of a mission class provides a general understanding of the most suitable approach to the mission.

Traditional space missions provide the highest level of reliability.

For Genesis and **LEO-PNT** the constraints linked to cost, fast development time and mission scope (scientific/demonstration) impose to optimise the various aspects of the mission against those constraints, implementing a **New Space** approach.

Optimisation of the mission wrt development time and costs	Requirements: Tailoring of Standards VS definition of dedicated ones VS reliance on contractor internal processes (excl. Safety and security)	PA, Safety, Dependability, EEE components& Materials selection, Radiation Hardness Assurance (RHA) etc.. SW PA assurance
Use of COTS and related aspects	Engineering standards Model philosophy qualification/acceptance	Management (including lean reviews, use of Agile approach), risk management

Use of Agile Mindset, Tools and Processes

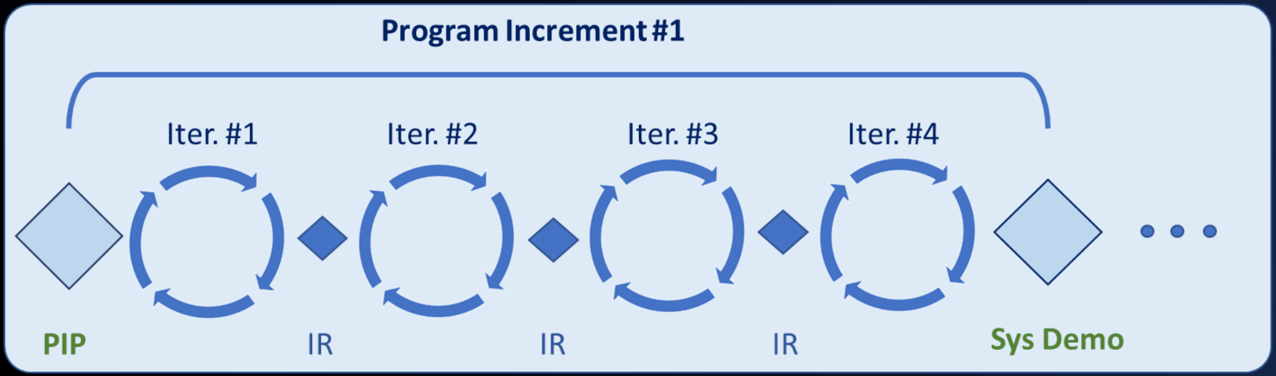
Agile development is encouraged, to **improve efficiency** and achieve a **faster development cycle.**

Inspired by Scaled Agile Framework SAFe

GUIDING PRINCIPLES

- Ensure **early and continuous delivery** of valuable work
- Welcome **changing requirements** and rapidly adapt to new constraints
- **Reduce mgt overhead** through self-organized cross-functional teams
- Focus on **working software and hardware**
- **Design** and develop iteratively with a **test-to-learn** approach
- **Involve the customer frequently** throughout the development process
- Use of **retrospective meetings** and tools for continuous improvement

WORK ORGANIZATION



DOCUMENTATION, REVIEWS AND MILESTONES

Use of **online documentation:**

- to allow timely feedback
- to optimise review cycles

Reviews focused on **System Demos:**

- Present the progress looking at the full system
- Discuss issues, risks and mitigations
- Take major decisions

ECSS milestones as technical gates within the iterative dev. cycles

Genesis & LEO-PND PA&S Requirements

- ✓ In the ESA Navigation Directorate, extensive tailoring of ECSS-Q Standards had already started with the preparation of the PA&S requirements for the Galileo 2nd generation satellites ITT – Mission Class II satellites
- ✓ Introduction of “State of Practice” concept: these ECSS requirements are related to well established and common space product assurance practices. No justification required in the Compliance Matrix for any requirement listed as “State of Practice”
- ✓ Genesis and LEO-PNT PA&S requirements are based on the Mission Class III ECSS-Q Standards tailoring, supplemented by the G2 Satellites tailoring.
- ✓ Goal to only have applicable PA requirements which are effectively needed:
- ✓ For LEO-PNT SV1 (lauch date 2025, class 3-4) the bidders may propose additional tailoring to the applicable PA&S requirements.

Why is Quality important?

- ✓ Quality is key to consistently produce space missions that are to the satisfaction of the stakeholders. Its importance increases as the complexity, cost and risk of space projects increase.
- ✓ The effects of a problem in a satellite, launcher or ground support equipment can be devastating in terms of cost, time, public or private property and even human life. It is here where quality contributes critically to the success of the mission.
- ✓ In the end, a chain always breaks at its weakest link; a single nut or bolt, a manufacturing step forgotten, a material of inferior strength can render a satellite useless in orbit or cause a catastrophic explosion of a launcher. Quality is there to ensure that each key method, process, part and material is adequate. Quality is there to ensure that changes along the way do not compromise the results. Quality is there to provide evidence that things have actually been performed in compliance with the applicable requirements.

CONCLUSIONS

- ✓ ESA is launching new projects for which a “new space” approach is envisaged.
- ✓ The new ESA mission classification concept is an important tool to define the appropriate management, engineering and product assurance controls, tailored to the profile of the mission
- ✓ The exercise to tailor the ECSS Q-standards based on the mission profile is very important and will help industry to focus on the essential requirements.
- ✓ The tailoring of the other ECSS series of standards (M and E) is ongoing and will help to further optimize the requiremens flowed to industry for specific missions.
- ✓ … but failure is still not an option!

https://youtu.be/bm3ILLwhGSQ

Thank you for your attention