navisp

Info day: Element 1 Workplan 2022

S. Binda

NAVISP Element 1 Manager

(webinar recorded)

Infoday: Element 1 Workplan 2022

19th April 2022, 14:00 – 16:00 CEST

Time	Topic	Speaker
14:00-14:10	Introduction and list of the Workplan 2022	S. Binda, ESA NAVISP Element 1 Manager
14:10-15:10	Workplan activities explained	ESA
15:10-16:00	Q&A	ALL

NAVigation Innovation and Support Programme

- supports European industry in the highly competitive and rapidly-evolving global market of PNT technologies and services
- supports participating States in pursuing their national objectives
- addresses all the elements of the end-to-end PNT value chain
- leverages on:
  - ESA expertise gained through the Galileo, EGNOS and Navigation Programmes
  - Industrial base of the European Navigation sector
- is fully coordinated with the European Union programmes

navisp structure

	ELEMENT 1	ELEMENT 2	ELEMENT 3
Content	**Innovation** Generate innovative concepts, techniques, technologies and systems linked to the PNT sector, along the entire value chain	**Competitiveness** Ensure the readiness of industry to effectively respond to emerging market opportunities by focusing its activities on products ready for the commercial or institutional market	**Support** Support to Member States National Programmes
General principles for implementation	Competitive tender, 100% ESA funding on the basis of yearly work-plan	Continuous open call, unsolicited proposals, Thematic windows, ESA 50-80% co-funding	Continuous open call, unsolicited proposals, Thematic windows, 100% ESA funding
Lead for the definition	ESA via call for ideas, NAVAC, stakeholders interactions, etc.	Industry	Member States

navisp implements the full Innovation Process

Institutions-Governments

Regulations

Industrial System
- Large Companies
- Small/Medium Enterprises
- New (technology based) firms

Actors

Knowledge/ Technology

Research System
- Education & Training
- Research
- Public Sector Research

Networks

Demand & Competition

Market

Creative Process

Idea Generation

Rough Concept

Detailed Concept

Market Launch

Innovation to the Market

nauisp and ESA Agenda 2025

- STRENGTHEN ESA-EU RELATIONS
  - Continue excellent collaboration with EU (and EUSPA)
- BOOSTING COMMERCIALISATION FOR A GREEN AND DIGITAL EUROPE
  - Most of the budget spent in Element 2 and Element 3
- DEVELOP SPACE FOR SAFETY AND SECURITY
  - Address technologies improving the resilience of PNT
- ADDRESS CRITICAL PROGRAMME CHALLENGES
  - providing billions of users with PNT capabilities for their professional or private use, contributing to a huge and growing downstream market of spacebased services
- COMPLETE THE ESA TRANSFORMATION
  - Further simplify the Programme's procedures, adjusting them to the nature of the desired product, to boost ESA's effectiveness and attractiveness

navisp current focus

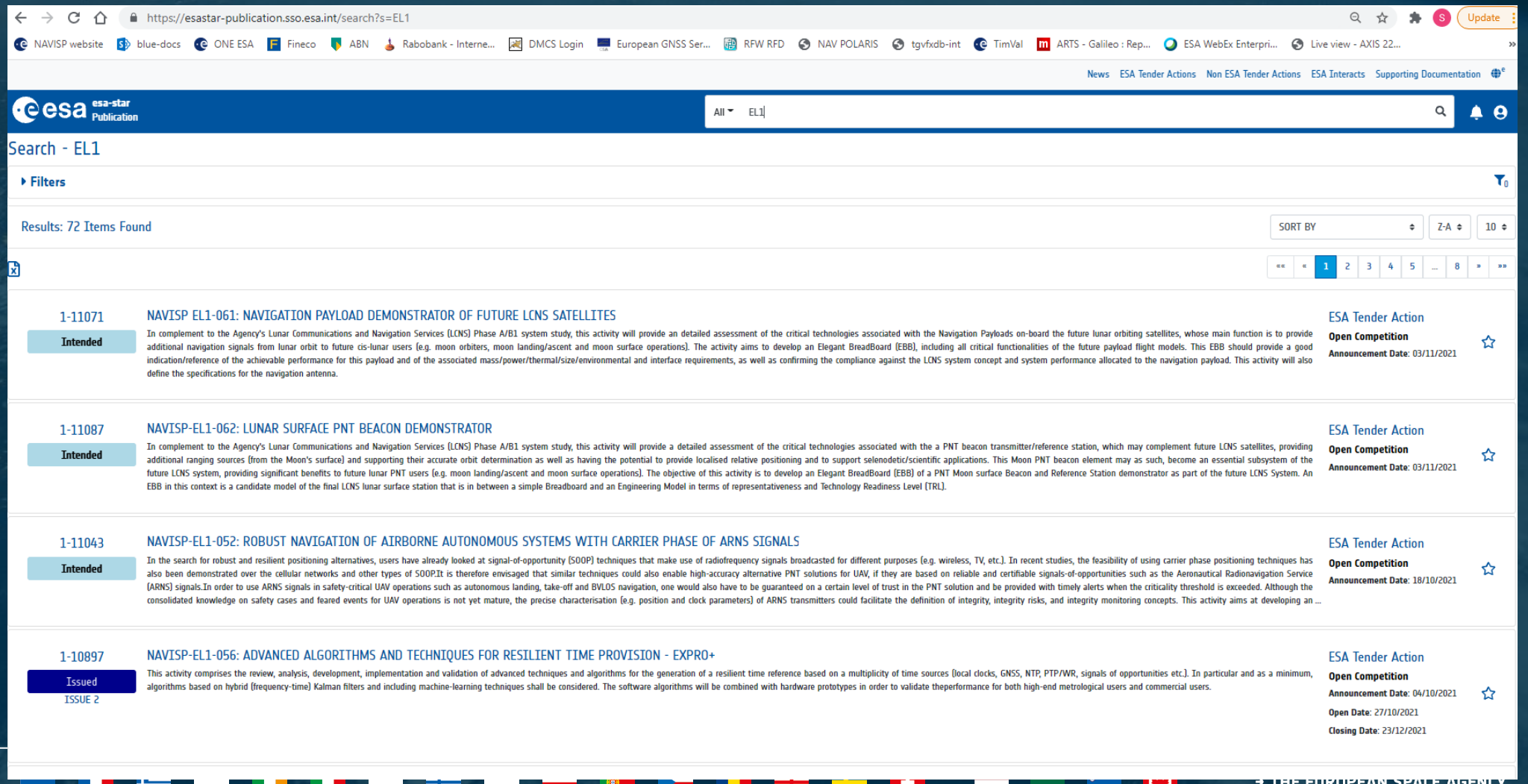
- From external NAVISP Advisory Committee:
  - Autonomous Transport and Green Mobility
  - Seamless PNT applications for Industry 4.0, e.g. for indoor infrastructure logistics
  - Alternate PNT timing, alternative or complementary to GNSS
  - PNT Robustness and resilience

- Element 2 Thematic windows published (one upcoming, stay tuned!):
    - PNT in 5G
    - Assisted GNSS with Imaging Sensors and 3D models for Mobility Applications

- From ESA's Accelerator "Space for a Green Future":
  - Underwater PNT for a greener Earth
    - PNT for Climate Change oceanographic exploration under-ice
    - PNT for underwater critical infrastructure

Where to find Tender Actions

- **navisp.esa.int** general info
- **https://esastar-publication-ext.sso.esa.int/** official



Element 1 Workplan 2021

- Under implementation, 053 awarded, 056/057 TEB

ID: Title	Status	Budget (k€)
NAVISP-EL1-052: Robust navigation of airborne autonomous systems with carrier phase of ARNS signals	ITT open (23/05/22)	600
NAVISP-EL1-054: Monitoring timing signals from space. A novel approach for a worldwide robust time and synchronisation capability	ITT to be reissued	450
NAVISP-EL1-055: Attitude control of autonomous ships navigating in ports	ITT open (17/05/22)	600
NAVISP-EL1-058: Demonstration of GNSS position bounding using satellite uplinks	ITT open (23/05/22)	450
NAVISP-EL1-059: Application of photonics technology for PNT user equipment	ITT to be reissued	600
NAVISP-EL1-060: Novel privacy preserving PNT processing techniques	ITT open (23/05/22)	450

Element 1 Workplan 2022

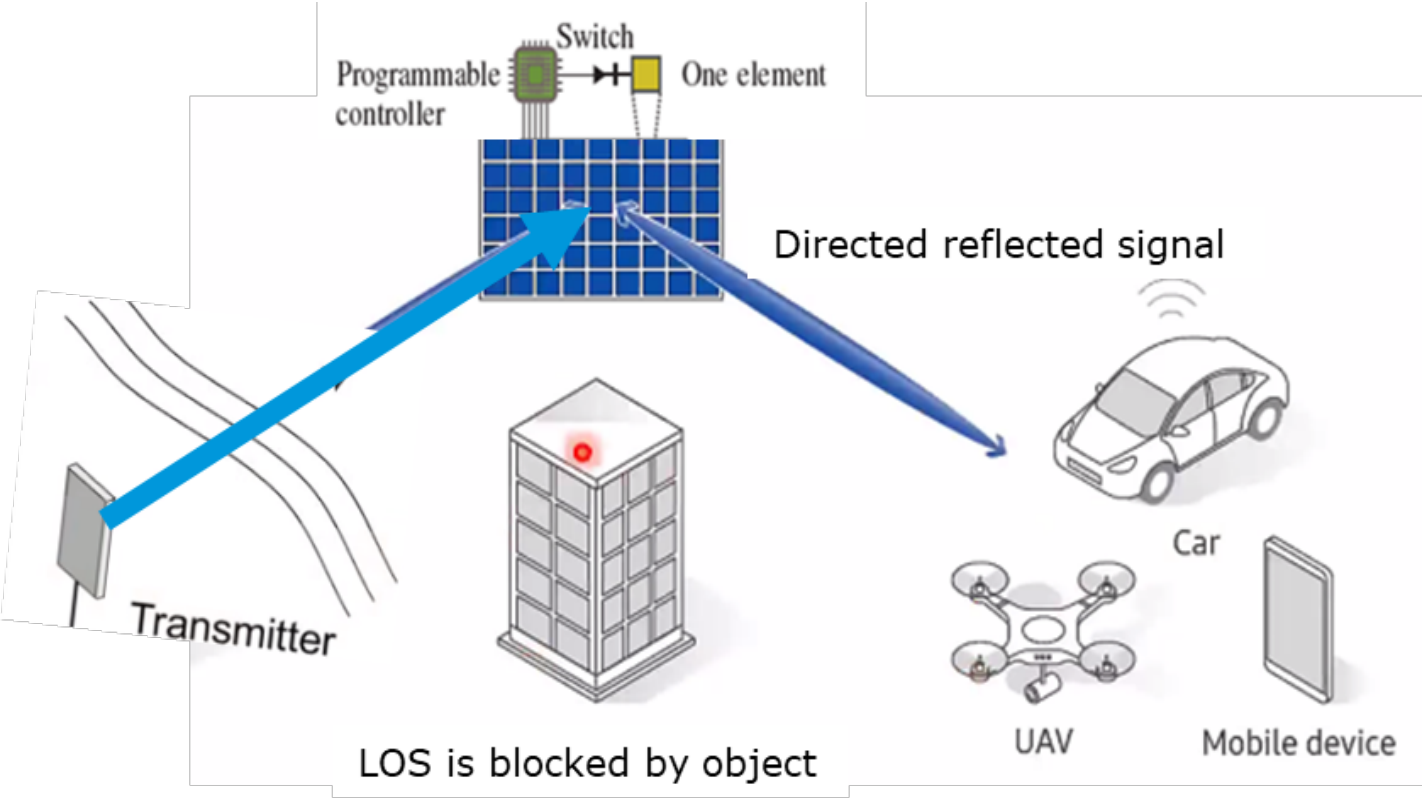
- Implementation ongoing

ID: Title		Status	Budget (k€)
NAVISP-EL1-063	RIS-aided wireless localization and mapping	Intended Q4	500
NAVISP-EL1-064	Block-box for an optimised GNSS spectrum monitoring network using AI	Intended Q2	450
NAVISP-EL1-065	eLoran antenna for handheld devices	Intended Q3	250
NAVISP-EL1-066	Deeply Coupled GNSS Vector tracking loop robust solution for autonomous vehicle	Intended Q1	600
NAVISP-EL1-067	Precision Agriculture - High precision coordinate and alignments transfer	Intended Q2	300
NAVISP-EL1-068	Biosensor and PNT Integration	Intended Q2	200
NAVISP-EL1-069	Enabling high performance PNT in lunar environment	Intended Q3	600
NAVISP-EL1-070	Advanced MEOSAR Test Beacon Setup	Intended Q2	300

RIS-aided wireless localization and mapping (1/2)

Rationale

- Propagation at radio waves suffers from obstructions due to objects blocking LOS path between the transmitter and the receiver. Multipath and obstructions due to environment are the main challenges every RF based positioning systems faces.
- The dependency on the LOS paths can be reduced through multipath-aided localization by exploiting intelligent surfaces with programmable reflection and refraction properties (RIS).



How RIS works? The Reconfigurable Intelligent Surfaces (RIS) are controlled by a local control unit that adjusts the phase profile of each individual element and thus can thus operate as a reconfigurable mirror made of metamaterial whose properties (scattering, absorption, reflection, diffraction) are reconfigurable rather than static.

All type of measurements are included: ToA, PoA, AoD, AoA, and the Doppler shift.

RIS is neither part of the Tx nor the Rx, but it is a controllable part of the wireless propagation environment.

RIS-aided wireless localization and mapping (2/2)

Objective

- The overall objective is to demonstrate how metamaterials can be used to control the EM environment to achieve multipath-aided positioning with low-resources
- Demonstration through measurements in Lab conditions

Kymeta mTenna (the size of a laptop)

Starting Point

- Metamaterials-based flat panel antennas
- Existing literature
- Holographic radio theory

Innovation

- Use RIS passive relays, deployed in the area of interest, to estimate 9D localization of Rx (position, orientation, and speed)
- Design the first ever RIS-aided localization algorithm
- Perform first evert RIS-aided localization based on real measurements
- Active area of research in telecom and positioning

What it enables

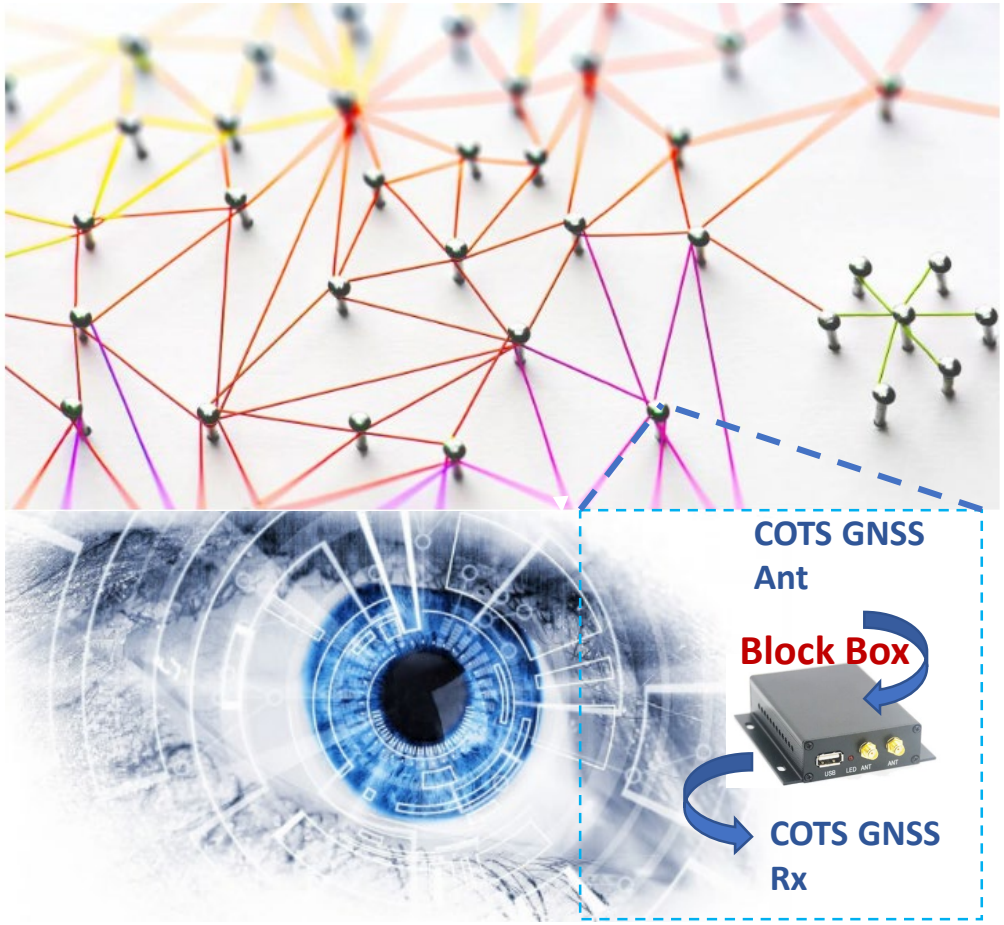
- Complementarily to pseudolites, extension of the the coverage of any wireless positioning systems in difficult environments e.g. indoor, tunnels, deep urban by deploying low-cost, low-energy passive relays.

Duration: 18 months Budget: 500k€

Block-box for an optimised GNSS spectrum monitoring network using AI (1/2)

Rationale

- There is an abundance of GNSS receivers deployed around the world providing measurements and PNT information, which are currently combined into networks for a variety of GNSS processing and monitoring applications
- These receivers remain vulnerable and cannot be used to isolate all sources of error on all GNSS signals and constellations due to the processed nature of the receiver output
- Block-box is an external RF2RF device targeting the enhancement of any COTS GNSS receiver
- It can be tuned to a variety of applications at user, downstream services or supporting monitoring functions and real-time signal cleaning.
- It is based on AI helping to locally detect, categorise and clean signal anomalies and interference together with time/frequency filtering
- After signal cleaning it provides an interference free signal to any COTS receiver



Block-box for an optimised GNSS spectrum monitoring network using AI (2/2)

Objective

- Investigate, prototype and validate an RF2RF GNSS receiver enhancement device using a GNSS spectrum sampler in order to monitor and clean the incoming signal, making use of AI/ML techniques.

Starting point

- Starting TRL is low and expected to be raised during the activity taking past/current TRP activities as input: TERMINATE and AIMGNSS.

Innovation

- RF2RF device for spectrum cleaning, local use of retrainable artificial intelligence for interference and signal anomalies detection & classification, enhancement of the raw measurements of the GNSS receiver through signal cleaning and extra measurement generations (e.g. for integrity).

What it enables

- Commercial products for general purpose signal cleaning, applicable to various use cases (e.g. mass-market, automotive, maritime, monitoring stations, …)
- Low cost upgrade of monitoring stations towards more resilience to interference and signal anomalies
- Effective AI/ML applied to detection & classification of interference and signal anomalies

Duration: 18 months Budget: 450k€

eLoran antenna for handheld devices (1/2)

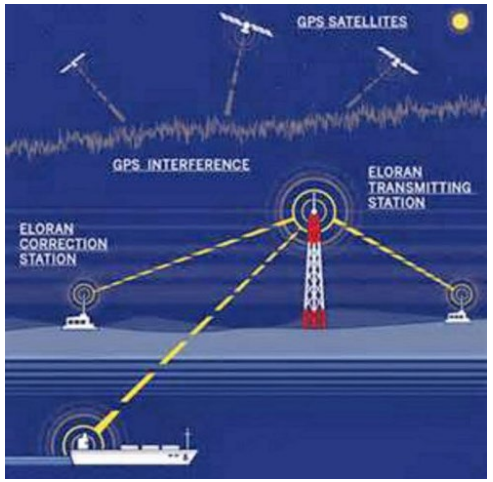
Rationale

- e-LORAN (enhanced-LORAN) is the latest of the low-frequency LOng-Range Navigation (LORAN) systems, and provides a PNT service for use by all modes of transport (land, maritime and aeronautic).

- Amongst other characteristics, LORAN can enhance geo-security through its jam- and spoof-resistant signal characteristics of high transmit power and low carrier frequency. It is a good candidate as an alternative and/or backup to the (currently non-redundant) GNSS navigation system.

- It is operating at the frequency band 90 - 110 kHz. At these low frequencies, classical antennas (generally magnetic loop and loaded monopole antennas) are of relatively large size, which is not adapted to professional consumer handheld electronic devices.

- For the handheld electronic device market the antenna has to be miniaturized, by keeping it efficient enough to receive and process e-LORAN signals both outdoors and indoors.



eLoran antenna for handheld devices (2/2)

Objective

- Development of a miniaturized and robust e-LORAN handheld professional user antenna.

Starting point

- Ferrite rod (high permeability) antennas are of relatively small size and are already much used at long wave frequencies, e.g. on portable transistor broadcast receivers as well as many hi-fi tuners. However, they have to be further miniaturized to be placed on handheld devices.
- The system study EI1 – 046 “Combining ELF signals with GNSS for improved PNT” has been kicked-off recently and hence the antenna requirements for the handheld device deduced from that study can be implemented into this activity.
- Some countries are considering to extend their eLoran capabilities and invest in new ones (e.g. UK, US, South Korea, etc.).

Innovation

- In order to support the development and the diffusion of the very low frequency application in the PNT service, the development of a new miniaturized and robust e-LORAN antenna (with dedicated LNA) is considered of crucial importance.

What it enables

- The new antenna shall be mounted on handheld devices for the localization of users in situations, in which the current GNSS is unavailable or degraded.

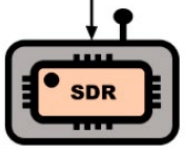
Duration: 18 months Budget: 250k€

Deeply Coupled GNSS Vector tracking loop robust solution for autonomous vehicles (1/2)

Rationale

- Tracking robustness issues common in several application (automotive, inland waterways vessels, drones, trains)
- VTL benefits in urban environment for automotive are demonstrated to improve tracking robustness and performances
- To meet integrity targets required for autonomous vehicles it is needed to **make the architecture robust.**
- Several studies in the past have progressed in various **individual** aspects of VTL robustness:
    - Detection and isolation of environmental effect (NLOS and MP)
    - Integrity Monitoring with adaptation of RAIM to VTL

NovAtel FireHose Front-end



Software Defined Receier (SDR)

Table 7. RMSE values for the dynamic scenario.

Parameter	Scalar Tracking	Vector Tracking
Horizontal Position (m)	6.3	1.9
Horizontal Speed (m/s)	1.12	0.12
Up Velocity Component (m/s)	3.88	0.05

Deeply Coupled GNSS Vector tracking loop robust solution for autonomous vehicles (2/2)

Objective

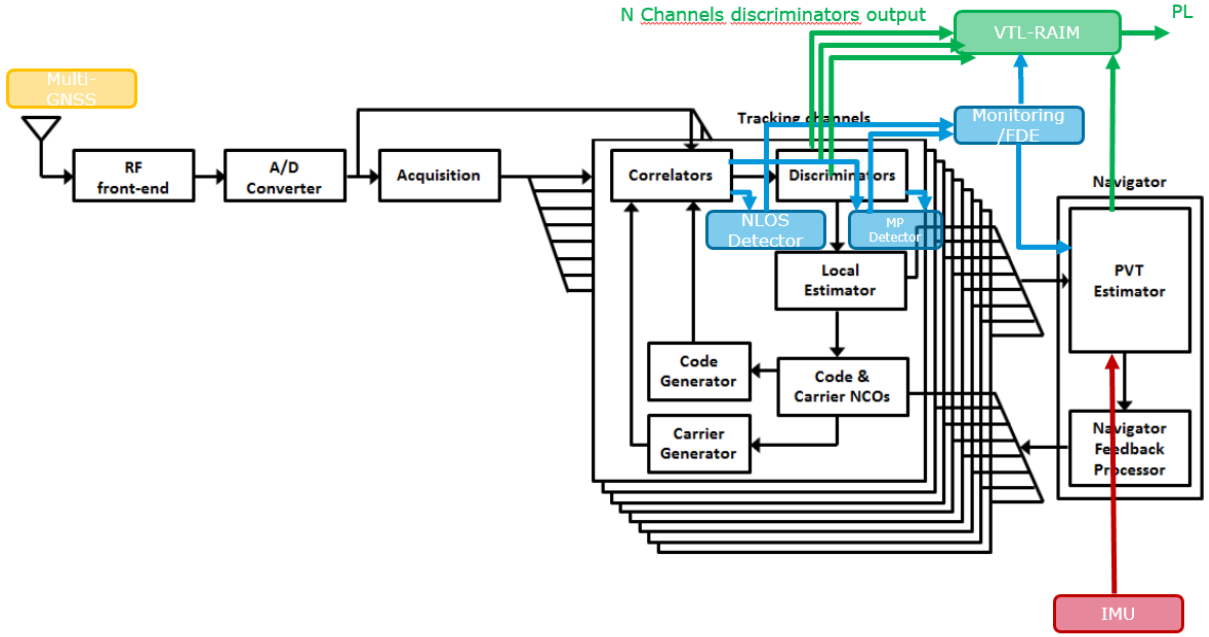
- Proof of concept of robust VTL architecture coupled with INS sensors and adapted to multi GNSS constellation
  - Deep Coupling, as opposed to 'loose/tight', with external sensors (inertial, odometer,….)
  - Multi-GNSS support
  - Fault detection and isolation strategy

Starting point

- Trade-off between architectures
- Detectors : Multipath, NLOS, C/No monitor, Phase lock monitor

Innovation

- Deep coupling to provide robustness against interference
- Monitor/FDE : excludes faulty channel of the solution
- VTL-RAIM : integrity monitoring
- Multi GNSS : counter balance exclusion of LoS due to detectors
- IMU : overall tracking robustness and coasting in outage conditions



What it enables

- Integration in a SDR for proof of concept, prototype and feasibility conclusions
- Demonstration in urban area vehcles, susceptible of extension through other projects

Duration: 16 months Budget: 600k€

Precision Agriculture - High precision coordinate and alignments transfer (1/2)

Rationale

- In future precision agriculture, each plant (e.g. corn) will get coordinates with 5 mm (95%) accuracy
- The plants and their coordinates will be stored in a database with additional agricultural information
- Already during the sowing process each finger of the seeder comb has to be coordinated within 5 mm. On the tractor usually a dual frequency multi-system professional GNSS receiver with differential corrections is used (RTK, PPP,….). Some of the systems may have also a MEMS or microOptic based inertial measuring unit. In order to avoid the cost for an additional high end package for the seeder, it could be possible to determine coordinates on the seeder by a typical lever arm solution, e.g. determining the transfer attitude (transfer alignment) by an integration of a CCD and gyro based system making use of the known linear dimensions of the seeder. Because the drawbar has a certain tolerance in the trailer hitch, an additional distance sensor (laser, ultra-sonic) must be implemented.
- Problem applicable to other land machines.

Precision Agriculture - High precision coordinate and alignments transfer (2/2)

Objective

- Develop a relative very high precision PNT-Attitude determination & transfer alignment system to determine each point of a seeder comb with +/- 5 mm (95%) TBC.

Starting point

- Assessment of PNT products in precision agriculture (John Deere, Fendt,….)
- Assessment of different agricultural machines like seeders from the portfolio of specific companies

Innovation

- Mathematical description of the seeder linear an rotational motion model
- Selection of sensors (IMU, CCD, ultra-sonic distance,…..), time synchronisation issues of the sowing process
- Development of Kalman filter
- Simulation of tractor – seeder kinematic motion
- Development of a breadboard and demonstration of the breadboard during field work
- Testing and performance evaluation

What it enables

- Solution of the relative kinematic coordinate determination problem with very high accuracy. Market survey. Development of a breadboard. Identification of other/similar applications in machine control & robotics, e.g. in civil engineering.

A comparative analysis of precision seed Planters - *ITESE-2019*

Duration: 12 months Budget: 300k€

Biosensor and PNT Integration: What is feasible? (1/2)

Rationale

- A biosensor integrates a biological element with a physiochemical transducer to produce an electronic signal proportional to a single analyte which is then conveyed on a detector
- A wide field of applications exists: Clinical (in vivo, in vitro) and non-clinical. Typical application fields are food-analyses (e.g. freshness sensor, artificial nose,..), drug development, crime detection, medical diagnosis (clinical & laboratory), environmental field monitoring, quality control, industrial process control, detection systems for biological agents (not only warfare), manufacturing of pharmaceutical & human organs, medical event monitoring and testing
- The integration of a PNT function in a biosensor may bring substantial added value to the measurements of the biosensor.
- A potential concept is that of the “Lab-on-a-Chip”.
- Several examples exist already: Digital Angel, Ring Sensor, Smart Shirt, Smart Spacesuit (NASA) EVA, quality & performance testing in sport (soccer, athletics, racing horses,…), monitoring of soldiers, fire-fighters, livestock, wildlife applications,…

Ring Sensor

Smart Shirt

Biosensor and PNT Integration: What is feasible? (2/2)

Objective

- Many different biosensors have been developed during the last 20 years. The integration of biosensors with a PNT function offers a very important application field. The objective of the project is to analyse different categories of biosensors and analyse the integration potential with PNT.

Starting point

- Bring at least two scientific groups together: Bioengineers and PNT engineers.
- Elaboration of an overview on Biosensors

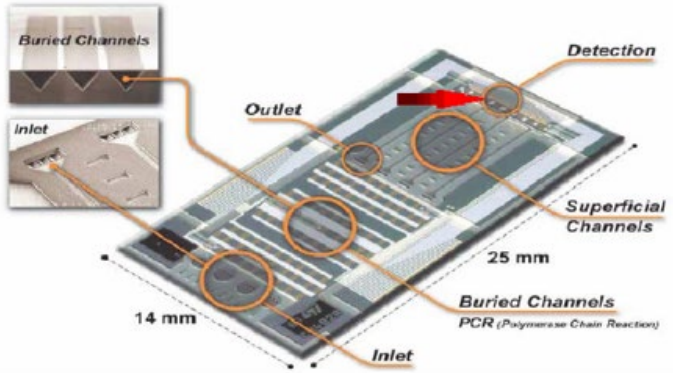
Innovation

- Selection of Biosensors, with promising interface to PNT
- Engineering level discussion, e.g. integration of Lab-on-Chip with IoT GNSS sensor
- Identification of current an future application fields, e.g. automatized drug or antigen testing
- Market analyses and suggestion on viable biosensor & PNT integrated applications

What it enables

- Study report: Fundamental assessment of this interdisciplinary application field. Identification of new application fields and technical developments . Market evaluation.

"Lab on a chip"



Duration: 24 months Budget: 200k€

Enabling high performance PNT in lunar environment (1/2)

Rationale

- Several dozens of commercial and institutional missions to the Moon are planned for the coming decades. In this context, the provision of a dedicated lunar communication and navigation service is identified as a clear need and a great opportunity.

- In particular, a significant R&D effort is ongoing towards the development of dedicated lunar infrastructures for enhanced Moon PNT services. The use of 1-way GNSS-like technologies, in particular, is being proposed by Europe throughout the Moonlight/LCNS system initiative, currently under Phase A/B1 system and planned to be proposed for CMIN 2022 for an operational service in 2027/2028.

- While preparing for the system development, the user equipment side shall be assessed in detail and, notably, innovative concepts explored. In this context, it is of high interest to study/understand in detail how Moon users could optimally combine the availability of a new GNSS-like dedicated orbiting system (Moonlight) with inertial and visual sensors lunar planned technologies. The synergies between these sensor technologies for lunar PNT applications is recognized as a priority research area, with a very high potential to achieve absolute metre-level accuracies on the Moon.

Enabling high performance PNT in lunar environment (2/2)

Objective

- This activity aims to study, develop and demonstrate hybrid positioning technologies in lunar environment, by investigating new approaches to achieve absolute meter-level positioning on the Moon and demonstrating them in field test campaign in realistic lunar like scenarios. Additionally, the activity aims to provide a detailed assessment of the tangible benefits provided by the high performance PNT solution for representative lunar users, such as rovers and landers The outcome of the activity will provide a complete understanding of achievable capabilities of future lunar positioning performances with a demonstrative breadboard and associated results.

Starting point

- Moonlight Phase A/B1 study outcomes
- NAVISP EI1-026, exploiting results and lessons-learned on sensor fusion, to be coordinated at appropriate project milestones

Innovation

- The future, Moonlight/LCNS could become the primary source of absolute accurate positioning, complementing and being complemented by the existing planetary navigation techniques for a much simpler and more efficient user navigation solution.
- The concept of combining GNSS, vision, inertial is reaching high TRL for terrestrial applications but the associated design and implementation parameters are not applicable/suitable for Lunar PNT. Indeed, intermittency of the signals, different gravity conditions, extremely weak magnetic field, almost complete absence of atmosphere, user dynamic, remote operations, navigation requirements, etc. are very different from what users experience on Earth. Thanks to the experience of the terrestrial implementations, the proposed concept is well formulated but it has not been studied and adapted to Lunar PNT, not even analytically. This means that the concept is at TRL 2 for Lunar applications (in line with ESA/EC/NASA, definitions), and the proposal is therefore very suitable for NAVISP (starting TRL on the high side of 2, targeting a TRL 4 after this activity).

What it enables

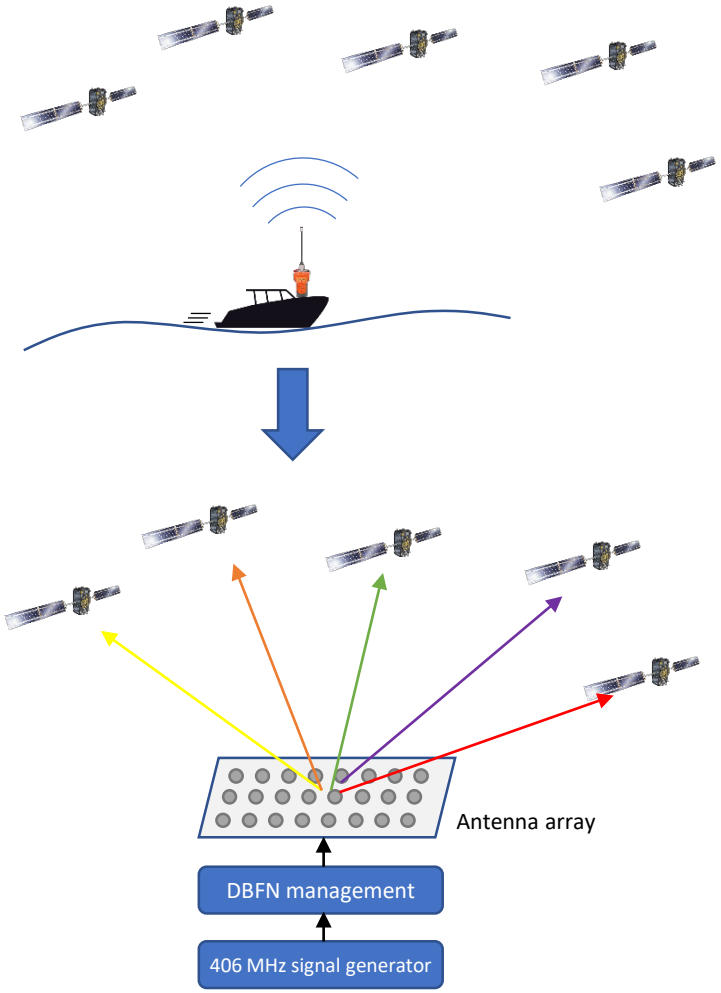
- Continuous and robust absolute navigation on the Moon
- Leveraging of existing technologies to further improve the value proposition of LCNS services.

Duration: 18 months Budget: 600k€

Advanced MEOSAR Test Beacon Setup (1/2)

Rationale

- Location methods used in the MEOSAR systems are sensitive to beacon motion. A lot of work has been undertaken during the past years to elaborate test means in order to evaluate the MEOSAR location performance with moving beacons
- Test means used have several drawbacks:
  - limited test time
  - limited speed range
  - reliability and/or transportability.



Advanced MEOSAR Test Beacon Setup (2/2)

Objective

- To develop an Advanced MEOSAR Test Beacon Setup consisting of a Digital Beam Forming Network (DBFN) antenna system and the supporting SW, for MEOSAR testing and performance evaluation, in particular in slow-moving and fast-moving cases and cases with local attenuation and masking

Starting point

- Developments in the ground telecommunication domain

Innovation

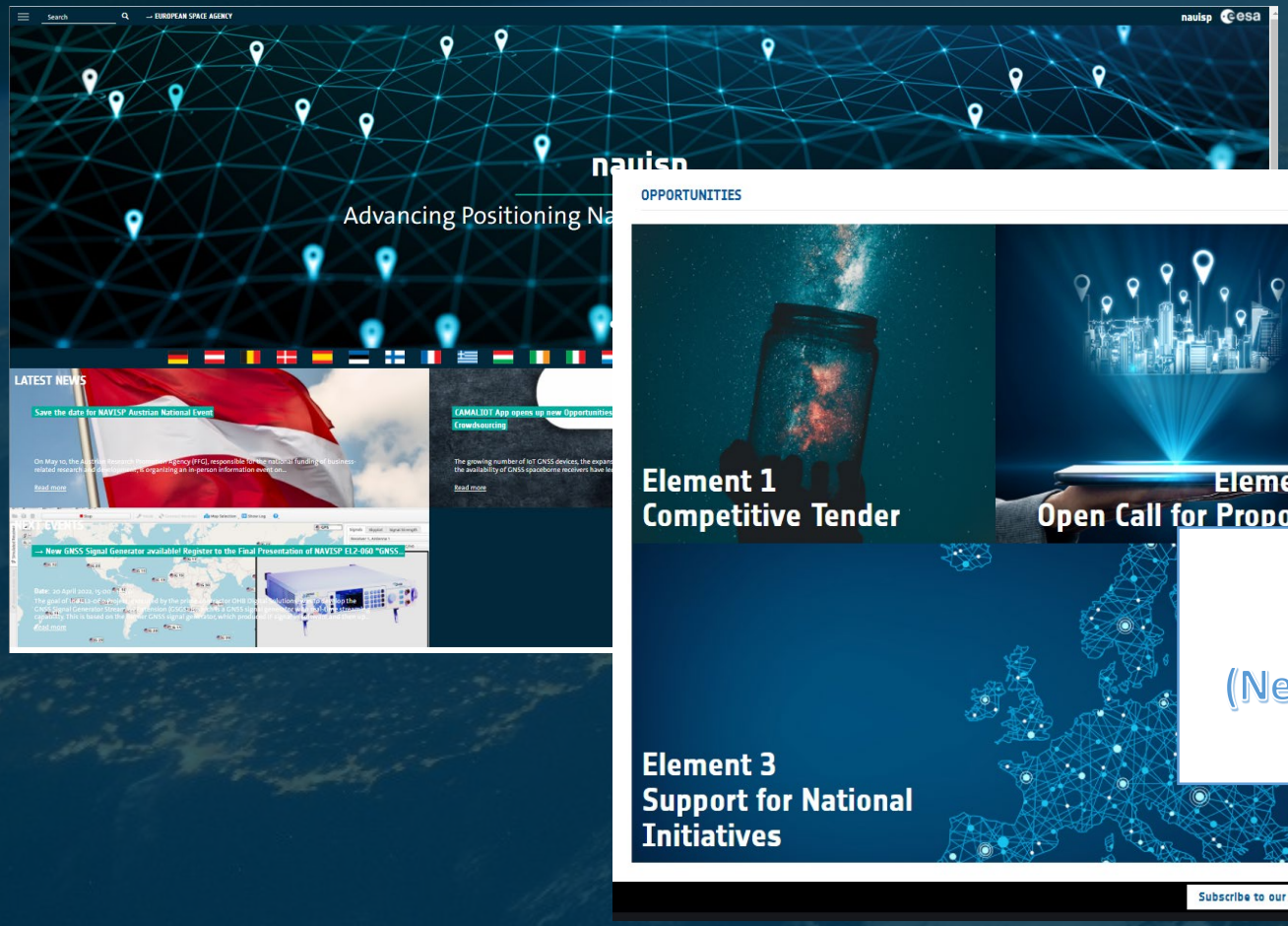
- Beamforming management including the definition of phase laws with respect to satellite positions and calibration
- Considerations of frequency, time and power shifts per satellite based on a scenario definition to emulate different Doppler, time of arrival (TOA) and local masks and attenuations

What it enables

- To support moving tests for MEOSAR
- To support monitoring service for the MEOSAR

Duration: 18 months **Budget: 300k€**

navisp Website and LinkedIn page



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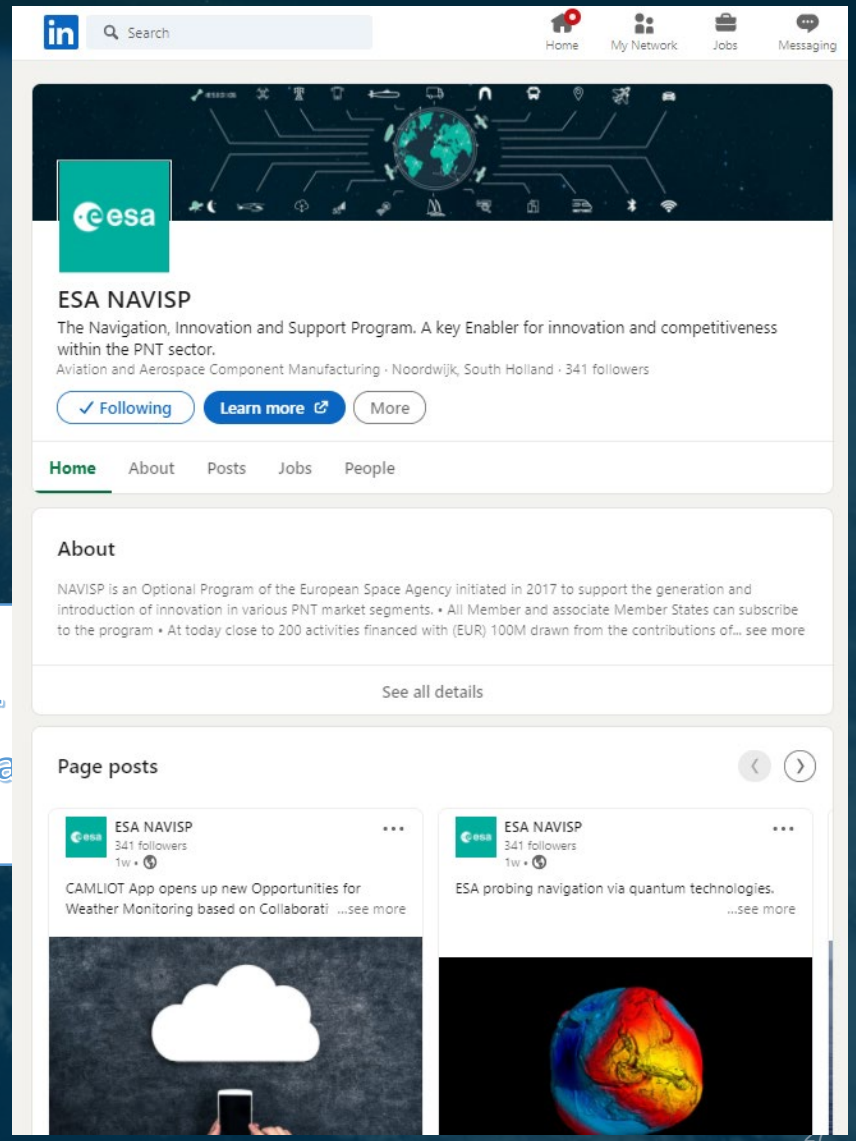

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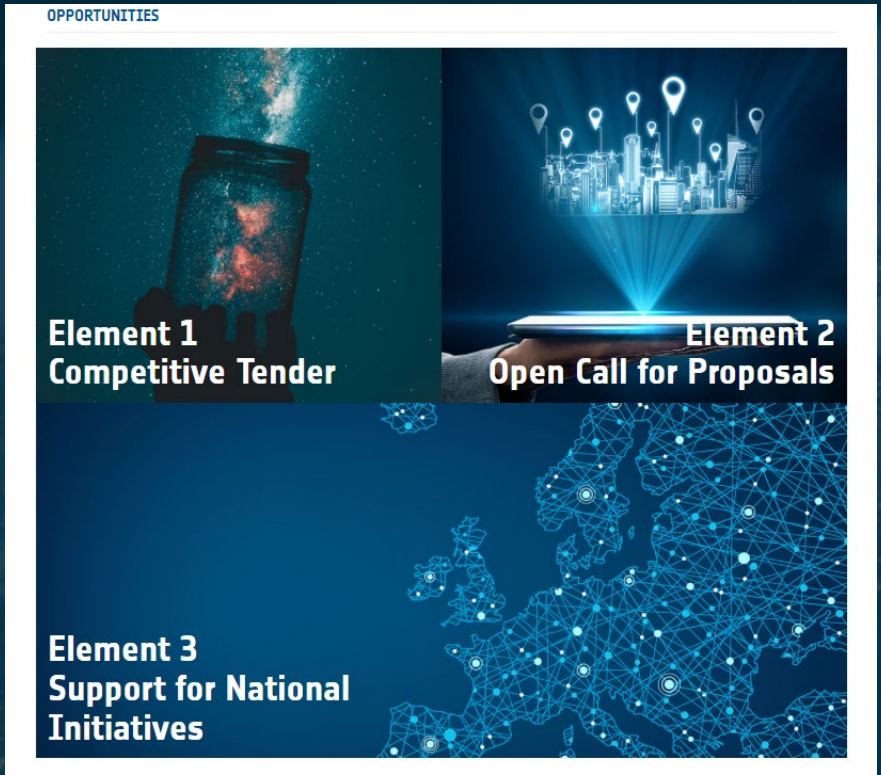
navisp Industry Days

Save the date!

NAVISP Industry Days come back on 16-17/06/2022 at ESA/ESTEC

- very long pre-summer days in NL
- listen to NAVISP success stories
- excellent opportunity for researchers, engineers, managers, product and service developers from all European countries to meet, exchange ideas, and setup collaborations

Thanks for your attention! Questions?



- For additional questions: navisp@esa.int
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