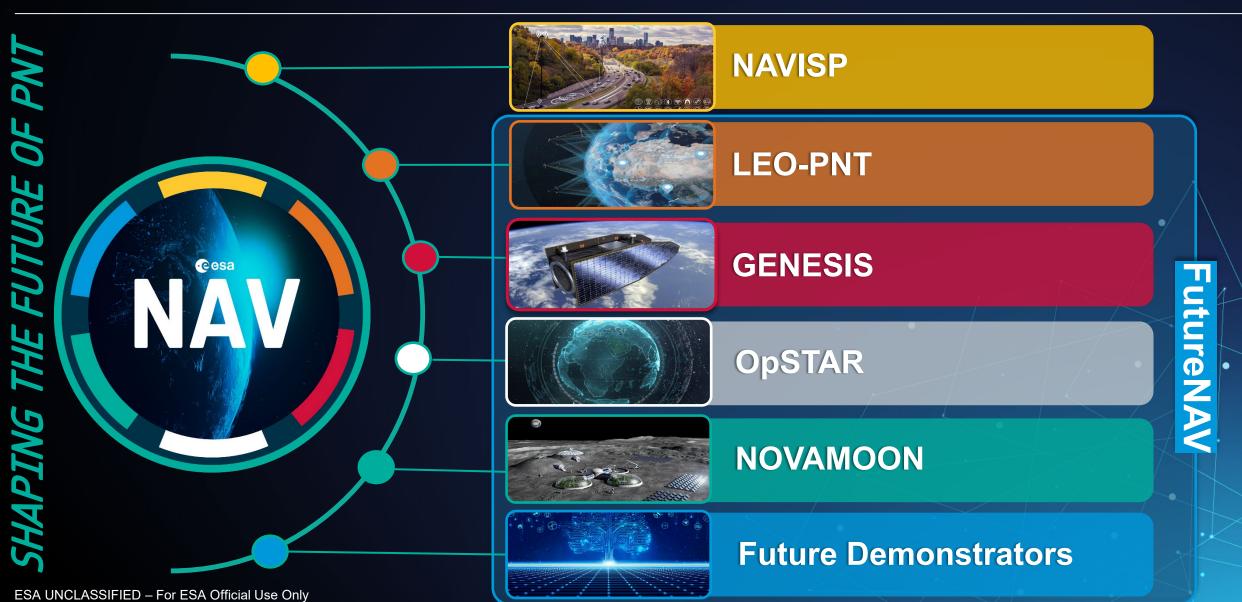


### **NAV CM25 Portfolio**





→ THE EUROPEAN SPACE AGENCY

#### What ESA-NAV offers next



# Robust next gen applications & services

Support the development of next-gen applications and technologies by leveraging Belgium's robust industrial base, such as through the development of resilient GNSS receivers



### Reinforce Sat-NAV Market leadership

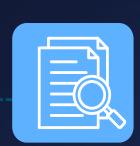
Strengthening national autonomy and technological capability in PNT satellite and payload design



#### Muli-Layer PNT

ESA offers strategic opportunities in a multi-layer PNT architecture. These technologies will be leveraged to enhance resilience and maximize opportunities for society & industrial players





#### **Advance PNT R&D**

Capitalise on strong ecosystem of universities, research institutes, and private sector innovation through enhanced collaboration between key stakeholders to drive added value and impact



# Critical Infrastructure Resilience

Advancing Technological Development, Reducing Strategic Dependencies, and Enhancing European Autonomy

### **Financial Scope**



			CM25	<b>CM28</b>	CaC
NAVISP	NAVISP Phase 4		110	tbc	n/a
FutureNAV	Component 1: LEO-PNT	In-Orbit Preparatory Phase (IOPP)	400	150 <sup>(*)</sup>	550
	Component 2: Genesis	Deployment & Exploitation	40	-	n/a
	Component 3: PNT Demonstrators	OpSTAR	130	200	330
		NovaMoon	25	45	70
		Phase 0/A/B1 of future Demonstrators	35	35	n/a

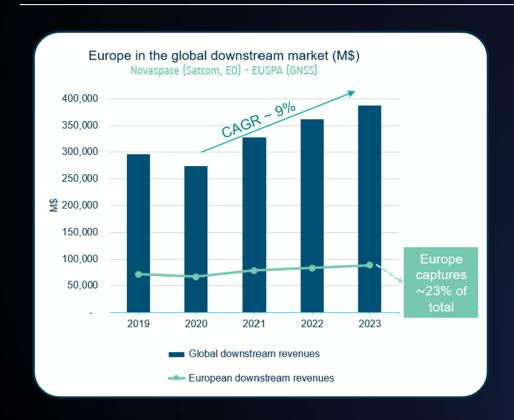
(\*) EC MFF or ESA (see FutureNAV Programme Proposal)



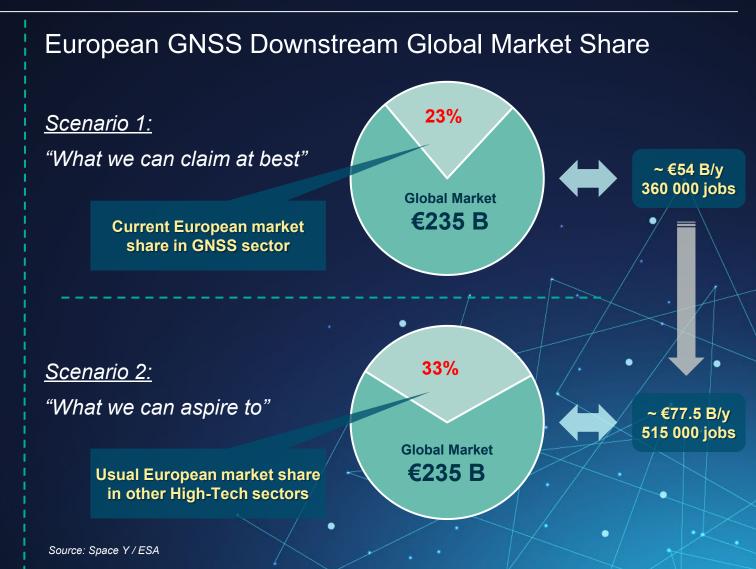


### The European Context





- Global downstream market ~\$400 B (€361.5 B), 65 %
   for GNSS (2023)
- > 90 % is commercial and accessible to European industry
- Europe losing market share in PNT (EUSPA / EIB)



### Why work with nauisp?



#### PNT focus

- Covering the whole PNT, not just GNSS
- PNT is a growing opportunity for European Industry
- Significant risks to tackle: productization, strong competition from other regions, upcoming national policies.

#### Supporting industry

- Sharing and mitigating risk across the R&D product cycle technology, market, regulation
- IP developed by industry, for industry
- ESA brand, a door opening

#### ESA support and expertise in PNT

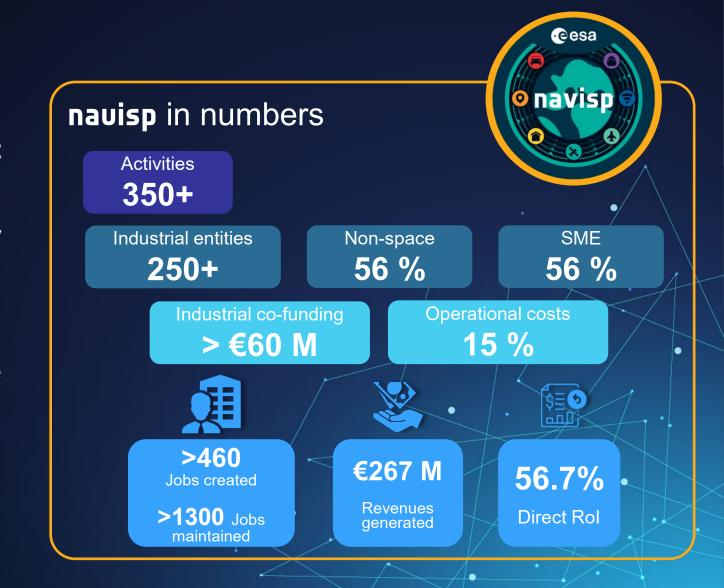
- Dedicated ESA staff support
- International industrial & institutional network
- nauisp phase 4 will be more agile and responsive to industry needs



### NAVISP: Facts & Figures



- Increased Member State Support targeted for CM25
- Proven Economic Impact: Study by London Economics (2024): €1M invested in NAVISP results in €1.8M in GDP
- NAVISP Industry Days 2025 have achieved record registration of > 300





#### **LEO-PNT** main benefits



- Increased robustness (new orbits, frequencies and services)
- Industry competitiveness at European and International level.
- Synergies with existing EU programmes and European smart factory developments.
- Industrialisation to reduce cost and ensure time-to-market via fast-track developments.

**LEO-PNT In-Orbit Preparatory Programme IOPP** 

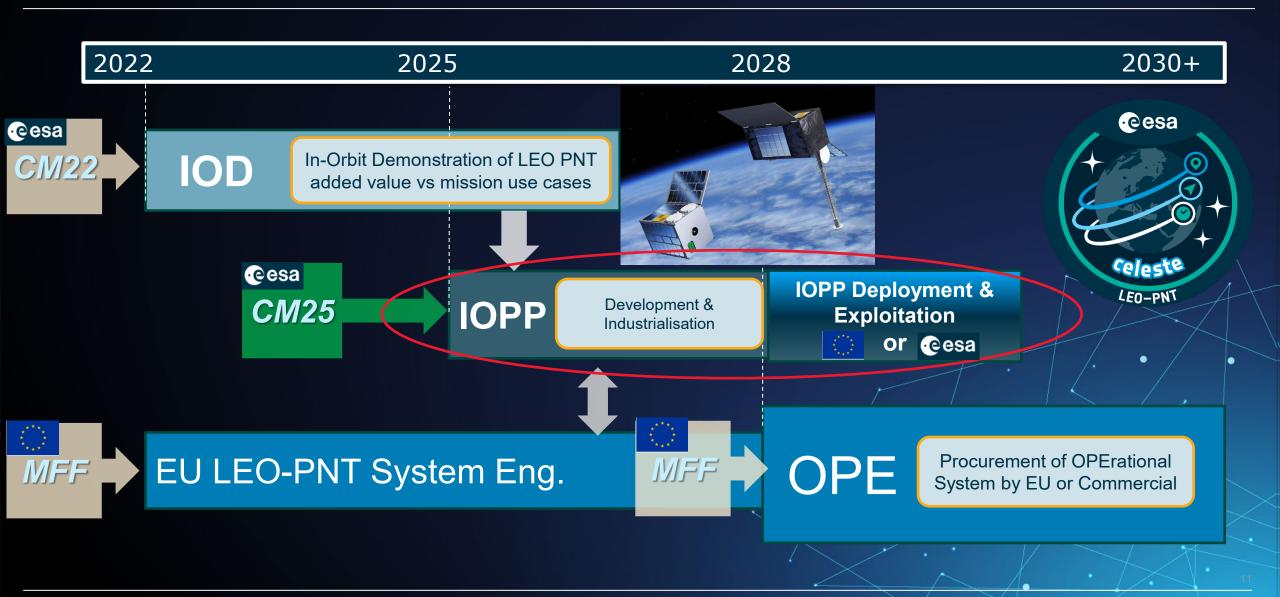
... from prototyping / demonstration to industrialisation / in-orbit validation



# LEO PNT In-Orbit Preparatory Phase (IOPP) and future EU LEO-PNT



→ THE EUROPEAN SPACE AGENCY



### **LEO-PNT IOPP System Architecture**



Preparatory programme towards an operational LEO-PNT (in Next MFF or in a Commercial setup) with the following objectives:



Novel **signal design** + additional **frequency bands** for resilience



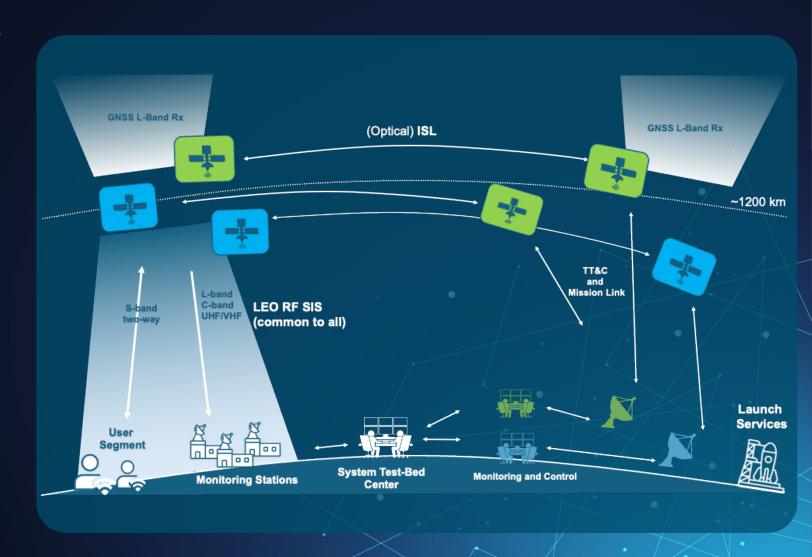
Miniaturised integrated Payload Modules for low SWaP-C and User Chipsets



Industrialisation of Building Blocks (existing sat. platform for low target unit price)



Boost innovation and European leadership for future market opportunities



### **ESA's GENESIS**

Mission Objective is to contribute to improve ITRF accuracy and stability, with an aimed accuracy of 1 mm and a stability of 0.1 mm/year.

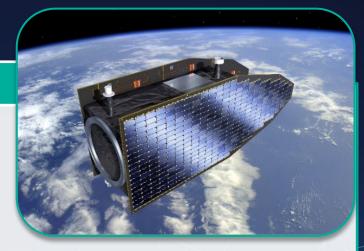


At the foundation of navigation



#### **Gensis in short**

- Prime OHB Italia S.p.A.
- ~400 kg Satellite
- Orbit
- ~ 6000 Km Altitude.
- ~ 95 deg inclination
- Very Precise on-Board Metrology
- PDR planned in 2025
- Launch in 2028



#### Mission scope

- Design, development, qualification and calibration of the satellite (incl payloads) and ground segment
- Launch and early operations including commissioning and in-orbit calibration
- Operations (2 years, option for extension)
- Data exploitation (Including processing, archiving and data distribution from ESA facilities)

### Genesis Deployment & Exploitation – Phasing





### **Component 3: PNT Demonstrators**





#### **PNT Demonstrators**

**Optical Demonstrator (OpSTAR)** 

**Lunar Reference Stations Demonstrator (NOVAMOON)** 



#### **Phase 0/A/B1 of Future Demonstrators**

First Workplan

- Quantum-Enabled Demonstrator
- Al and Payload Digital Technologies Demonstrator







#### **Enhancing Resilience**

of PNT-dependent critical infrastructure



## Secure PNT Infrastructure

against emerging threats



## Safeguarding against interference .

of intentional and unintentional nature

Increased Autonomy.

in orbit and on ground



#### Optical Synchronized Time and Ranging (OpSTAR) In Orbit Demonstrator





User

- ✓ **Improved PNT performance** (sub-cm position accuracy, ps time accuracy)
- ✓ New (optical) PNT services and users



Resilient & certified timing



Robust governmental timing and ranging



System

- ✓ Increased **Resilience us.** 
  - on-board atomic clocks performance
  - Interference/jamming of mission links
  - ground dependency (i.e. on-board autonomy)
- ✓ Secure and accurate time and frequency dissemination using innovative PNT-tailored quantum-optical concepts

Optical PNT Standard for Timing & Ranging:

Made in Europe

Worldwide







Optical PNT: GNSS Game changer Redefining PNT Architecture Towards Multilayer





LEO



MEO/GEO

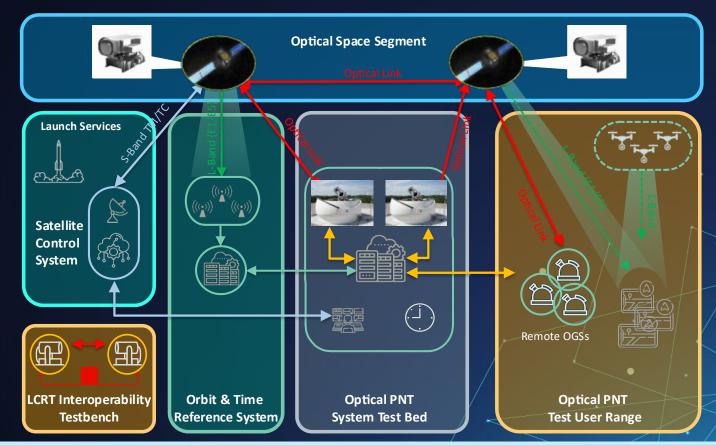


### **OpSTAR Demonstrator**



#### Optical Synchronised Time And Ranging (OpSTAR) In-Orbit Demonstrator (IOD)





Optical PNT: A new concept for optical time synchronization and ranging for PNT ESA leading the future Standard of optical technology for timing and ranging

ESA UNCLASSIFIED - For ESA Official Use Only

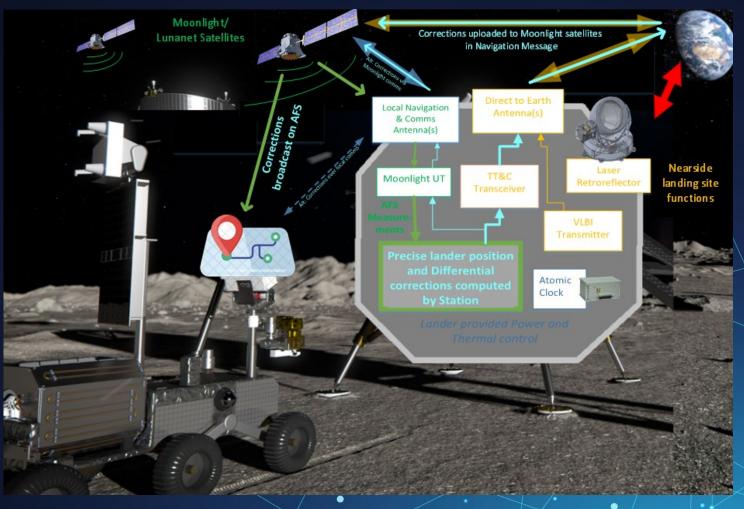
#### NOVAMOON FutureNAV Mission Lunar differential and Selenodetic station



- 1. Reference local differential station (augmenting Moonlight to submeter accuracy!) on Lunar South Pole
- 2. Reference International "geodetic" Lunar station on the lunar surface (~cm level surveyed)
- 3. Reference "Lunar Time International" Laboratory establishing the basis for the set-up of a lunar reference time

## Cooperation between ESA NAV and HRE Directorate:

- Demonstration payload on Argonaut first mission (5 years life time)
- NAV Payload delivery to Argonaut via FutureNAV Programme (CMIN25)



NovaMoon Payload integrated in Argonaut-1 Mission (2031)
5 years mission – A very high international interest

#### **Phase 0/A/B1 of Future Demonstrators**



#### Quantum PNT

Quantum Sensing for precise orbit determination, RFI monitoring, remote sensing and navigation sensor fusion

Secure Time Transfer through space-ground optical link with Quantum Key Distribution

Optical Quantum Clocks for high accuracy timekeeping

Rydberg Receivers for multi-frequency, multi-system compatibility

#### **NAV Digital Payloads**

Software-defined Radios for On-orbit reconfigurable navigation messages

**Beamformers & Steerable PNT** Antennas for jamming/spoofing mitigation

**Self-Assembling Structures for large** PNT space segment antennas

Pulsar Antennas for independent timing

#### AI for PNT

**Al-driven System Improvements for** ground and space segment (fault detection, autonomy improvements, distributed clock synchronisation,...)

Data Lakes for PNT data-centric solution development

PNT Digital Twins for modelling of PNT systems

**Edge Computing** For autonomous management of large PNT systems



















**Evaluate benefits and integration** to PNT systems

**Explore new PNT system** concepts and user needs







#### Conclusion



- GNSS / PNT is a strategic sector for Society, Economy, Safety, Security
- Europe is playing a leading role
- ESA / EU partnership implementing well-coordinated portfolio of programmes
- NAV CM25 to strengthen Europe's competitiveness and pioneer the future of PNT
  - NAVISP essential instrument to develop the market and boost European Industry competitiveness.
  - FutureNAV shaping the future of GNSS/PNT
    - LEO-PNT
    - GENESIS
    - OpSTAR
    - NOVAMOON
    - Disruptive technologies and System concepts (Quantum, Al) future in-orbit demonstrators

Industry a strategic partner, delivering programmes and supporting ESA in defining the future of GNSS/PNT