

EUROPEAN SPACE AGENCY

NAVISP Element 1 Work Plan 2026

List of Proposed Procurements

ID	Name	Duration (months)	Funding Required (k€)	ITT issue
EL1-116	Design of CRPAs for aviation and high-accuracy services	24	900	May-26
EL1-117	Resilience Techniques and Algorithms for GNSS Space Receivers in Interference, Jamming and Spoofing Conditions	24	500	Sep-26
EL1-118	On demand PNT services during crisis	18	500	Jul-26
EL1-119	Dual Polarization Arrays for compact resilient GNSS Receivers	18	800	Sep-26
EL1-120	Resilient PNT Critical National Infrastructure validation test bench	18	600	Jun-26
EL1-121	Resilient PNT based on Lasers	24	900	Jan-26
EL1-122	Acoustic arrays for Drones localization and identification	24	600	Apr-26
EL1-123	Quantum Magnetometer and algorithms for integrated Map Matching and Map Building	18	800	Jan-26
EL1-124	Optimisation of PVT engines for LEO measurement diversity	18	600	Apr-26
EL1-125	Receiver Architectures and Beam Scheduling Strategies for Fused-PNT Concept	24	900	Nov-26
EL1-126	Approximate Computing for Low-Power GNSS Signal Processing	18	250	May-26
EL1-127	Cross-Domain Nonlinear State Estimation for Autonomous Systems Using Unscented Kalman Filtering	18	500	Apr-26
EL1-128	Resilient PNT Critical National Infrastructure case study	12	200	Feb-26
EL1-129	Identification of Growth Opportunities in PNT Consumer Market	12	200	Jan-26

Table 1 – List of proposed activities and their budget allocations

1.1. EL1-116: Design of CRPAs for aviation and high-accuracy services

Jamming and spoofing of GNSS are a major concern. A controlled reception pattern antenna (CRPA) is one of the most powerful technologies to mitigate jamming and spoofing. As a result, it is attractive to start using CRPAs for several applications, including aviation and high-accuracy services. However, the use of a specific CRPA for specific applications requires a detailed evaluation of the performance of this CRPA. In the field of aviation, it is mandatory to identify which designs of CRPAs avoid unacceptable side effects such as large biases. Unacceptable side effects are side effect which may impact the safety of the aviation user. In the field of high-accuracy services, it is mandatory to identify which designs of CRPAs avoid unacceptable side effects such as large phase centre offsets. Unacceptable side effects may lead to a major impact on the performance of PPP and RTK.

The objective of this activity is to provide recommendations for: 1) the design of a real-time CRPA for aviation, 2) the design of a real-time CRPA for high-accuracy services, and 3) the requirements on CRPAs, to allow the introduction of CRPAs in aviation.

The tasks to be performed shall include:

- Develop an off-line aviation CRPA and an off-line high-accuracy CRPA (laboratory set-up, post-processing only);
- Perform laboratory tests (using a combination of RF simulations and software simulations):
 - o characterize the aviation CRPA's nominal and non-nominal performance (during GNSS Feared Events, jamming and spoofing attacks, CRPA hardware failures);
 - o characterize the high-accuracy CRPA's performance (during jamming and spoofing attacks: impact for example on cycle slips, biases, noise);
- Derive recommendations for the design of a real-time CRPA for aviation and the design of a real-time CRPA for high-accuracy services;
- Derive recommendations to introduce a CRPA in aviation standards.

The main outputs of the activity will consist of:

- Two offline CRPAs (one for aviation and one for high accuracy);
- CRPA software simulator;
- Technical Notes documenting the outcome of the tasks performed.

It is noted that no Participating State expressed their opt-out for this activity (EL1-116).

<i>Funding required: 900k€</i>	<i>Duration: 24 months</i>	<i>ITT issue: May-2026</i>
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1.2. EL1-117: Resilience Techniques and Algorithms for GNSS Space Receivers in Interference, Jamming and Spoofing Conditions

The threats of ground-based interference, jamming, and spoofing impacting terrestrial and aviation receivers are well recognised by the navigation community, driving many system-level and user-level mitigation studies and technology developments. However, sufficient attention has not yet been given to the impact and mitigation of these threats on GNSS space receivers in LEO (commercial and institutional activities alike). Events of jamming impacting the space receivers flying over areas with known jammer presence have been recently reported, which could cause degradation of the received signal quality and sometimes reduction of the number of usable satellites for PVT. The ever-growing number of missions at the LEO altitude and the wide adoption of GNSS receivers for more advanced spacecraft autonomy and autonomous manoeuvres call for the adoption of techniques increasing the resilience of the space infrastructure. Shared and clear specifications about the threats and related scenarios supporting GNSS space receiver development are also needed.

The objective of this activity is to study and prototype detection and mitigation techniques of GNSS space receivers against interference, jamming, and spoofing, and to define standardised threats and scenarios to support future specifications.

Given the very wide scope of jamming and spoofing attacks, the activity will be defined very carefully allowing the best usage of the limited allocated budget.

This activity is not focusing on RFI monitoring (which is a prerogative of ITU administrations, i.e. ITU member states) but addresses the “Toughening” part of the PTA paradigm, to devise means at space receiver level to identify and mitigate RFI. Drawing a parallel with terrestrial, they implement various techniques, at Antenna and Signal Processing level, to increase the resilience to RFI. These receivers do not ‘monitor’ the environment in the sense they do not store or forward information about the RFI. Their only objective is to maintain the performance during RFI events.

The tasks to be performed shall include:

- To study and evaluate possible novel approaches or spin-in technologies from terrestrial applications to improve the receiver’s resilience against jamming and spoofing, leveraging the specific operational conditions in space;
- To analyse interference, jamming, and spoofing threats and scenarios and propose their standardisation to support future specifications of space receivers;
- To prove the concept through simulations and early prototyping of down-selected technologies.

The main outputs of the activity will consist of:

- Technical notes summarizing the solutions;
- Results of simulations and early breadboarding;

- Definition of threats and scenarios;
- Validation report summarizing the achievable PVT performance.

It is noted that no Participating State expressed their opt-out for this activity (EL1-117).

<i>Funding required: 500k€</i>	<i>Duration: 24 months</i>	<i>ITT issue: Sep-2026</i>
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1.3. EL1-118: On demand PNT services during crisis

The success of satellite-enabled PNT applications is accompanied by a growing dependency of our society and economy on the availability of GNSS, which has motivated R&D, demonstration as well as deployment of so-called Alternative PNT systems (APNT).

This dependency extends to GNSS augmentation systems and PNT capabilities relying on local terrestrial infrastructures which can be exposed to outages, for instance in situation of natural disaster or humanitarian crisis. Examples include sensors stations, emergency call location by terrestrial networks, AGNSS, RTK, PPP and differential augmentation systems, and timing terrestrial distribution (e.g. NTP and PTP).

Satellite systems such as satnav, satcom and earth observation have since long demonstrated their utility in supporting crisis management. As the feasibility of using satellite communications for PNT is being demonstrated, satcom capabilities could be activated for PNT on a temporary and/or regional basis, in support of crisis management and for recovering the terrestrial PNT capabilities, delivering capabilities, on-demand and as seamlessly as possible, to relevant stakeholders such as first responders and operators affected by the outages.

The objective of this activity is to investigate concepts to leverage satellite communications systems for on-demand PNT capabilities in support of crisis management, and encompass small-scale, laboratory level proof of concepts. For this, the study will contemplate advanced satellite communications systems for broadband internet (e.g. Ku/Ka-band links) as well as Direct-to-Handheld by satellite.

The foreseen tasks shall therefore include:

- Survey of the relevant state-of-the-art (for example, PNT and APNT, satellite communications, lessons learned from past use of satellite communications in crisis management), and identification of candidate use cases and potential applications;
- Definition of potential system concepts and requirements mapped to the identified use cases, contemplating in particular backward compatibility with nominal systems, the impact on the user equipment, and seamless handover to the ad-hoc capability;

- Preliminary design and feasibility assessment of the candidate concepts, identification and demonstration of key components and functions with small scale proof of concepts in laboratory environments;
- Derivation of a roadmap towards broader scale demonstration and potential pre-operational systems to be demonstrated in subsequent activities of ESA R&D Programmes.

The main outputs of the activity will consist of:

- Mission study and roadmap report;
- Verification report of the laboratory proof of concept.

It is noted that no Participating State expressed their opt-out for this activity (EL1-118).

<i>Funding required: 500k€</i>	<i>Duration: 18 months</i>	<i>ITT issue: Jul-2026</i>
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1.4. EL1-119: Dual Polarization Arrays for compact resilient GNSS Receivers

The ability of exploiting the spatial dimensions has made array antennas valuable for many applications, e.g., multipath and interference mitigation, spatial diversity, and localization. Consequently, over the past years, array antennas, i.e. Controlled Reception Pattern Antennas (CRPA), have been deployed with GNSS receivers either to provide a spatial filter (null steering techniques) or to improve the SNR level using beamforming techniques. Nonetheless, in order to achieve a high spatial resolution, a large array antenna aperture should be employed. However, in many applications a large array antenna is not possible due to size limitations. Therefore, utilizing dual polarization antennas, instead of single polarization antennas, will provide a compact solution. This compact antenna array antenna exploits a small size while increasing the array antenna degrees of freedom.

Because of the usage of Dual Polarisation, this compact array will enable the following features:

- High beamforming gain compared to single polarization antenna array of the same size;
- Higher amount of jamming and spoofing signals mitigation than the number of deployed antennas;
- Deeper nulls towards interference, spoofing and multipath effect compared to a single polarization array antenna;
- Accurate Angle of Arrival (AoA) estimations of the satellites genuine signals, jamming and spoofing signals and, reflected multipath signals;
- The accurate AoA estimates will enable angle-based positioning solutions for resilient coarse PNT solutions, i.e. operation in service denied environments.

The objective of this activity is to design a compact Dual Polarization Arrays Antennas (DPAA) that is suitable for vehicles, planes, drones or mobile devices.

The tasks to be performed shall include:

- study the state of the art of DPAA systems in the context of navigation;
- design a dual polarization CRPA that can suppress various jamming and spoofing attacks that vary from low to high power, single to multiple attackers, low to high altitude attacks. Furthermore, include in the design the capability to exploit the dual polarization multiple antennas to estimate the AoA of the genuine signals, jamming and spoofing signals, and reflected multipath signals;
- validate the system performance in controlled and real-life environments (target TRL=5), including:
 - o a very high jamming and spoofing suppression gain;
 - o AI-based identification techniques for various jamming and spoofing attacks, and suitable countermeasures;
 - o AoA optimized estimation techniques that exploit the spatial and polarization diversities able to provide a coarse positioning and timing solutions in a denied service environment.

The main outputs of the activity will consist of:

- Design Justification File that contains the outcome of the State-of-the-Art review and the description of the system design;
- Hardware and Software implementation;
- Test report

It is noted that no Participating State expressed their opt-out for this activity (EL1-119).

<i>Funding required: 800k€</i>	<i>Duration: 18 months</i>	<i>ITT issue: Sep-2026</i>
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1.5. EL1-120: Resilient PNT Critical National Infrastructure validation test bench

Satellite navigation has widespread usage and very satisfactory performance for most of the professional and consumer applications. However, for certain uses, there is increasing awareness of satellite navigation weaknesses and limitations.

In his keynote address at the IEEE/ION PLANS 2025 the “Father of GPS” Dr. Brad Parkinson, who proposed the “Protect, Toughen, Augment” (PTA) framework for PNT applicable to Governments, Industry and Academia, attempted to push forward the implementation of the resilience in PNT. The message was that it is important to recognize the weaknesses and limitations, and design layered responses to overcome them and provide PNT assurance. In his intervention, he tries to define what “assured PNT” is, as a function of the performance the product or service has to deliver as a minimum. He defines therefore 5 Categories of applications: Common, Basic, Advanced, Survey and Time.

In 2020, the US Department of Homeland Security defined four levels of resilience as part of the US Resilient Positioning, Navigation, Timing Conformance Framework, that is now transitioning to the IEEE P1952 Standard. The ascending order is aligned with the increasing level of resilience, but not all applications require the maximum level 4.

In several ESA Member States initiatives have emerged on the subject, with, among the others, studies and technology developments implemented under NAVISP, which also helped to frame the problem (from the early EL3-014 “GNSS Event Notification Service” to the recent EL3-037 “Supporting the UK public sector in PNT Awareness, Research and Knowledge” and EL3-031 “National GNSS Knowledge Center”).

As a notable example, the Royal Institute of Navigation (RIN) in UK realized a “Resilient PNT Resources portal” on the Internet, to support Critical National Infrastructure (CNI) operators and suppliers to understand why resilience to intentional and unintentional, natural and man-made threats and, in general, PNT disruptions, is important for their mission. According to RIN, the key principles for Resilient PNT are: 1) “Prepare for PNT disruptions”; 2) “Act when PNT disruptions occur”; and 3) “Recover from PNT disruptions”. Fundamental aspects in the application of these key principles are, respectively, to “Test system responses to understand effects of PNT disruptions on system behaviour”, to “Detect disruption events as soon as possible after they occur” and to “Share lessons learned when reporting incidents and their associated impacts”.

The objective of the proposed activity is to make available in the ESA Member States industries the most important technologies to ensure that CNI Operators and suppliers can comply with the requirements of the Prepare/Act/Recover key principles for Resilient PNT. In the event that the activity has to use or generate sensitive information, it will be handled in compliance with the national law of the Contractor and with the provisions for Limited Distribution information (Protection Level 2) at ESA level.

The tasks to be performed shall include:

- Survey common and typical CNIs and define use cases of PNT technology integrated into them and its related potential disruptions. For example, GNSSs is used almost everywhere to achieve time synchronisation to UTC, standalone (often with an external clock to provide a holdover mechanism during disruptions) or in combination with network protocols like NTP/PTP. For several CNIs (for example tracking of dangerous goods), location of assets will also be based on GNSS;
- Design and develop a validation test bench, with the capability to inject to representative equipment, sub-systems, and systems under test, as applicable, signals impairment, also collected in the field with RF signal samplers, with different levels of disruption (for example, GNSS RF jamming and spoofing), and to measure the impact over nominal performance;
- Develop a comprehensive, well-labelled training database for GNSS interference detection using Machine Learning (ML), to support the benchmarking of ML algorithms;
- Perform independent FTA and FMECA analysis of existing products and services, in collaboration with PNT products and services suppliers, to suggest products and services improvements as regards the mechanisms and the latency for the detection of disruption events;

- Design a searchable database of Lessons Learned, including all the technical details regarding the characteristics of the events and their impact on various classes of PNT equipment, necessary to perform searches and correlations with newly observed events, and populate it with representative records.

The main outputs of the activity will consist of:

- Validation test bench to evaluate the response to PNT disruption events, with user manual;
- Database of Lessons Learned populated with representative records, with user manual;
- Final report incorporating use cases descriptions, test bench design and verification, description of disruption events detection mechanisms and Lesson Learned database description.

It is noted that no Participating State expressed their opt-out for this activity (EL1-120).

<i>Funding required: 600k€</i>	<i>Duration: 18 months</i>	<i>ITT issue: Jun-2026</i>
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1.6. EL1-121: Resilient PNT based on Lasers

GNSS-based systems are increasingly exposed to interference, RF jamming and spoofing. This is an unacceptable risk for safety-critical operations. A laser-based positioning system can mitigate these threats through the inherent resilience and directionality of optical links. Narrow beams allow for selective PNT services and make interception or false-signal injection difficult. This results in a significantly more robust solution, providing a high-integrity backup or alternative to RF navigation. Such capability is particularly valuable for ILS and private PNT services, where continuity, integrity, and controlled coverage are essential.

The objective of this activity is to create and validate the concept of a Laser-Based Positioning System that employs a multi-beam optical receiver terminal capable of independent, real-time state estimation. Therefore, it must be able to acquire, demodulate PNT signals over an optical carrier wave. This system aims to provide a secure, interference-immune alternative to GNSS, SBAS or GBAS for critical infrastructure scenarios such as aircraft landing systems.

The tasks to be performed shall include:

- Design a multi-beam optical receiver terminal capable of autonomously acquiring, tracking, and demodulating multiple laser beams.
- Implement a PNT processing chain that utilizes ToA/TDoA/AoA (or a hybrid approach) for position determination on the receiver side.
- Combine the optical transmitter and receiver subsystems into a functional prototype for a precision instrument approach and landing system. Multi-beam reception to be demonstrated on land.

- Demonstrate an optical PNT link between the receiver prototype developed under this activity carried by an aircraft and at least two transmitters on ground can be achieved. This will validate that PNT based on lasers is a viable option for a precision instrument approach and landing system.

The main outputs of the activity will consist of:

- A demonstration that PNT signals can be transmitted over an optical carrier.
- A mobile user terminal that autonomously acquires multiple laser beams and computes its position onboard in real-time.
- Performance data of the prototype in flight compared to RF based ILS systems
- Documentation of the design, testing procedures, and performance benchmarks.

It is noted that no Participating State expressed their opt-out for this activity (EL1-121).

<i>Funding required: 900k€</i>	<i>Duration: 24 months</i>	<i>ITT issue: Jan-2026</i>
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1.7. EL1-122: Acoustic arrays for Drones localization and identification

Drones, or Unmanned Aerial Vehicles (UAVs), have evolved from defence applications into versatile platforms used across industries. They can fly autonomously or via remote control and are equipped with sensors and payloads for tasks such as crop monitoring, infrastructure inspection, environmental surveillance, logistics, and emergency response. As drone technology advances, features like AI, real-time analytics, and swarm coordination are enabling smarter, more adaptive aerial systems.

With growing drone usage, localization and identification have become critical—whether for monitoring legitimate operations or detecting malicious intent. Traditional methods for tracking and detecting drones include radar and RF signal tracking. While radar is effective, it is easily detectable and, hence, it can be circumvented. RF monitoring works well unless drones operate silently, without transmitting signals—a trend seen in Silent Drones.

In such cases, acoustic noise becomes the only detectable signature. Acoustic surveillance, widely used underwater, is now being explored for aerial drone detection. This activity proposes a large-scale acoustic array—thousands of sensors—to detect, localize, and identify drones based on their sound emissions, typically generated by the propellers' blades. Early demonstrations using 64 microphones in controlled environments have shown promising results in tracking drone movement (see for example “Flight path tracking and acoustic signature separation of swarm quadcopter drones using microphone array measurements”. Quiet Drones conference, Paris 2020”).

The objective of this activity is to study, design, and demonstrate various identification and localization techniques, for drones and UAVs, using the acoustic signature of the airborne object.

The tasks to be performed shall include:

- Design of a Ultra-large acoustic array and a high-speed processing unit;
- Design of algorithms that exploit the ultra-large acoustic array to estimate the AoA of the drones' acoustic noise;
- Implementation of localization algorithms based on the AoA estimates from multiple acoustic arrays;
- Implementation of AI-empowered algorithms to identify, among the others, the drones' size and type;
- Validation and experimentation of the system in real-life environment.

The main outputs of the activity will consist of:

- Design Justification File (DJF) that contains a review of the State-of-the-Art and the system design;
- Hardware and Software implementation;
- Test report

It is noted that no Participating State expressed their opt-out for this activity (EL1-122).

<i>Funding required: 600k€</i>	<i>Duration: 24 months</i>	<i>ITT issue: April-2026</i>
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1.8. EL1-123: Quantum Magnetometer and algorithms for integrated Map Matching and Map Building

Magnetic crustal anomaly navigation is an alternative PNT technique which leverages the fact that the Earth's crustal magnetic field exhibits spatial variations that can serve as a unique "fingerprint" for positioning. With sufficient sensitivity, these anomalies can be measured and matched to reference maps, enabling navigation in environments where other signals are unavailable or degraded. This approach is inherently passive, weather-independent, and resistant to external manipulation.

Recent research in quantum sensing, notably nitrogen vacancy diamond (a diamond presenting a vacancy in the structure and a nitrogen atom replacing a carbon atom) and atomic vapor cell magnetometers, enables sub-nanotesla resolution at room temperature. In addition, AI-based algorithms now allow for improved noise suppression to make the measurements in the field feasible. These developments open the door to a new class of

navigation systems that combine quantum sensors, AI, and distributed map matching to deliver alternative positioning across land, sea, air, underground, and potentially space domains. A core capability of adding a magnetometer to a navigation platform is on-board magnetic map building: during normal operations, the quantum magnetometer incrementally constructs and maintains a high-resolution magnetic map of the environment, which can then be relied upon for robust map matching and localization in GNSS-degraded or GNSS-denied scenarios. Initiatives in this direction are underway outside Europe (for example by SandboxAQ in US and Q-CTRL in Australia), but comparable efforts are not yet established within Europe.

The objective of this activity is to design, develop, and demonstrate a map-matching and map-building quantum crustal magnetometer-based navigation platform.

The tasks to be performed shall include:

- System design for a set of operational scenarios determined during the activity
- Prototype of a room-temperature quantum magnetometer breadboard integrated in a navigation platform to perform map matching and building;
- AI-based filtering algorithm development;
- Field demonstrations in one of the operational scenarios.

The main outputs of the activity will consist of:

- Breadboard of the quantum magnetometer navigation platform;
- Software stack of the automated map matching/building ability;
- Test Campaign/Demonstration datasets;
- Field test report;
- Documentation package including system architecture and operation of the prototype.

It is noted that no Participating State expressed their opt-out for this activity (EL1-123).

<i>Funding required: 800k€</i>	<i>Duration: 18 months</i>	<i>ITT issue: Jan-2026</i>
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1.9. EL1-124: Optimisation of PVT engines for LEO measurement diversity

LEO-PNT stands out among the very promising evolutions of spaceborne PNT systems towards Multi-Layer Satellite Systems (MLSS), leveraging differentiators such as:

- Whitening of measurements, in particular multipath;
- More diverse opportunities to exploit doppler measurements in addition to ranging;

- Faster transition between LOS and NLOS status, beneficial to the awareness of the signal LOS nature;
- Shorter cycles between obstructed and unobstructed signals, which can be exploited to optimise the fusion with drifting dead-reckoning.

So far, most works that showcase LEO-PNT differentiators have derived LEO-PNT performances based on GNSS PVT engines (assuming atomic clocks on board satellite, Code Division Multiple Access and four simultaneous ranging measurements) processing LEO-PNT measurements, or tailoring GNSS models to LEO measurements in synthetic scenarios. Despite outstanding performances and availability resulting from R&D capitalised over 30 years and more, these engines have been optimised with and for MEO measurements, which are likely sub-optimal for LEO and therefore possibly not exploiting the full benefits of LEO measurement diversity and the aforementioned differentiators.

The objectives of the activity are to study, design, and demonstrate optimal PVT engines exploiting measurements diversity of LEO-PNT in challenging environments, for standalone and hybrid (dead-reckoning) concepts of operations. Two design approaches will be implemented and compared: conventional design featuring Kalman Filtering, and use of AI/ML allowing to exploit potentially unknown or unexpected behaviour of LEO measurements.

The activity will complement the ongoing and planned upstream activities in Europe (R&D, demonstration and in-orbit preparation) by maturing further downstream technologies suitable for the prospects of both commercial and institutional LEO-PNT systems.

The tasks to be performed shall include:

- Survey the state-of-the-art for LEO-PNT signal processing and positioning engines;
- Investigate the various nature and potential benefits of LEO-PNT measurements diversity, such as multipath whitening, optimal use of Doppler, exploitation of the higher transition rates between NLOS/LOS and obstructed/unobstructed signals, for standalone and hybrid (dead-reckoning) concepts of operations;
- Implement two design approaches: 1) a conventional design featuring Kalman Filtering, and 2) an AI/ML-based design allowing to exploit potentially unknown or unexpected behaviour of LEO measurements;
- Compare the two novel design approaches against a more traditional MEO GNSS-based design with a measurement campaign in the field (either in real time or post processing depending on the opportunities).

The main outputs of the activity will consist of:

- State of the art, optimal design of PVT engines exploiting LEO-PNT measurement diversity;
- Breadboard, benchmark against a PVT engine devised based on MEO GNSS principles, performance test report;
- Roadmap for commercialization, including potential Navisp EL2 activities and lessons-learned / feedback to pursue optimal design of European's LEO-PNT systems.

It is noted that no Participating State expressed their opt-out for this activity (EL1-124).

<i>Funding required: 600k€</i>	<i>Duration: 18 months</i>	<i>ITT issue: Apr-2026</i>
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1.10. EL1-125: Receiver Architectures and Beam Scheduling Strategies for Fused-PNT Concept

The current and future LEO satcom constellations operating in Ku and Ka bands are considering, along with the provision of the main communication services, also a native provision of positioning, navigation, and timing (PNT) services. Leveraging the existing satcom frequency bands and signals, the concept of such integration is referred to as Fused PNT, promising increased resilience and independence of the user segment from GNSS. Examples include Starlink, which already offers GNSS-free operation at the user level, OneWeb and Amazon Kuiper, for which PNT studies are ongoing. Provision of PNT service with 5G/6G Non-Terrestrial Networks (NTN) is also being actively investigated by 3GPP. The satcom signal coverage in Ku and Ka bands is achieved through highly directive spot beams. To ensure that the user can collect measurements from enough satellites for PNT (ideally 4 or more), a specific receiver architecture and a suitable beam scheduling strategy at the satellite level have emerged as some of the key enablers of the Fused PNT concept. PNT with a lower number of satellites, requiring multi-epoch processing, is also of interest, albeit the achievable performance is lower.

The objective of the activity is to study receiver architectures and suitable beam scheduling strategies and to develop a receiver prototype enabling the Fused PNT concept with 5G/6G non-terrestrial networks (NTN) in Ku and Ka bands, learning also from other satellite constellations designs.

This activity has been coordinated with activities run in the context of Horizon Europe.

The tasks to be performed shall include:

- To study receiver architectures and solutions that enable Fused PNT concept with 5G/6G NTN, including among the others the 5G PRS signal, in Ku and Ka bands.
- To perform a field campaign with OneWeb and Starlink downlink signals, and assess real-world PNT performance (possibly based on network-based differential PNT) for satcom mega-constellations and beam scheduling strategies.
- To study suitable beam scheduling strategies at the satellite level that ensure that the user can collect measurements from enough satellites for PNT (ideally 4 or more).
- To benchmark realistic satcom terminals in terms of number of beams and beam switching time, with a basic signal generator.
- To prove the concept through development of a prototype receiver, verified in an anechoic chamber.

The main outputs of the activity will consist of:

- Technical notes summarizing the field campaign, receiver architectures and solutions, and evaluation of different beam scheduling strategies matching the user capabilities.
- Prototype receiver.
- Validation report summarizing the results of benchmarks and achievable PNT performance.

It is noted that no Participating State expressed their opt-out for this activity (EL1-125).

<i>Funding required: 900k€</i>	<i>Duration: 24 months</i>	<i>ITT issue: Nov-2026</i>
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1.11. EL1-126: Approximate Computing for Low-Power GNSS Signal Processing

Global Navigation Satellite Systems (GNSS) play a crucial role in providing accurate positioning, navigation, and timing information for a wide range of applications, ranging from daily mobile phone use to infrastructure and military activities. Nevertheless, GNSS receivers often require considerable computational resources to process the received GNSS signals, especially during the correlation process between the input signal and the local replica signal. As these systems evolve toward more energy-efficient processing solutions, new methods must be employed in a way to achieve the right balance between accuracy, speed, and power efficiency.

Approximate Computing (AxC) provides approximate results within an acceptable precision for the intended application, offering the advantage of considerably reducing energy consumption. This is achieved by using specially designed logical circuits, such as approximate adders and multipliers, that simplify calculations by trading off some accuracy for lower power and faster processing. AxC can significantly extend battery life in mobile GNSS devices. This is particularly beneficial for consumer electronics, wearables, and IoT devices where power efficiency is crucial. Thanks to this feature, AxC could find use also in the acquisition and tracking of the Galileo E5 Quasipilot signal, which is designed to ease the GNSS signal acquisition process, particularly in limited Power platforms. Moreover, AxC techniques could also be relevant for spaceborne GNSS receivers, where power and processing resources are often limited. However, the challenge is maintaining accuracy within acceptable bounds.

The objective of this activity is to explore how AxC techniques can be applied to GNSS signal processing to reduce power consumption while maintaining sufficient accuracy at acquisition, tracking and PVT stages.

The tasks to be performed shall include:

- Identify the most relevant AxC for GNSS signal processing.
- Development of a prototype of a GNSS receiver using AxC and exact computations.
- Tests to characterize the performance of the receiver (in terms of power consumption, accuracy, correlation degradation, etc.).

Note that as the budget is limited, data from ESA Navigation Laboratory can be provided and can be replayed on the AxC GNSS receiver from different environments: open sky, urban, and jamming environments.

The main outputs of the activity will consist of:

- Technical Notes to describe the tradeoffs and the design
- Prototype of a complete GNSS receiver using AxC (acquisition, tracking and PVT). The receiver does not need to work in real time, but it needs to provide two modes (nominal mode and AxC-mode). It shall provide:
 - Bit grabber to collect IQ samples from live data and playback from a laboratory (e.g. a USRP and a GNSS antenna);
 - Test equipment to Control and Monitor GNSS receiver and the bit grabber.

It is noted that no Participating State expressed their opt-out for this activity (EL1-126).

<i>Funding required: 250k€</i>	<i>Duration: 18 months</i>	<i>ITT issue: May-2026</i>
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1.12. EL1-127: Cross-Domain Nonlinear State Estimation for Autonomous Systems Using Unscented Kalman Filtering

Autonomous systems, whether operating on land, in the air, at sea, or in structured indoor environments, require robust, real-time state estimation to navigate complex, dynamic, and GNSS-challenged conditions. Traditional estimation techniques such as the Extended Kalman Filter (EKF) often rely on local linearization of the system dynamics and measurement models, which can result in degraded performance in highly nonlinear and uncertain environments. This limitation is particularly acute when combining heterogeneous sensors (e.g., GNSS, IMU, LiDAR, and vision), where unmodeled nonlinearities and noise can accumulate rapidly and compromise safety, resilience, and autonomy.

This study proposes the development of a modular Unscented Kalman Filter (UKF)-based state estimation engine designed to operate reliably in GNSS-challenged and sensor-degraded scenarios. The UKF, which propagates a distribution of sigma points through nonlinear dynamics without requiring Jacobian calculations, has demonstrated superior accuracy over EKF in simulated and real-world applications. Despite its theoretical advantages, the UKF remains underutilized in real-time autonomous platforms due to computational concerns and a lack of integrated cross-domain frameworks.

The objective of this activity is to design, prototype, and validate a real-time, UKF-based estimation framework optimized for autonomous systems, enabling robust multi-sensor fusion and accurate vehicle state estimation under challenging conditions.

By leveraging advanced unscented transformations and adaptive noise modelling techniques, the framework will be designed to preserve accuracy and integrity even in scenarios involving sensor degradation, GNSS outages, or highly dynamic motion.

The activity will target, as the primary domain, either ground vehicles, integrating data from automotive-relevant sensors (GNSS, IMU, odometry, LiDAR), or aerial systems (e.g.

drones), at the discretion of the bidder, to demonstrate feasibility via an experimental campaign.

Key innovations include:

- Nonlinear estimation without linearization, preserving model fidelity and accuracy;
- Adaptive noise modelling to enhance robustness in variable conditions;
- Modular, domain-specific architecture suitable for integration into ADAS, autonomy stacks, or vehicle control systems;
- Platform validation, including optional demonstration on ground vehicle and / or UAVs to illustrate domain portability.

The tasks to be performed shall include:

- Use Case Description & Requirements Capture;
- System Modelling & Sensor Abstraction;
- UKF Framework Design;
- Prototype Deployment and Hardware-in-the-Loop (HiL) Testing;
- Field test Validation, performing comparative testing with EKF and other benchmarks;
- Impact Assessment & Roadmap for commercialization or further development

The main outputs of the activity will consist of:

- A validated UKF prototype for real-time multi-sensor fusion;
- A performance benchmark against EKF and other conventional filters;
- A reference dataset for testing in automotive scenarios, including urban, rural, and off-road use cases, or in aerial systems scenarios;
- An integration roadmap for commercial automotive or aerial systems applications, including, for example, potential follow-up work on compliance to ISO-26262 (Road vehicles – Functional safety standard), automotive-grade hardware deployment, and open-source module release.

It is noted that no Participating State expressed their opt-out for this activity (EL1-127).

<i>Funding required: 500k€</i>	<i>Duration: 18 months</i>	<i>ITT issue: Apr-2026</i>
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1.13. EL1-128: Resilient PNT Critical National Infrastructure case study

The rationale and context for this study are similar to as “EL1-120: Resilient PNT Critical National Infrastructure validation test bench”.

One of the considerations that can be derived by the analysis of the context is that the extent of the exposure of CNIs operators and suppliers to the risks posed by intentional and unintentional, natural and man-made RF interference threats is not very well known in all member states. Indeed, according to the Organisation for Economic Co-operation and Development, in the civilian realm alone, “space-based systems are integral to more than 50% of critical infrastructure and services” in its members.

The objective of the activity is to make a status of the stances of CNIs with respect to the implementation of a Resilient PNT posture. In the event that the activity has to use or generate sensitive information, it will be handled in compliance with the national law of the Contractor and with the provisions for Limited Distribution information (Protection Level 2) at ESA level.

The tasks to be performed shall include:

- Organise surveys, interviews with CNI operators and suppliers in ESA Member States, sampling their posture for the implementation of Resilient PNT in their systems; offer briefings to explain and promote Resilient PNT Best Practices and to give practical guidance on the subject;
- Provide anonymised qualitative and quantitative assessment of the CNI operators and supplier awareness on Resilient PNT importance;
- Provide anonymised case studies showcasing behaviours which represent minimum, average and full adherence to the Resilient PNT mindset.

The main output of the activity will consist of:

- a report on the Resilient PNT posture of CNI operators and suppliers;
- a dashboard illustrating the Resilient PNT posture figures, aggregated and per Participating State;
- a booklet illustrating representative Case studies.

It is noted that no Participating State expressed their opt-out for this activity (EL1-128).

<i>Funding required: 200k€</i>	<i>Duration: 12 months</i>	<i>ITT issue: Feb-2026</i>
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1.14. EL1-129: Identification of Growth Opportunities in PNT Consumer Market

The global GNSS market is predicted to grow considerably in the next decade, with revenues coming from the sale of devices and even more services, and the wider PNT domain revenues are even bigger. Europe share in this market is around 23%, mostly in the professional markets, and it is not expected to increase. Except for few manufacturers located in Europe (e.g. uBlox and STM), the consumer market is typically presided over by non-European companies. Several European stakeholders and organizations wish to try to change this situation. For example, the EC has drawn up the European Chips Act, noting

that the EU's share of the global chip market is only 10%. At ESA, two of the goals for the near future are to “Strengthen European autonomy and resilience” and to “Boost Growth and competitiveness”. The ESA GSTP program is investing millions in the development and manufacturing of integrated circuits for space infrastructure. The NAVISP Advisory Committee has recommended in the recent past the Programme to devote budget to more risky developments of PNT microchips. At Member States level, GNSSs, PNT and Space systems in general are recognized as providing considerable economical value, with related products and services bearing strategic importance, and requiring important focus and investments. One recent example representing this direction is the 1.3B€ investment by the Italian government, for a total investment value of 3.2 B€, with the Singaporean company Silicon Box in a new “chiplet” factory in the Piedmont region, in Northern Italy.

The objective of the proposed activity is to identify the PNT technologies that could be incorporated into products and services for consumer applications, following the renovated interests of ESA member states in European industrial and supply chain autonomy and resilience.

The tasks to be performed shall include:

- Review of the state of the art in technologies employed for the realization of PNT consumer product and services, both hardware and software;
- Analysis of the trends and identification of the gaps that are considered worth filling;
- Derive recommendations for endorsing an existing trend also in the European industry or for filling an identified and promising gap that could give an advantage to European industry, in particular in the field of microelectronic chipsets, “chiplet”, Systems-On-Chip, ASICs, FPGAs, Photonics Integrated Circuit, Approximate Computing, leveraging possibly on the novel Platform-as-a-service business model, and in the related SW components;
- Identification of the potential industrial actors and possible activities outlines.

The main output of the activity will consist of:

- Final report demonstrating and justifying the potential technologies which might increase the European industry capability to compete for the delivery of PNT products and services to global consumers;
- Identification of industrial players, and description of potential activities.

It is noted that no Participating States expressed an opt-out for this activity (EL1-129).

<i>Funding required: 200k€</i>	<i>Duration: 12 months</i>	<i>ITT issue: Jan-2026</i>
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2. Work Plan 2026 activities schedule

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

ID	Name																																							
		2026												2027												2028														
		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
EL1-116	Design of CRPAs for aviation and high-accuracy services					ITT																																		
EL1-117	Resilience Techniques and Algorithms for GNSS Space Receivers in Interference, Jamming and Spoofing Conditions									ITT																														
EL1-118	On demand PNT services during crisis							ITT																																
EL1-119	Dual Polarization Arrays for compact resilient GNSS Receivers									ITT																														
EL1-120	Resilient PNT Critical National Infrastructure validation test bench						ITT																																	
EL1-121	Resilient PNT based on Lasers	ITT																																						
EL1-122	Acoustic arrays for Drones localization and identification				ITT																																			
EL1-123	Quantum Magnetometer and algorithms for integrated Map Matching and Map Building	ITT																																						
EL1-124	Optimisation of PVT engines for LEO measurement diversity				ITT																																			
EL1-125	Receiver Architectures and Beam Scheduling Strategies for Fused-PNT Concept										ITT																													
EL1-126	Approximate Computing for Low-Power GNSS Signal Processing					ITT																																		
EL1-127	Cross-Domain Nonlinear State Estimation for Autonomous Systems Using Unscented Kalman Filtering				ITT																																			
EL1-128	Resilient PNT Critical National Infrastructure case study		ITT																																					
EL1-129	Identification of Growth Opportunities in PNT Consumer Market	ITT																																						

Table 2 - Activities' ITT and Contract execution planning