NAVISP Programme Overview and perspectives for ESA Space19+ CMin

Brussels, Belgium, 30 September 2019

Giorgio Solari
Head of NAVISP Element 1 Innovation Office
Why PNT? Ubiquitous Positioning

What is Ubiquitous Positioning?

- **Multi-sensor, low-cost and robust positioning**
  - Based on single or multiple users
  - Different types of platforms and sensors
  - Autonomous or cooperative navigation
- **Seamless transition when transitioning between different environments**
  - Different sensors
  - Different platforms
  - Different algorithms
- **Continuous positioning across all environments**
  - Open areas
  - Partially obstructed
  - Indoor

![GNSS Diagram]

More GNSS satellites
More GNSS signals

3-Dimensional Dead Reckoning

Dead-reckoning sensors

Terrestrial radio navigation

E-LORAN
Others

GNSS

Ubiquitous Positioning

Communications

5G, WiFi / RFID
UWB, Sparse Band
Digital broadcasting

Features-matching sensors

Inertial Measurement Units
LIDAR
Others

Mapping

Digital mapping
Indoor and outdoor
**Innovation in PNT**

*New Technology – New Applications – New Challenges*

**New technology**
- More GNSS satellites
- More GNSS signals
- Communications
  - *WiFi / RFID*
  - *UWB, Sparse Band*
  - *Digital broadcasting*
- Pseudolites, Locatalites
- Smaller, cheaper inertial sensors
- Digital mapping (outdoor & indoor)
- More processing power

**New applications**
- Seamless indoor-outdoor personal navigation
- Intelligent Transport Systems
- Rail signalling & control
- Precision aircraft landing
- Ships in harbours
- Location-dependent billing
- Virtual security fences
- Tracking people/animals/assets
- Social inclusion

**Drives new applications**

**Creates new challenges**

*Courtesy of Dr Paul Groves, UCL*
PNT Challenges

Artificial Intelligence PNT
Quantum PNT
Resilient PNT
PNT Innovations
PNT for Autonomy

Courtesy of Prof Terry Moore
University of Nottingham
Critical infrastructures that depend on GNSS for its positioning or timing requirements should be equipped with interference monitoring, detection, and alert service, and should have alternative non-GNSS back-up solution.
New concepts for improved PNT Resilience and Robustness

Protect
Toughen
Augment
against PNT Threats

Typical GNSS Vulnerabilities
- Spoofing
  - Covert
  - Deception
- Multipath
- Interference
  - Intentional
  - Unintentional
- Cyber Attacks
  - Non-RF
- GNSS Segment Errors
  - Erroneous upload data
  - SV Faults (E.g., SVN49)
- Atmosphere
  - Scintillation
  - Solar Activity

Maritime Jamming Reports
- VIP Protection & Conflict
- Disrupt Oil/Gas Surveys?
- Armed Conflict
- Illegal Fishing?
- Unknown
Improved PNT for professional applications

- Basic dGNSS: 0.8-3m
- RTK: 1-2cm
- High Quality dGNSS: 20-80cm
- Standalone GNSS: 5-10m
Highly Sensitive Spaceborne PNT Receivers in support of Interplanetary Navigation
GNSS and 5G: A mutually-beneficial partnership

Extend coverage of high-accuracy positioning
(outside NR hotspots)

Augment GNSS
(e.g. convergence time, integrity, reliability)

5G Network synchronization
(for precise network-based positioning)

Broadcast HA-GNSS corrections
(perfect dissemination channel for commercial applications)

Ubiquitous high-accuracy PNT
(seamless positioning service, indoor to rural)

Drive PNT innovation
(GNSS and 5G are key building blocks for new PNT architectures)
GNSS Market Size Predictions 2017

Global revenue by type

- Devices and augmentation services
- Added-value services

€ (Billions)

Cumulative Revenue 2015-2025 by market segment

- LBS 43.4%
- Road 50.0%
- Other 6.6%
- Agriculture 1.3%
- Surveying 2.6%
- Maritime 0.7%
- Aviation 0.7%
- Timing & Sync. 0.7%
- Drones 0.5%
- Rail 0.1%

GSA
IoT value chain and examples of PNT players

Most relevant for NAVISP
The concern of the European GNSS industry

1) Market Trends are not in favour of Europe
   • European market share approximately around 20%, limited amount of European champions

2) Risk for sufficient and robust EU autonomy
   • Dependence on GNSS increases together with the Market
   • Galileo may not be used as intended
   • European Autonomy is dependent on robust performance and wide usage of Galileo, with equip/apps made in EU and full integration into the broader space and terrestrial services and applications landscape

3) US, Russia, China, Japan have established national strategy/programme
   • 5 times higher investment in GPS systems evolutions R&D compared to Galileo for the operational timeframe 2023-2040
   • Massive funding from R&D to manufacturing capabilities
   • Regulation
   • Massive Public Procurement
GNSS patent shares

Global GNSS Patent Applications
(1980-2013, % of Total)

By Patent Office

- USPTO: 24
- SIPO: 13
- JPO: 20
- EPO: 8
- SIPO: 8
- DPMA: 5
- KIPO: 4
- Others: 17

By Type

- Priority Applications: Original Inventions
  (Total: 23,971)
  - USPTO: 34%
  - JPO: 29%
  - SIPO: 18%
  - EPO: 9%
  - KIPO: 4%
  - Others: 6%

- Related Applications:
  Extensions to Strengthen Legal Protection
  (Total: 25,488)


Source: E.C. STP Analysis.
**NAVISP**, the ESA programme designed to foster innovation & competitiveness of the European PNT sector

To leverage these upcoming opportunities, the European PNT sector will need to:

- Develop cutting-edge technologies & effective products & solutions
- Maintain & increase competitiveness of the research and industrial sectors to keep them at par with existing and emerging solutions worldwide

**Objectives of NAVISP**

- **Improve industrial innovation** and competitiveness at all industrial levels and all industrial sizes, and driving growth and jobs
- **Flexibility for MS** to target investments to support national objectives, under MS control
- Enables ESA MS to invest in developing industrial capacity, e.g. qualify **new entrants for the market**
- Uses best practice in terms of **responsiveness and fast contracting procedures**
- Open for **non-space industry** to capture **the full spectrum of PNT innovation and commercialisation**
- Designed to **avoid any duplication** with work funded by the EU under H2020 or Fundamental Elements
# NAVISP The Programme Structure

<table>
<thead>
<tr>
<th>Content</th>
<th>ELEMENT 1 [Innovation in Satellite Navigation]</th>
<th>ELEMENT 2 [Competitiveness]</th>
<th>ELEMENT 3 [Support to Member States]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyses and developments linked to new and emerging design and operational concepts, techniques and technologies related to satellite navigation systems</td>
<td>Ad hoc technological &amp; product developments and pre-operational activities along the whole satellite navigation value chain in support of the competitiveness of the industrial sector in the participating Member States</td>
<td>Support to MS national Programmes &amp; Activities in satellite navigation and along the whole value chain</td>
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<tr>
<td>Competitive tender, 100% ESA funding on the basis of yearly work-plan adopted by PB NAV</td>
<td>Continuous open call, unsolicited proposals, ESA co-funding (level of support to vary according to TRL level), MS support letter</td>
<td>On request by MS, ad-hoc mechanism to be established on a case-by-case basis that ensures ESA’s full costs are met</td>
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**Lead for the definition of the activities**

- **ESA**
- **Industry**
- **Member States**
**NAVISP Financial Status: Contributions**

Contribution to the financial envelope covering NAVISP phase I:

<table>
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<td><strong>TOTAL</strong></td>
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<td><strong>33.5</strong></td>
<td><strong>127.00</strong></td>
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NAVISP implementation status

• WP’s for Element 1 2017, 2018 and Addendum are being implemented: 22 contracts already awarded for a total of 39 approved activities including WP2019

• Element 2 activities have been incubated at a very fast pace together with several Member States and key European PNT stakeholder for a total of 50 activities

Nature of actors involved:

- 60% of the Primes are SME
- 11 Mixed Public/Private consortia (large/SME/universities and research centres)
- New actors: 34 among all actors involved (88 Primes and subcos) have never worked with ESA before

• Element 3 has also been rapidly implemented since last year CfP kick off

• 65% of the total available funds already engaged

• Several NAVISP activities very much linked to the broader PNT sector and partnerships with new non-space entrants
NAVISP motivation to participate

- The Programme is managed with 15% of overhead
- IPR remains with the Contractor
- All information is treated as commercial sensitive
- Transferable product ownership upon contract completion
- ESA partnering and facilitating the procurement and execution
NAVISP on the way....

- **Further MS’s subscriptions** to NAVISP are already materialising:
  - New Participant States, with Germany that joined in Q3 2018
  - Increase of subscribed amount, e.g. Poland

- **A High-Level NAVISP Advisory Committee (NAVAC)** has been set-up to support the programme with external expert advice.....
NAVAC rationale

• NAVISP aims to foster innovation on the PNT field while supporting industry and member states interests.

• NAVISP portfolio of activities is quite heterogeneous: mix of ESA-driven, industry-driven initiatives, namely bottom-up in an attempt to capture the broad scope of NAVISP.

• Is the NAVIPS portfolio complete? Is it meeting the needs of an evolving and highly competitive PNT market?

• An advisory committee of high-profile experts has been set up to provide an external view to help ESA in answering the above questions.

  • NAVAC: NAVigation Innovation and Support Programme Advisory Committee
NAVAC Composition

- 5 members appointed in Sept 2018:
  - Roger Mc Kinlay: Chair
  - Stefano Debei: Member
  - Peter Grognard: Member
  - Bernd Eissfeller: Member
  - Luis Mayo: Member

- NAVAC Secretariat provided by ESA: Rafael Lucas
**NAVAC Work Status**

- NAVISP Element 1 WP2019 comments:
  - Portfolio of activities supported

- Recommendations for future WPs:
  - Increase of activities portfolio addressing integration of space/non space sensors
  - Strengthen link between use-cases and proposed solutions
  - Acceleration of schedule in Proof-of-Concept projects
  - Cross linking of activities results

- Evaluation of achievements of NAVISP phase I just completed, in support of NAVISP phase II programme proposal preparation
NAVISP Outreach

• Outreach events:
  - participation/presentation of NAVISP in many fora
  - dedicated national workshops
  - NAVISP industry days

• Other outreach activities:
  - operational website: https://navisp.esa.int
  - flyers
  - video
Second NAVISP Industry Days in January 2020 (TBC)
Save the Dates!
Solicited by
the increasing interest of Member States,
ESA is preparing NAVISP Phase II
in view of Cmin Space19+
doubling the funding request
from 20 to 40 MEuro per year
<table>
<thead>
<tr>
<th>Proposed Activity</th>
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<tbody>
<tr>
<td>Application of Machine Learning Technology for GNSS IoT Data Fusion</td>
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<tr>
<td>An innovative concept for the Risk Assessment of Geological Hazards using GNSS and Solid Earth tides modelling</td>
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<tr>
<td>Earth Moon GNSS spaceborne receiver for In Orbit Demonstration</td>
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<tr>
<td>Next Generation Network-assisted PNT Assurance</td>
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<td>User antenna diversity algorithms for efficient multipath mitigation</td>
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<tr>
<td>Quantum metrology for secure PNT</td>
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<tr>
<td>Cooperative Positioning and Integrity Concept in Vehicle Platooning</td>
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<tr>
<td>Proof-of-concept of Hybrid 5G/GNSS positioning with local ad-hoc overlay</td>
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<tr>
<td>Next Generation motion sensor for hybrid GNSS/INS solutions in high-accuracy machine control applications</td>
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<tr>
<td>New concept for evolutive mitigation of RFI to GNSS</td>
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<tr>
<td>Interference Monitoring from Space</td>
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<td>Hollow Corner Cube Retro-Reflectors for in-orbit PNT</td>
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<tr>
<td>Multi-layer PNT for SAR</td>
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<tr>
<td>Combining ELF signals with GNSS for improved PNT</td>
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</tbody>
</table>
Future of Positioning, Navigation, and Timing

Karen Van Dyke
U.S. Department of Transportation
The NAVISP Portal

A web portal serves as a “gateway” to the NAVISP programme.

The goals of this portal is:
- Serve as a ‘notice board’ for NAVISP calls, ITTs, news stories, events, workshops
- Repository of documentation and information / education tool for user
- Promotional tool for NAVISP activities (workplan, on going projects, etc.)
- Promotional tool for NAVISP actors (list of actors involved contacts, etc.)
- A central single entry point (of contact) for all NAVISP

https://navisp.esa.int