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**EUROPEAN SPACE AGENCY**

# NAVISP Element 1 Work Plan 2027

## Subject

This document presents the NAVISP Element 1 Work Plan 2027 activities.

## Eligibility

AT, BE, CH, DE, ES, FI, FR, GR, HU, IE, IT, NL, NO, PL, PT, RO, SE, UK

Note that in this Work Plan there are Opt-Outs for specific activities.

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# 1. OVERVIEW

The Work Plan 2027 includes twenty-one (21) innovative activities and one (1) study, for a cumulative budget of **14.25 M€**.

The activities belong to the following classes:

- AI and Digital Tools
- Antenna and RF resilience
- Frequency and Time (F&T) generation and distribution
- GNSS Receivers
- Non-GNSS/Hybrid PNT

Table 1 gives an overview of the prioritisation classes and Figure 1 gives the percentage of the budget allocated per class.

| NAVISP ID | Name | Duration (months) | Budget (k€) | Class | TRL Start/End |
|---|---|---|---|---|---|
| EL1-135 | Resilient Geodetic Infrastructure for Next-Generation PNT | 18 | 600 | AI and Digital tools | 2/4 |
| EL1-136 | AI-Generated GNSS Multipath Digital Twins for Drone-Based Infrastructure Inspection, Planning, and Safety Assurance - Leveraging React-G-Inspired Geometric Modelling | 24 | 800 | AI and Digital tools | 3/6 |
| EL1-137 | 4D Ionospheric concept/simulator to allow multilayer high precision applications | 18 | 750 | AI and Digital tools | 2/5 |
| EL1-138 | Improved interference mitigation by using novel multi-element antenna techniques | 18 | 600 | Antenna and RF resilience | 2/5 |
| EL1-139 | Multi-Band CRPA Architecture for Next-Generation GNSS Services | 12 | 400 | Antenna and RF resilience | 2/4 |
| EL1-140 | Locating jammers using cooperative aircraft CRPAs | 24 | 1000 | Antenna and RF resilience | 2/5 |
| EL1-141 | Low-Power Compact Array receivers for Resilient GNSS Navigation | 18 | 900 | Antenna and RF resilience | 3/6 |
| EL1-142 | Wide-Angle C-Band CRPA Technology for Enhanced GNSS Resilience | 12 | 400 | Antenna and RF resilience | 2/4 |
| EL1-143 | C-band Ultra Wide-band & Omni Compact Antenna System for Hand-Held Users | 24 | 600 | Antenna and RF resilience | 3/6 |
| EL1-144 | Compact high TRL Atomic Clock development for PNT applications | 24 | 800 | F&T Generation and distribution | 3/5 |
| EL1-145 | eLoran disciplined oscillator for improved and resilient terrestrial timing dissemination | 18 | 600 | F&T Generation and distribution | 3/5 |
| EL1-146 | ADHA 3U High Accuracy GNSS Space Receiver | 24 | 1000 | GNSS Receivers | 4/6 |
| EL1-147 | Compressed-Sensing Snapshot GNSS Receiver for Low-Power Devices | 18 | 300 | GNSS Receivers | 3/5 |
| EL1-148 | A Snapshot-Based Receiver Concept for LEO PNT | 18 | 500 | GNSS Receivers | 3/6 |
| EL1-149 | Highly Power-Efficient Snapshot GNSS Space Receiver | 24 | 500 | GNSS Receivers | 3/6 |
| EL1-150 | Re-configurable SDR Space Receiver Technologies | 24 | 600 | GNSS Receivers | 3/5 |
| EL1-151 | Deployable tactical eLoran system | 24 | 800 | Non-GNSS/Hybrid PNT | 3/6 |
| EL1-152 | Signals of opportunity fused with eLoran for drone navigation | 18 | 750 | Non-GNSS/Hybrid PNT | 3/6 |
| EL1-153 | User-Level Integrity Architecture for eLoran in Resilient PNT Systems | 18 | 750 | Non-GNSS/Hybrid PNT | 3/6 |

| | | | | | |
|---|---|---|---|---|---|
| EL1-154 | Low luminosity technology for PNT | 18 | 500 | Non-GNSS/Hybrid PNT | 2/4 |
| EL1-155 | Gravity Map Matching | 24 | 800 | Non-GNSS/Hybrid PNT | 2/5 |
| EL1-156 | Societal and Economic Impact and Benefit of ESA's NAVISP Program | 12 | 300 | Impact study | NA |

Table 1 – Classes of proposed activities and their budget allocations

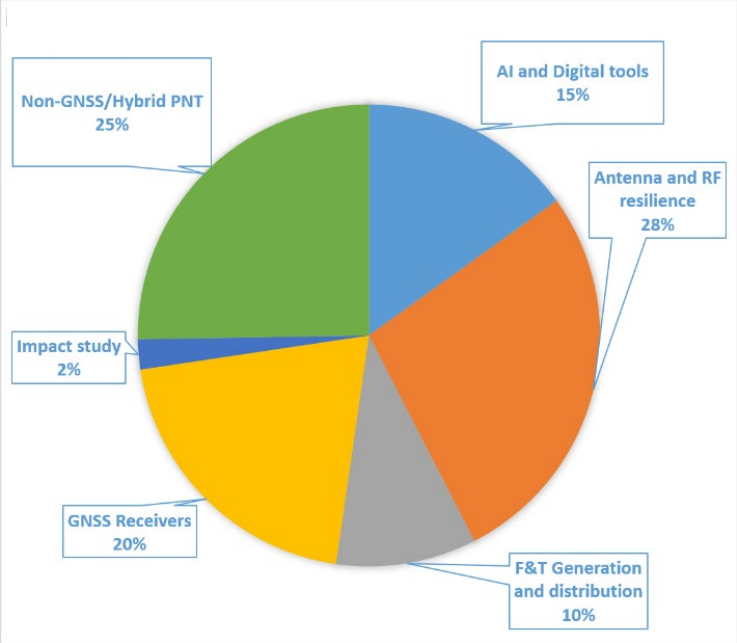



Figure 1 – Budget allocation to the classes

# 2. WORK PLAN 2027 ACTIVITIES DESCRIPTIONS

## 2.1. AI and Digital Tools

### 2.1.1. EL1-135: Resilient Geodetic Infrastructure for Next-Generation PNT

The geodetic infrastructure, often referred to as the Geodesy Supply Chain (GSC), provides the foundation for precise Positioning, Navigation and Timing (PNT) and underpins a wide range of space and societal applications. However, it is largely operated on a best-effort basis, with fragmented governance and not fully coordinated holistic approach, resulting in a mismatch with the resilience requirements of downstream applications.

While the Genesis mission aims to improve the accuracy and stability of the International Terrestrial Reference Frame (ITRF), one of the key products of the Geodesy Supply Chain, downstream users continue to rely on best-effort geodetic products, thereby limiting the reliability and resilience of their services.

By analysing how infrastructure disruptions propagate into geodetic products and ultimately affect user applications, the study aims to define geodetic integrity indicators that can support navigation service providers, critical infrastructure operators, autonomous systems, and other high-value end users. This aligns with ESA's strategy to strengthen European technological sovereignty and enable trusted next-generation PNT and Earth Observation services.

The objective of the activity is to assess and mitigate the impact of geodetic infrastructure anomalies on critical geodetic products and downstream PNT/EO services through the development of integrity and service-assurance mechanisms.

The tasks to be performed shall include:

- Quantification of the propagation of vulnerabilities in the current geodetic infrastructure (across sensors, networks, processing facilities, and data/product centers) into navigation products, considering the GSC Task Force's review as input
- Analysis of stakeholder needs, including accuracy, latency, continuity, availability, and integrity information requirements
- Definition, trade-off analysis, and development of frameworks for assigning integrity indicators at geodetic product level and translating them into actionable service-quality metrics
- Performance assessment across representative PNT and EO user domains, quantifying the combined impact of the availability of geodetic integrity indicators and any vulnerability in the geodetic infrastructure
- Proposal of algorithmic integrity strategies to detect and bound the impact of geodetic infrastructure vulnerabilities on downstream navigation products and services

The main outputs of the activity will consist of:

- Performance assessment with quantified effects on both geodetic product and user level under disruptions
- Proof-of-concept demonstrator for a geodetic product integrity framework and user-oriented service confidence indicators enabling commercial service-level commitments

It is noted that Austria expressed their opt-out for this activity (EL1-135).

| | | |
|---|---|---|
| *Funding required: 600k€* | *Duration: 18 months* | *ITT issue: Apr-2027* |

### 2.1.2. EL1-136: AI-Generated GNSS Multipath Digital Twins for Drone-Based Infrastructure Inspection, Planning, and Safety Assurance

UAV inspection in ports, energy corridors, bridges, rail yards, industrial plants, and urban canyons is limited today because GNSS multipath and NLOS can push horizontal errors from sub-meter to several meters, causing navigation dropouts and wrong geo-tagging exactly where drones fly closest to obstacles.

Operators currently lack high-fidelity tools able to accurately characterise site-wide, altitude-dependent GNSS quality before flights; manual tests and classical ray-tracing are too local and too slow, and generic RF models ignore the real 3D geometry, leading to mission aborts, re-flights, and conservative no-fly buffers.

Building on modelling principles inspired by React-G (Zhang, Bohan & Gutierrez, Julian & Agrawal, Ankit. (2025). React-G: GNSS Signal Multipath Simulation Framework for small Uncrewed Aerial Systems. 1170-1181. 10.1109/PLANS61210.2025.11028333), the proposed GNSS Multipath Digital Twin turns lidar/photogrammetry/BIM into 3D maps that give, for every point and flight level, multipath/NLOS risk, CEP-95, and protection levels. Mission-planning software queries these maps along candidate routes, automatically avoids “red” zones, and locks trajectories into “green” GNSS corridors; in flight, integrity monitors use the same data to trigger slow-down, climb, or return-to-home when margins are violated.

By embedding these high-resolution GNSS performance maps into planning and integrity, the system is expected to cut GNSS-induced aborts and re-flights, tighten protection-level bounds while preserving integrity, and open more usable low-altitude airspace for inspection, compared with today’s point measurements and generic models.

The objective of the activity is to develop an open, modular GNSS multipath digital twin and UAV navigation framework that converts 3D geospatial data into accurate, updatable PNT performance maps and exploits them within the UAV navigation engine to enable safe, predictable inspection missions in complex infrastructure environments.

The tasks to be performed shall include:

- Create an AI-driven, React-G–inspired GNSS multipath digital twin that transforms lidar, photogrammetry, and BIM into a unified 3D scene and predicts multipath, NLOS, and signal-quality degradation with far higher scalability than classical ray-tracing.
- Generate PNT performance layers (CEP-95, protection levels, GNSS risk indices).
- Implement a UAV navigation engine (mission-planning and guidance function) that queries these layers along candidate 4D trajectories to select GNSS-safe flight paths.
- Validate the complete chain with UAV flight data in representative industrial and urban sites.

The main outputs of the activity will consist of:

- Software prototype of the multipath digital-twin engine and the navigation/flight-planning module.
- Validated GNSS performance maps for representative industrial inspection environments (port, urban, energy corridor, industrial site).
- API and reference datasets.
- Commercialisation roadmap (pathway to NAVISP EL2).

It is noted that Austria expressed their opt-out for this activity (EL1-136).

| | | |
|---|---|---|
| *Funding required: 800k€* | *Duration: 24 months* | *ITT issue: September-2027* |

## 2.2. Antenna and RF resilience

### 2.2.1. EL1-137: 4D Ionospheric concept/simulator to allow multilayer high precision applications

LEO-PNT systems introduce new observations that can significantly enhance ionospheric monitoring and modelling capabilities. The ionosphere remains one of the principal error sources limiting instantaneous high precision Position, Velocity and Timing (PVT) performance.

Galileo High Accuracy Service (HAS), particularly Service Level 2 (SL2), targets convergence to its final accuracy within 100 seconds. However, the current SL2 ionospheric correction approach relies on a simplified 3D ionospheric model primarily suited to ground users receiving MEO signals. This limits its ability to support rapid convergence on high-accuracy applications involving LEO-PNT observations.

C-band LEO-PNT, for which dedicated high precision ionospheric correction models do not yet exist, also needs a model to correct the ionospheric delay to achieve high accurate PVT. At 5.02 GHz, the ionospheric delay can range from approximately 0.8 m to 2.4 m under typical European ionospheric conditions, depending on satellite elevation. Such errors are incompatible with the sub-decimetre positioning performance targeted by future high-accuracy services.

At lower frequencies, the ionospheric impact becomes even more significant, affecting emerging applications based on VDES and UHF LEO systems. In addition, several current and future Earth Observation missions, particularly low-frequency SAR systems, could benefit from accurate 4D ionospheric information.

The objective of this activity is to study, design, simulate and demonstrate a high precision 4D ionospheric model capable of supporting next-generation Navigation and Earth Observation applications.

The activity will investigate how combined MEO and LEO observations can enable near-instantaneous high-accuracy positioning, targeting convergence times below 10 seconds for at least 95% of time, significantly improving upon current Galileo HAS SL2 performance.

The tasks to be performed shall include:

**1. Development of a High-Precision 4D Ionospheric Model**

- Define and assess advanced 4D ionospheric modelling concepts.
- Investigate the use of combined MEO and LEO observations to improve ionospheric estimation accuracy and spatial-temporal resolution.
- Quantify the resulting benefits for high-accuracy PVT applications.
- Demonstrate the achievable reduction in convergence time for Precise Point Positioning and related techniques.

**2. Development of an End-to-End Simulation Framework**

- Develop a simulation environment capable of generating realistic MEO and LEO observables.
- Support assessment of multiple ionospheric modelling approaches in representative operational scenarios.
- Evaluate performance both in terms of ionospheric estimation accuracy and positioning performance.
- Investigate applicability to navigation, VDES positioning and Earth Observation missions.

The main outputs of the activity will consist of:

1. **A high precision 4D ionospheric model architecture** suitable for Navigation and Earth Observation applications.
2. **An end-to-end simulation tool** capable of generating and processing MEO and LEO observations for advanced ionospheric and PVT performance assessment.

3. **Recommendations for future EU LEO-PNT systems**, including potential applicability to the full Celeste and IOP constellations.
4. **System-level implementation guidelines**, covering:
    a. required observation types and data products
    b. message design and optimisation
    c. ground segment and space segment infrastructure needs

It is noted that Austria expressed their opt-out for this activity (EL1-137).

| | | |
|---|---|---|
| *Funding required: 750k€* | *Duration: 18 months* | *ITT issue: March-2027* |

### 2.2.2. EL1-138: Improved interference mitigation in PNT by using novel multi-element antenna techniques

Controlled Reception Pattern Antenna (CRPA) systems have traditionally been developed for defence applications, where they provide robust protection against Global Navigation Satellite System (GNSS) interference. However, the increasing prevalence of jamming and spoofing threats is creating a growing need for resilient Positioning, Navigation and Timing (PNT) solutions in civil applications, including emergency services, critical infrastructure, autonomous vehicles and unmanned aerial systems.

Current CRPA solutions are often based on complex digital beamforming architectures requiring high-performance FPGA processing, resulting in high cost, size and power consumption. To enable wider adoption in civil markets, more affordable approaches are needed.

Recent developments in compact reconfigurable antennas, low-cost RF networks and intelligent control algorithms have demonstrated the potential to achieve interference mitigation with significantly simpler and lower-cost architectures. The successful deployment of such systems requires advances in areas such as direction-of-arrival estimation, calibration methodologies suitable for mass production, high-accuracy phase shifting and variable gain control networks.

In parallel, emerging antenna technologies offer new opportunities for compact interference-resistant GNSS receivers. Multi-mode and metamaterial-based antennas can exploit multiple feed points and resonant modes within a single antenna structure to generate adaptive radiation patterns and create interference nulls within a compact footprint.

Additional opportunities arise from novel antenna concepts and materials, including **acoustic** and **topologically protected antenna** architectures (by carefully patterning materials, compact devices can be created, where traveling electromagnetic waves are protected against scattering and defects, even when navigating sharp corners and controlling the leak of radiation at precisely defined angles). These technologies can enable the creation of multiple interference nulls across a hemispherical field of view, allowing simultaneous suppression of several interference sources.

Furthermore, antenna arrays employing element spacing smaller than half a wavelength (**sub-λ/2**) may provide compact solutions for spoofing detection and mitigation, although they introduce additional challenges in pattern control and calibration.

The objective of this activity is to investigate, design and demonstrate innovative antenna-based techniques for the detection and mitigation of GNSS jamming and spoofing. The activity will assess the suitability of novel CRPA concepts, including analogue beamforming, hybrid RF architectures, multi-mode antennas, metamaterial-based antennas and sub-λ/2 array configurations, with a focus on low-cost civil PNT applications.

The tasks to be performed shall include:

- Civil Requirements Review
    - Review state of the art in low-cost CRPA technologies, RF architectures and compact multi-element antenna solutions.

    - Identify current and future civil applications for CRPA systems including emergency services, infrastructure and autonomous vehicles.
    - Capture application-specific operational needs and derive a consolidated set of technical requirements and performance targets
- Concept and System Design:
    - Using the technologies identified in the Civil Requirements Review, the two most promising solutions will be developed into broader concepts for interference mitigation, against the requirements identified.
    - Modelling will be undertaken of two complementary concepts to assess anticipated performance with respect to jamming mitigation and spoofing detection.
    - A detailed design of the system including antenna subsystem, RF architecture and associated signal processing algorithms will be performed.
- Prototype Development, Verification Validation
    - Manufacture prototypes of the two selected antenna solutions
    - Characterise antenna and RF subsystem performance through laboratory testing.
    - Integrate, verify and validate the complete RF system under representative interference scenarios in laboratory facilities and, where feasible, in realistic operational environments.
    - Document the achieved performance and lessons learned.
- Exploitation Roadmap
    - Define a technology maturation and generate an exploitation roadmap for how the technology can be matured for PNT use cases.

The main outputs of the activity will consist of:

- State-of-the-art, Requirements and Concept and System Design reports
- Two Prototype demonstrators implementing distinct technical approaches
- Verification and validation reports, including recommendations for integration into next generation GNSS receiver architectures.
- A technology exploitation and commercialisation roadmap supporting progression towards NAVISP Element 2 activities.

It is noted that no Participating State expressed their opt-out for this activity (EL1-138).

| | | |
|---|---|---|
| *Funding required: 600k€* | *Duration: 18 months* | *ITT issue: June-2027* |

### 2.2.3. EL1-139: Multi-Band CRPA Architecture for Next-Generation GNSS Services

In the context of Global Navigation Satellite System resilience, reliance on vulnerable L-band signals alone exposes PNT services to jamming and spoofing, motivating the use of complementary S- and C-band channels to provide independent timing, ranging, and authentication paths.

By distributing PNT functions across L-, S-, and C-band, LEO-PNT introduces frequency diversity that enables cross-band interference detection, robust integrity monitoring, and continuity of service under contested RF conditions.

This multi-band architecture directly supports the development of advanced CRPA systems capable of adaptive beamforming, interference suppression, and resilient multi-frequency signal fusion.

The objective of the activity is to design, develop, and demonstrate an ultra-wideband CRPA capable of operating across the L-band as well as next-generation GNSS frequencies in the C- and S-bands, while providing robust interference-suppression capability.

The tasks to be performed shall include:

- Development of an ultra-wideband CRPA capable of operating across L-, S-, and C-band frequencies, focusing on the radiating elements technology, to enhance resilience of positioning, navigation, and timing (PNT) services in contested electromagnetic environments.
- Extension of traditional narrowband CRPA architectures to a multi-frequency, wideband system, enabling simultaneous spatial filtering, interference nulling, and signal authentication across disparate spectrum allocations.

The main outputs of the activity will consist of:

- An ultra-wideband CRPA breadboard demonstrating real-time adaptive beamforming and interference suppression across L-, S-, and C-bands, with quantified anti-jam and anti-spoof performance improvements in representative GNSS-denied scenarios.
- Integrated multi-band signal processing framework enabling coherent fusion of L/S/C-band signals for resilient PNT, including cross-band interference detection, integrity monitoring, and performance benchmarking against conventional narrowband CRPA systems.

It is noted that Austria expressed their opt-out for this activity (EL1-139).

| | | |
|---|---|---|
| *Funding required: 400k€* | *Duration: 12 months* | *ITT issue: June-2027* |

### 2.2.4. EL1-140: Locating jammers using cooperative aircraft CRPAs

Jamming and spoofing of GNSS-signals is a major concern, especially for aviation. Many aircrafts are impacted daily, in particular in regions which are close to conflict areas (e.g., the Baltic region and Eastern Europe). One of the main technologies to mitigate jamming and spoofing are CRPAs. Aviation standardisation organisations (Eurocae and RTCA) have initiated working groups to produce standards for CRPAs. These standards shall allow the production of CRPAs which are certified for aviation. It is expected that a large percentage of the aircrafts will deploy a certified CRPA, once available.

Although the main purpose of CRPAs is the mitigation of jamming and spoofing, the deployment of CRPAs may have other benefits, such as the concept of this project. A jamming signal will lead to a null (in the gain pattern of the CRPA) in the direction of the jammer. When the same jamming signal is received by multiple CRPAs at different locations, the directions of the nulls of the CRPAs can be used to locate the jammer.

Locating jammers using multiple CRPAs could also be performed using ground-based or space-based approaches, yet an approach using cooperative aircrafts would have several advantages. First and foremost, in a future scenario, it is assumed that a large number of CRPAs installed on aircrafts will observe the same jammer (please note that there are around 30.000 flights per day in Europe). This would be beneficial for the accurate determination of the location of jammers. Second, aircrafts operate in open sky conditions, hereby improving performance in locating jammers. Third, as CRPAs would be deployed on aircrafts for the purpose of robust navigation, the concept of locating jammers would not require the installation of additional CRPAs, hereby reducing costs. Nevertheless, the concept of locating jammers using cooperative aircraft CRPAs may also have drawbacks requiring further analysis. For instance, jamming signals typically arrive from low or even negative elevation angles, which may impact the accuracy of setting the null in the direction of the jammer.

The objective of the activity is to develop a method to locate jammers using CRPA measurements from multiple aircrafts.

The tasks to be performed shall include:

- Study of CRPA gain patterns for interference coming from low or even negative elevation angles, using a combination of analysis, simulation, and laboratory tests.
- Perform field tests (e.g., flight trials and/or static tests at JammerTest in Norway) to complement the study above.
- Develop a method to locate jammers using CRPA measurements from multiple aircrafts.
- Derive the input for simulations, e.g.:
    - Select a region for which simulations shall be performed

    - Derive several scenarios for the number and type of jammers and spoofers in this region, or close to this region
    - Derive a realistic scenario of the aircrafts in this region (number of aircraft, altitude, flight path, banking angles, etc.)
    - Derive several scenarios for the CRPA designs per aircraft.
- Execute simulations for the combinations of scenarios defined above.
- Provide a high-level design of a future operational system (considering not only CRPAs but also data-links and a processing facility).
- Conclude on the performance of the method to locate jammers using cooperative aircraft CRPAs.

The main outputs of the activity will consist of:

- Results of laboratory tests.
- A CRPA processor.
- a RF interference localisation simulator.
- A report showing performance of the RF interference localisation under relevant conditions.

It is noted that Austria expressed their opt-out for this activity (EL1-140).

| | | |
|---|---|---|
| *Funding required: 1000k€* | *Duration: 24 months* | *ITT issue: October-2027* |

### 2.2.5. EL1-141: Low-Power Compact Array receivers for Resilient GNSS Navigation

Receiving systems based on Controlled Reception Pattern Antenna (CRPA) provide the most protection for GNSS receivers against jamming and spoofing attack. Such systems usually combine multiple elements and processing units for several antennae and frequency bands. Their power requirements and form-factor scale up with the number of elements and frequencies. Compared to other ESA CRPA activities (e.g. EL1-097 and EL1-107), the low power aspect has not been tackled.

With the emerging low-power IoT applications, ultra-low power consumption GNSS receivers have become very desirable, accordingly, technologies such as Low Power and Reconfigurable Digital RF (DRF) are getting an interest for providing active power consumption below 10 mW. Furthermore, techniques such as Dynamic Reconfiguration (in nominal scenarios the receiver dynamically powers down auxiliary antenna elements and processes only a single band while if jamming is detected, it instantly "wakes up" the rest of the array to perform null-steering) have emerged.

Exploiting low form-factor and low power consumption technologies with array receivers will enable beamforming for applications with power constraints such as drones and spaceborne receivers where power consumption has a significant impact.

The objective of the activity is to study, design, and demonstrate the use of a low power and low form factor Array GNSS receiver.

The tasks to be performed shall include:

- Assessment of application-specific constraints (size, aperture limits, power budget) and their impact on achievable performance.
- Assessment of application-specific achievable TRL level
- Design and development of the ultra-low power Array GNSS frontend and processing unit.
- Implement low power beamforming and null-steering algorithms to provide the required performance giving the power constraint.
- Estimating the direction of jamming and spoofing devices.
- Demonstrate the new implementation for various applications such as airborne receivers.

The main outputs of the activity will consist of:

- Survey of state-of-the-art review, design justification and testing reports.
- Low power and low form-factor navigation array receiver (HW and SW).

It is noted that no Participating State expressed their opt-out for this activity (EL1-141).

| | | |
|---|---|---|
| *Funding required: 900k€* | *Duration: 18 months* | *ITT issue: April-2027* |

### 2.2.6. EL1-142: Wide-Angle C-Band CRPA Technology for Enhanced GNSS Resilience

Next-generation CRPA systems aim to operate with higher-bandwidth signals in the C-band, which require increased antenna gain to reliably close the link budget.

However, conventional user-terminal antennas based on classical planar phased arrays are limited by the geometric “cosine-rule,” resulting in scan losses of around 3 dB at ±60° for a reference 7-element CRPA configuration.

Although extending the scan range beyond ±60° while mitigating scan loss is feasible through faceted or conformal array geometries, these approaches might introduce additional manufacturing complexity, integration constraints, and overall system cost.

These limitations motivate the need for innovative antenna concepts and manufacturing processes that can deliver wide-angle scanning while maintaining adequate gain and robustness under practical constraints.

The objective of the activity is to design, develop, and demonstrate a C-band CRPA capable of suppressing interference and achieving wide-angle steering performance (up to ±70°) while targeting a gain variation below 3dB.

The tasks to be performed shall include:

- Investing scan loss compensating techniques and conformal geometries to improve angular coverage and maintain high gain at low elevation.
- Detailed electromagnetic design.
- Prototype fabrication.
- Characterization of the array radiation, scanning and interference-rejection performance.

The main outputs of the activity will consist of:

- A fully tested C-band breadboard CRPA demonstrating wide-angle beam steering up to ±70°, targeting <3 dB gain reduction across the steering range.
- A consolidated performance assessment, design documentation, and recommendations for future development and integration into LEO-PNT user terminals.

It is noted that Austria expressed their opt-out for this activity (EL1-142).

| | | |
|---|---|---|
| *Funding required: 400k€* | *Duration: 12 months* | *ITT issue: September-2027* |

### 2.2.7. EL1-143: C-band Ultra Wide-band & Omni Compact Antenna System for Hand-Held Users

The usage of signals with large frequency bands in C-band is being considered for PNT purposes to achieve robust and resilient high-accuracy solutions (code-based), including hand-held / smartphone-like applications, where CRPA/beamforming is not an option (since very low SWaP-C is targeted).

The design of compact antennas with the following specifications is not trivial and does not yet exist:

- Ultra wide-band, covering from 5 up to 5.25 GHz, or even up to 5.6 GHz
- Semi-omnidirectional, with positive gain (ideally 3–5 dBi; at least 0 dBi) in the hemisphere of interest
- RHCP polarised

- Phase center offsets (PCO) and variations (PCV) well controlled across the full band
- Very low SWaP-C

These specifications/performances are key to supporting a large number of future hand-held PNT users requiring small compact antennas to exploit these large frequency bands and achieve resilient and high-accuracy solutions without requiring beamforming/CRPA antennas.

Specific design, tuning and optimisation of the antenna characteristics and performances is required, trading off design options end-to-end, including their impact on the PNT receiver solution.

The objective of the activity is to study, define, design, implement and demonstrate an ultra wide-band compact antenna prototype with very low SWaP-C for C-band, supporting resilient high-accuracy PNT solutions in hand-held receivers.

The tasks to be performed shall include:

- Study, define, design, implement and demonstrate a compact antenna for C-band that simultaneously achieves multiple system performance targets.
- Iteratively optimise and fine-tune the design and target specifications considering the end-to-end PNT user receiver solution and form factor.
- Demonstrate the antenna's end-to-end performance at ranging/PNT level in controlled laboratory tests using wide-band PNT-like signals and, optionally, field tests using existing C-band signals.

The main outputs of the activity will consist of:

- Antenna design and prototype, including PNT receiver elements used in the performance demonstration
- Test results and specifications
- Roadmap for commercialization, including potential NAVISP EL2 activities

It is noted that Austria expressed their opt-out for this activity (EL1-143).

| | | |
|---|---|---|
| *Funding required: 600k€* | *Duration: 24 months* | *ITT issue: May-2027* |

## 2.3. F&T generation and distribution

### 2.3.1. EL1-144: Compact Space Atomic Clock development for PNT applications

Low-SWaP clocks are in high demand for missions such as extra-terrestrial PNT (e.g. Moonlight, Novamoon), deep-space navigation, secure telecommunications, and holdover applications (e.g. LEO-PNT). In these applications, the typically stringent requirements of GNSS-grade clocks can be relaxed, due either to lower positioning accuracy needs or to shorter holdover durations associated with discontinuous time reference sources. In contrast, accommodation constraints are highly critical, given the use of smaller satellites or the need to keep the clock operational using energy stored in batteries, for example during the lunar night.

Several successful activities in compact clock development have demonstrated the potential to improve stability performance within reduced SWaP constraints. These improvements are achieved through the adoption of optical technologies, pulsed operation schemes, and the miniaturization of the physics package, while maintaining the atomic resonator transition in the microwave domain. This approach enables the reuse and further development of existing high-TRL solutions while limiting technical development risk.

The objective of the activity is to design, manufacture, and test a compact, high-performance, low-SWaP atomic clock with a timing performance of a few tens of nanoseconds per day (<5E-13 ADEV). The clock shall feature a compact architecture with low power consumption (<5 W) and a volume of less than 1 litre.

The tasks to be performed shall include:

- Conduct a trade-off analysis of potential solutions, assess application-specific constraints (size and power budget), and evaluate their impact on achievable performance.
- Assess the achievable TRL level.
- Identify critical items and develop a preliminary design for the various subunits.
- Develop the associated low-power electronics and algorithms required for autonomous operation.
- Engineer a compact atomic clock Elegant BreadBoard.
- Demonstrate achievable performance at the BreadBoard level.

The main outputs of the activity will consist of:

- An Elegant BreadBoard of the compact, low-SWaP atomic clock Physics Package, including the optical module, if applicable.
- Design of a compact electronics module, including the identification of algorithms for autonomous operation.

It is noted that Austria expressed their opt-out for this activity (EL1-144).

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| *Funding required: 800k€* | *Duration: 24 months* | *ITT issue: May-2027* |

### 2.3.2. EL1-145: eLoran disciplined oscillator for improved and resilient terrestrial timing dissemination

eLoran service is being re-initiated as an alternative source of PNT, especially precise timing. International initiatives and collaborations have been initiated in recent years, with new developments and testing activities in this technical area.

The timing service from eLoran is characterized by good precision and accuracy in the long term, but it is still limited by short-term noise.

Multiple developments in eLoran receivers and antennas have been performed in recent years.

The introduction of a disciplined oscillator based on the eLoran signal can improve the timing precision provided at user level by taking advantage of the increased maturity at the receiver side. Furthermore, the disciplined oscillator can improve robustness by mitigating eventual discontinuities through holdover mode. In this regard, the use of chip-scale atomic clocks may be beneficial for maintaining better accuracy than classical oscillators.

Another functionality to be assessed is the anomaly mitigation processing: in case of eLoran timing issue, the unit shall be able to detect it and minimize the impact in the output timing signal. This may require additional internal or external timing sources.

The objective of the activity is to study, design, and develop a prototype eLoran disciplined oscillator and test the prototype with real eLoran signals.

The tasks to be performed shall include:

- Conduct a trade-off analysis among potential solutions to increase robustness of eLoran timing receivers with embedded oscillators.
- Design and validate a prototype eLoran disciplined oscillator.
- Demonstrate improved timing precision, especially in the short term, by introducing an internal oscillator and/or chip-scale atomic clock.
- Demonstrate holdover capability in the event of issues in the eLoran signal, triggered by anomaly-mitigation processing in the receiver.
- Validate the unit with real or simulated eLoran signals

The main outputs of the activity will consist of:

- Survey of the state of the art of eLoran receivers and disciplined oscillators
- Design and prototyping of an eLoran disciplined oscillator
- Prototype of eLoran disciplined oscillator
- Roadmap for commercialization, including potential NAVISP EL2 activities

It is noted that Italy and Austria expressed their opt-out for this activity (EL1-145).

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| *Funding required: 600k€* | *Duration: 18 months* | *ITT issue: March-2027* |

## 2.4. GNSS Receivers

### 2.4.1. EL1-146: ADHA 3U High Accuracy GNSS Space Receiver

Recently, there has been increased interest in modular electronics equipment on-board spacecraft to reduce spacecraft development time and cost through reduced non-recurring engineering and to allow incremental improvements of on-board systems as new key components become available. ESA, in collaboration with European industry involved in on-board data handling and LSIs, initiated the definition of the Advanced Data Handling Architecture (ADHA) standards, which feature standardized, interchangeable, and interoperable electronics modules within a single electronics box. Many ADHA-related hardware developments are currently underway to enable an end-to-end data-handling/avionics ecosystem of products. The smaller ADHA 3U form factor targets ESA Class Gamma missions, including New Space missions and constellations. ADHA 3U has generated a strong interest from industry, with multiple developments advancing to pre-qualification.

As part of ADHA 3U, a high-accuracy GNSS space receiver is needed for integration with data-handling and avionics functions within the same ADHA unit while ensuring interoperability with other ADHA functions, such as the OBC. This activity aims to develop the first ADHA 3U GNSS Receiver Module.

The development and demonstration of the receiver is in line with the Technology Harmonisation Dossier of On-Board Radio Navigation Receivers 2025, R&D Line 2.2.

The objective of the activity is to develop and validate an Engineering Model of a High Accuracy GNSS Space Receiver compliant with ADHA 3U for Class Gamma ESA missions, including New Space missions.

The tasks to be performed shall include:

- To consolidate mission and user requirements for ADHA 3U High Accuracy GNSS Space Receiver.
- To develop and validate the Engineering Model of a High Accuracy GNSS Space Receiver compliant with ADHA 3U with at least following capabilities:
    - Support applications of precise on-board orbit determination and GNSS radio occultation applications.
    - Support multi-frequency navigation with at least two constellations: Galileo E1/E5/E6 and GPS L1/L5.
    - Provide high-quality carrier-phase measurements.
    - Allow the use of COTS components.
- To demonstrate the integration and interoperability of the High Accuracy GNSS Space Receiver with ADHA 3U units, including operation together with an ADHA-compliant OBC.
- To define a roadmap for the evolution of the development Engineering Model towards a flight-representative implementation.

The main outputs of the activity will consist of:

- Engineering model of a High Accuracy GNSS Space Receiver compliant with ADHA 3U
- Reports and documentation

It is noted that no Participating State expressed their opt-out for this activity (EL1-146).

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| *Funding required: 1000k€* | *Duration: 24 months* | *ITT issue: June-2027* |

### 2.4.2. EL1-147: Compressed-Sensing Snapshot GNSS Receiver for Low-Power Devices

Conventional GNSS receivers rely fundamentally on continuous Nyquist-rate sampling and substantial on-board processing, which places significant demands on power, computation, and data-handling resources. These requirements are particularly challenging for IoT nodes, nanosatellites, and autonomous sensors, where available resources are inherently limited.

Snapshot GNSS receivers reduce continuous processing but still rely on Nyquist-rate sampling and on-board correlation. This work proposes a sub-Nyquist randomized sampling approach where sparse IQ data is sent to the cloud, reducing the amount of transmitted data and therefore lowering the power consumption of the IoT device.

Exploiting the sparsity of GNSS signals, code delays are reconstructed off-board using compressed sensing, enabling pseudorange estimation and PVT computation while reducing on-device processing complexity. A key advantage of the proposed approach is that the low-power device transmits only a compact snapshot of randomly sampled IQ measurements, significantly reducing data volume compared with Nyquist-sampled.

The objective of the activity is to demonstrate and validate a proof-of-concept cloud-assisted snapshot GNSS receiver that reconstructs pseudoranges from randomly sampled sub-Nyquist IQ measurements. The activity will quantify the trade-off between data volume reduction, receiver power consumption, and navigation performance, and compare the results against a conventional Nyquist-sampled snapshot GNSS receiver.

The tasks to be performed shall include:

- Study, design, and demonstrate a snapshot GNSS receiver based on compressed sensing.
- Collect randomly sampled IQ measurements at a low sampling frequency using a low-power device.
- Transmit the measurements to cloud-based processing for pseudorange reconstruction.

- Perform the reconstruction of pseudoranges and PVT off-board using compressed-sensing techniques.
- Compare the results against a conventional snapshot GNSS receiver operating at Nyquist sampling rates.

The main outputs of the activity will consist of:

- Survey of the state of the art on compressed sensing for GNSS
- Prototype and test report
- Performance assessment against state-of-the-art snapshot GNSS approaches
- Power and data-volume reduction analysis
- Roadmap for commercialization, including potential NAVISP EL2 activities

It is noted that no Participating State expressed their opt-out for this activity (EL1-147).

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| *Funding required: 300k€* | *Duration: 18 months* | *ITT issue: October-2027* |

### 2.4.3. EL1-148: A Snapshot-Based Receiver Concept for LEO PNT

Snapshot receiver technology has significant interest in recent years, proposing itself as an alternative to conventional GNSS receiver architectures, particularly for handheld/low-power devices.

With the rise of LEO constellations for PNT services, snapshot receiver architectures must evolve accordingly, exploiting the opportunities and taking into account the differences and challenges of this novel paradigm. In this scenario, the advance of Multi-Layer Satellite Systems concept shall be considered, adding further complexity to the navigation landscape and calling for a comprehensive assessment of the applicability and performance of snapshot receiver technologies in such environments.

The solution can benefit from both LEO and snapshot receiver advantages:

- **Enhanced Resilience:** LEO signals are harder to jam and spoof because of their high power on the ground and fast satellite dynamics.
- **Reduced Power Consumption:** the device can remain inactive for extended periods and activated only briefly to capture snapshots of the received signals.
- **Lower Implementation Cost:** because of its simplified front-end, snapshot receivers can offer a cost-effective alternative to traditional receiver designs.

Several challenges associated with the application of snapshot receiver technology to LEO-based and multi-layer PNT systems require further investigation, including:

- **Extended Doppler Search Space:** LEO satellites exhibits a higher velocity compared to traditional MEO satellites, leading to a larger Doppler shifts/rates. This, in turn, poses several challenges in snapshot receiver processing, such as:

  - Higher computational load
  - Increased acquisition time
  - Risk of missing the correct Doppler bin if the search spacing is not adequately fine
- **Clock Instability:** The short integration time and increased Doppler shifts make clock instability and drift far more critical.

The objective of the activity is to study, design, and test the performance of a snapshot receiver solution compatible with:

- MEO PNT Systems, including at least GPS L1 C/A and Galileo E1
- LEO PNT Systems
- Multi-Layer Satellite Systems

The activities shall include the following tasks:

- Analyse disruptive signal-processing techniques for LEO snapshot signal processing and multi-layer PNT snapshot signal processing.
- Develop a multi-layer PNT snapshot receiver prototype.
- Test the solution in a laboratory environment using both simulated and real data.

The main outputs of the activity shall consist of:

- Technical notes describing the trade-offs and design
- Prototype of a software-defined GNSS snapshot receiver
- Laboratory setup for representative user-scenario characterization, including clocks and SDRs
- Roadmap for commercialization

It is noted that no Participating State expressed their opt-out for this activity (EL1-148).

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| *Funding required: 500k€* | *Duration: 18 months* | *ITT issue: June-2027* |

### 2.4.4. EL1-149: Highly Power-Efficient Snapshot GNSS Space Receiver

Highly power-efficient GNSS receivers are well established in terrestrial applications, such as asset tracking, environmental monitoring, and emergency and safety beacons. Similarly, highly power-efficient GNSS receivers for space would enable novel applications and support the proliferation of European GNSS technology into many future high-risk missions lasting one to three years and flying pico, nano, or larger satellites.

Enabled applications include science and space situational awareness, where wide adoption of snapshot GNSS space receivers would provide large amounts of PNT data necessary for more accurate space surveillance and tracking or space-weather monitoring.

The development and demonstration of the receiver is in line with the Technology Harmonisation Dossier of On-Board Radio Navigation Receivers 2025, R&D Line 3.3.

The objective of the activity is to develop, qualify, and validate an engineering model of a highly power-efficient GNSS space receiver based on COTS for high-risk missions.

The tasks to be performed shall include:

- To consolidate mission and user requirements for a highly power-efficient GNSS space receiver.
- To develop and validate an Engineering Model of a highly power-efficient GNSS space receiver with at least following capabilities:
  - Address the challenges of the space environment, high satellite dynamics, related signal processing, and PNT algorithm development.
  - Target power consumption at least one order of magnitude lower than current receivers.
- To assess the suitability of the use of automotive-grade COTS components with necessary radiation shielding for high-risk missions lasting one to three years.
- To define a roadmap for the evolution of the development Engineering Model towards a flight-representative implementation.

The main outputs of the activity will consist of:

- Technical notes summarizing the receiver architecture and algorithms
- Engineering model of the highly power-efficient GNSS space receiver
- A validation report summarizing achievable PVT performance

It is noted that no Participating State expressed their opt-out for this activity (EL1-149).

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| *Funding required: 500k€* | *Duration: 24 months* | *ITT issue: November-2027* |

### 2.4.5. EL1-150: Re-configurable SDR Space Receiver Technologies

Current space receivers are dimensioned to exploit, at most, the current GNSS signals available, and not all at the same time. Furthermore, the introduction of new signals and features is slow compared with ground receivers.

New signals and features are planned for the evolution of current GNSS systems, exploiting the potential benefits of different bands (L, S and C) and constellations (MEO and LEO).

Re-configurable, re-programmable and modular “pure” SDR space receiver architectures adaptable to different signals and processing platforms, such as System-on-Chip, are of interest for different applications to flexibly exploit the new L-band signals expected to become available over the next few years.

The objective of the activity is to study, design and implement re-configurable, re-programmable and modular “pure” SDR space receiver architectures adaptable to different signal properties and processing platforms.

The tasks to be performed shall include:

- Study, design and implement SDR receiver architectures suitable for future applications using different signals, bandwidths, signal features and processing platforms.
- Include signals in different bands (L, S and C) and from different constellations (MEO and LEO).
- Demonstrate how re-configurability, re-programmability and modularity/scalability are achieved.
- Develop and test an elegant breadboard with simulated signals in representative scenarios.

The main outputs of the activity will consist of:

- SDR elegant breadboard
- Roadmap for commercialization, including potential NAVISP EL2 activities

It is noted that no Participating State expressed their opt-out for this activity (EL1-150).

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| *Funding required: 600k€* | *Duration: 24 months* | *ITT issue: May-2027* |

## 2.5. Non-GNSS/Hybrid PNT

### 2.5.1. EL1-151: Deployable tactical eLoran system

The potential impact of GNSS disruptions on essential PNT services and applications at national and regional levels is receiving increasing attention.

Alternative PNT (A-PNT) technologies for critical infrastructure and essential services are being explored to ensure the required quality and continuity of service. Several countries worldwide have initiated efforts to assess and implement complementary, resilient PNT solutions to support and safeguard services currently reliant on GNSS.

eLoran is the modernized successor to Loran-C: a terrestrial, low-frequency (LF) radio-navigation system using powerful transmitters operating at around 90–110 kHz. Its high-power long-wave signals are inherently different from GNSS signals and are less susceptible to wide-area disruption, enabling resilient positioning and, in particular, timing when satellite navigation is degraded.

Countries including China, South Korea and the UK have deployed or modernised fixed Loran infrastructure as part of broader efforts to strengthen PNT resilience. This renewed

interest is creating opportunities for deployable eLoran systems that could complement existing networks and provide rapid capability where fixed installations are unavailable.

The objective of the activity is to design, deploy and demonstrate a tactical eLoran transmitting station for resilient timing applications, and to assess through simulations the performance of networks comprising deployable and fixed transmitters.

The tasks to be performed shall include:

- Identify and assess use cases for deployable tactical eLoran transmitters supporting complementary LF PNT services within Europe.
- Examine how a standalone tactical transmitter could support the creation of localized LF timing micro-cells, typically with a radius of a few kilometres, providing GNSS-independent UTC for critical infrastructure.
- Examine how multiple tactical transmitters could form a localized LF PNT testbed.
- Examine how a mixed network of fixed and deployable eLoran transmitters could support cross-border A-PNT collaboration.
- Design and develop a deployable eLoran transmitting station.
- Select an appropriate installation site.
- Prepare the site and install the transmitting station.
- Conduct a measurement campaign to assess signal quality, timing performance, data-channel performance and the achievable coverage area.
- Extrapolate the results obtained with a single deployable transmitter to a network of multiple deployable and fixed transmitters.
- Assess how deployable eLoran systems could contribute to a complementary terrestrial timing layer within future hybrid A-PNT architectures.
- Present the results to potential user communities and stakeholders and gather feedback.

The main outputs of the activity will consist of:

- A standalone, deployable eLoran transmitting station providing GNSS-independent UTC timing capabilities for critical infrastructure applications
- Performance extrapolations for networks of deployable and fixed eLoran transmitters
- A commercialisation roadmap providing a pathway towards NAVISP EL2 activities

It is noted that Austria expressed their opt-out for this activity (EL1-151).

| | | |
|---|---|---|
| *Funding required: 800k€* | *Duration: 24 months* | *ITT issue: January-2027* |

### 2.5.2. EL1-152: Signals of opportunity fused with eLoran for drone navigation

eLoran is the modernized successor to Loran-C: a terrestrial, low-frequency radio-navigation system using powerful ground transmitters around 90–110 kHz. Because its signals are high-power and at a very different frequency from GNSS, eLoran can provide resilient positioning and especially timing when satellite navigation is degraded or unavailable.

Signals of opportunity (SoOp) use existing radio signals not originally designed for navigation. For example, Starlink's low-Earth-orbit satellites are numerous, move quickly and transmit relatively strong broadband signals. Receivers can exploit Doppler shifts, timing features or, with greater difficulty, carrier measurements to estimate position or velocity.

eLoran is mature in concept, but depends on national infrastructure and calibration. Signal-of-opportunity-based navigation is mostly experimental and non-cooperative. Combining both approaches is therefore considered a promising resilient architecture for dynamic environments such as Unmanned Aerial Systems.

The objective of the activity is to study, design and demonstrate the combination of eLoran and satellite SoOp for small Unmanned Aerial Systems.

The tasks to be performed shall include:

- Combine the resilience of eLoran measurements with the convenience of numerous satellite signals of opportunity for the PNT of small UASs.
- Equipment design: Develop a compact eLoran receiver and satellite-signal-of-opportunity user equipment suitable for a small UAS weighing 15–150 kg.
- Ensure that the equipment can operate in a potentially challenging electromagnetic-noise environment and uses antennas suitable for installation on a small UAS.
- Use a suitably compact SDR for processing.
- Test and demonstration: Fit the equipment to a suitable UAS and test its performance in flight.
- Provide suitable ground truth, such as RTK GNSS, while operating the system itself without GNSS input.
- Exploitation roadmap: Define how the technology can be matured and applied to PNT use cases.

The main outputs of the activity will consist of:

- Design documentation predicting UAS performance as a function of the eLoran implementation and selected signal-of-opportunity characteristics.
- SDR breadboard integrating eLoran and signal-of-opportunity joint-processing capabilities.
- eLoran/signal-of-opportunity processing software and Field Test Report.
- Commercialisation roadmap providing a pathway to NAVISP EL2.

It is noted that Italy and Austria expressed their opt-out for this activity (EL1-152).

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| *Funding required: 750k€* | *Duration: 18 months* | *ITT issue: April-2027* |

### 2.5.3. EL1-153: User-Level Integrity Architecture for eLoran in Resilient PNT Systems

The growing exposure of GNSS to jamming, spoofing, and space-weather effects underscores the need for complementary terrestrial PNT capabilities.

eLoran, as a high-power, low-frequency system that is inherently more resistant to jamming and spoofing than GNSS, is a strong candidate for integration into multi-layer resilient PNT architectures, especially as a means of transferring time.

Existing eLoran augmentation concepts, including the dissemination of differential corrections and integrity warnings, can improve performance and support integrity-related functions. However, their effective integration into safety-critical and regulated applications depends upon a clearly defined and validated user-level integrity framework.

The objective of the activity is to define, implement and validate a user-level integrity architecture tailored to eLoran signal characteristics. The bidder shall select and justify a representative application domain for its development and validation.

The tasks to be performed shall include:

- Conduct a state-of-the-art review and gap analysis of existing eLoran integrity approaches.
- Select and justify a representative target application domain for the development and validation of the integrity architecture.
- Define appropriate integrity metrics and performance measures, including protection levels, alert limits, time-to-alert and integrity risk, and derive the associated integrity requirements for the selected application domain.
- Develop an error model for eLoran, including system-level faults and error sources relevant to the selected application domain.
- Adapt relevant principles from GNSS user- and system-level integrity frameworks, such as RAIM/ARAIM and SBAS, to the eLoran domain.
- Develop system-level eLoran integrity concepts incorporating established augmentation and integrity-support mechanisms, including Additional Secondary Factor (ASF) calibration, Differential eLoran services and integrity data broadcast via the Loran Data Channel.
- Formally define the user-level integrity concept.
- Define a structured integrity architecture tailored to eLoran signal characteristics and the selected application domain, building upon the system-level and user-level integrity concepts.
- Develop mathematical models and algorithm specifications supporting the integrity architecture.
- Develop receiver-level fault-detection and exclusion algorithms based on time-of-arrival residuals, signal-quality monitoring and geometry analysis.
- Implement the integrity architecture and associated algorithms.
- Validate the integrity architecture through assessment of stand-alone eLoran receivers and hybrid configurations combining eLoran with GNSS and inertial sensors.

The main outputs of the activity will consist of:

- A user-level integrity architecture for eLoran tailored to the selected application domain, including integrity requirements, error models, supporting algorithms and interfaces to system-level integrity services
- Simulation framework, test scenarios and validation results supporting assessment of the integrity architecture
- Recommendations for integration into next-generation eLoran receiver designs
- Recommendations for enhancements to eLoran system architecture and standards
- Prototype software implementing the simulation environment and integrity-monitoring algorithms
- Prototype receiver implementation integrating positioning and integrity-monitoring functions, preferably in real time for field validation
- A commercialisation roadmap providing a pathway towards NAVISP EL2 activities

It is noted that Italy and Austria expressed their opt-out for this activity (EL1-153).

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| *Funding required: 750k€* | *Duration: 18 months* | *ITT issue: March-2027* |

### 2.5.4. EL1-154: Low luminosity technology for PNT

Resilient PNT aims to reduce reliance on GNSS signals, which may be unavailable, degraded or spoofed. Many navigation systems with low size, weight, power consumption and cost (SWaP-C) use visible cameras and therefore depend on adequate scene illumination, while infrared cameras can impose additional cost, power and integration constraints. Emerging passive and active low-light sensing technologies offer the potential to observe and track terrestrial features under very low illumination.

The objective of this activity is to identify, integrate and evaluate promising low-light sensors and associated sensor-fusion techniques, and to quantify their contribution to resilient PNT performance against visible-camera and infrared-camera baselines in representative environments.The tasks to be performed shall include:

- Define representative use cases, illumination conditions, navigation requirements and performance indicators for the experimental evaluation
- Conduct a state-of-the-art and market survey of passive and active low-light sensing technologies and select a limited number of promising sensors using performance, maturity, availability, SWaP-C and integration criteria
- Characterise the selected sensors under controlled low-light conditions and establish visible-camera and infrared-camera baselines
- Integrate the selected sensors into a prototype navigation chain and implement or adapt feature-tracking and sensor-fusion techniques, including fusion with inertial measurements
- Conduct controlled and representative field tests covering very low illumination and transitions between different illumination conditions

Evaluate navigation accuracy, drift, availability, robustness, processing demand and SWaP-C against the established baselines, and identify remaining technology gapsThe main outputs of the activity will consist of:

- State-of-the-art and sensor selection report
- Sensor characterisation
- Prototype navigation testbed and sensor-fusion software
- Experimental dataset and test report from controlled and representative environments
- Navigation performance evaluation against visible-camera and infrared-camera baselines
- Recommendations and roadmap for future development and demonstration

It is noted that Austria expressed their opt-out for this activity (EL1-154).

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| *Funding required: 500k€* | *Duration: 18 months* | *ITT issue: March-2027* |

### 2.5.5. EL1-155: Gravity Map Matching

Due to the shape and composition of the Earth's crust, each location in 3D space has a unique "gravity fingerprint", given sufficient sensitivity. Space missions such as ESA's GOCE have enabled the creation of gravity maps with an accuracy of 10-5 m/s².

Quantum sensors that can measure the gravity field with exquisite accuracy, together with recent advances in AI software that enable the removal of measurement noise, can allow the determination of location and navigation on land, in the air, at sea and underground, for manned and autonomous platforms. A particular focus is gravity-map generation to aid navigation with classical IMUs.

A quantum-enhanced gravimetric navigation system offers a passive, weather-independent and manipulation-proof backup to GNSS. Large-scale deployment of gravimetric sensors could also help produce better gravity maps for future resilient navigation.

The objective of the activity is the definition, implementation, and validation of a Gravity Map Matching navigation system.

The tasks to be performed shall include:

- Develop or select a high-performance gravity-measurement device based on quantum principles.
- Define and validate methods for determining location using a gravity map.
- Determine, through simulation, methods for updating the gravity map using measurements obtained by several devices in operation.

- Literature review and requirements: Review classical and quantum gravity sensors, including SWaP-C, performance, operational constraints, stabilisation requirements, dynamic range and ITAR constraints.
- Review techniques for making gravitational measurements from moving platforms.
- Review algorithmic techniques for converting raw gravity measurements into a map.
- Determine the requirements for a gravity map to aid classical inertial navigation in at least one operational environment.
- Concept and design: Select an operational environment and define a high-level architecture for generating a gravity map.
- Determine through simulation the improvements obtained by using several field devices and AI/ML processing methods.
- Build: Procure and integrate the required components into a demonstration system.
- Test: Conduct a field trial, generate a gravity map over a representative area and compare the data with the standard gravity model used in INS.

The main outputs of the activity will consist of:

- Simulation-framework definition, test scenarios and validation results.
- Prototype equipment.
- Recommendations for integration into next-generation GNSS/INS designs.
- Commercialisation roadmap providing a pathway to NAVISP EL2.

It is noted that Austria expressed their opt-out for this activity (EL1-155).

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| *Funding required: 800k€* | *Duration: 24 months* | *ITT issue: February-2027* |

### 2.6. EL1-156: Societal and Economic Impact and Benefit of ESA's NAVISP Program

In preparation for the Council at Ministerial level in 2028, ESA intends to assess and demonstrate the value, impact and benefits of its programmes on Participant States and participant economic operators. To ensure timely and adequate support, the Executive intends to initiate an external independent socioeconomic impact assessment of the NAVISP Programme, evaluating programme activities against the objectives defined in the Declaration.

The activity will evaluate the contribution of NAVISP to the objectives set out in the Programme Declaration through a comprehensive assessment of its economic, societal, technological and strategic impacts. The study will provide evidence of the benefits generated by NAVISP investments and serve as a dedicated contribution to the Agency-wide impact assessment planned in support of CM28.

The objective of the activity is to evaluate NAVISP's societal and economic impacts throughout its operational lifespan. These impacts shall identify the returns on investment

achieved, catalytic effects on industrial Research, Development and Innovation expenditure, and benefits to society arising from NAVISP outputs. This should be done using NAVISP data collected, researched information, stakeholder interviews, and expected future developments. A methodology consistent with the one used in other similar ESA's studies for other programs will be employed to guarantee comparison of the outputs.

The tasks to be performed shall include:

- Provide quantitative and qualitative assessments of the societal and economic impacts of the three NAVISP Elements.
- In addition to standard competitiveness metrics such as sales, job creation or patents filed, evaluate knowledge returns, impacts along value chains and outcomes from policy action.
- Estimate the value of the products developed by NAVISP in terms of resilience, sovereignty, and other geopolitical indicators.
- Develop case studies showcasing NAVISP successes across the different Elements and Participating States.
- Understand the data and practices that NAVISP should acquire and adopt to facilitate future analysis.
- Present recommendations to maximise future NAVISP impacts and benefits, reflecting the status of the PNT industry and best practices in public and private innovation and competitiveness support.

The main outputs of the activity will consist of:

- A report on the NAVISP socioeconomic impact and benefit, with recommendations for future phases
- A booklet illustrating success stories and the role played by NAVISP
- A report illustrating data and practices to adopt for future related studies

It is noted that Austria expressed their opt-out for this activity (EL1-156).

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| *Funding required: 300k€* | *Duration: 12 months* | *ITT issue: February-2027* |

## 3. WORK PLAN 2027 ACTIVITIES SCHEDULE

Table 2 summarizes the timeline for all the activities, including the Work Plan 2027 activities, considering the expected date for the Invitation-To-Tender (ITT) issue, the negotiation process and the Contract award and execution.

| ID | Name | 2027 | | | | | | | | | | | | 2028 | | | | | | | | | | | | 2029 | | | | | | | | | | | | 2030 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M |
| EL1-135 | Resilient Geodetic Infrastructure for Next-Generation PNT | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-136 | AI-Generated GNSS Multipath Digital Twins for Drone-Based Infrastructure Inspection, Planning, and Safety Assurance | | | | | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-137 | 4D Ionospheric concept/simulator to allow multilayer high precision applications | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-138 | Improved interference mitigation by using novel multi-element antenna techniques | | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-139 | Multi-Band CRPA Architecture for Next-Generation GNSS Services | | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-140 | Locating jammers using cooperative aircraft CRPAs | | | | | | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-141 | Low-Power Compact Array receivers for Resilient GNSS Navigation | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-142 | Wide-Angle C-Band CRPA Technology for Enhanced GNSS Resilience | | | | | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-143 | C-band Ultra Wide-band & Omni Compact Antenna System for Hand-Held Users | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-144 | Compact high TRL Atomic Clock development for PNT applications | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-145 | eLoran disciplined oscillator for improved and resilient terrestrial timing dissemination | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-146 | ADHA 3U High Accuracy GNSS Space Receiver | | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-147 | Compressed-Sensing Snapshot GNSS Receiver for Low-Power Devices | | | | | | | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-148 | A Snapshot-Based Receiver Concept for LEO PNT | | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-149 | Highly Power-Efficient Snapshot GNSS Space Receiver | | | | | | | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-150 | Re-configurable SDR Space Receiver Technologies | | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-151 | Deployable tactical eLoran system | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-152 | Signals of opportunity fused with eLoran for drone navigation | | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-153 | User-Level Integrity Architecture for eLoran in Resilient PNT Systems | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-154 | Low luminosity technology for PNT | | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-155 | Gravity Map Matching | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| EL1-156 | Societal and Economic Impact and Benefit of ESA's NAVISP Program | | ITT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 2 - Activities' ITT and Contract execution planning