NAVISP Programme Overview and perspectives for ESA Space19+ CMin

Brussels, Belgium, 30 September 2019

Giorgio Solari
Head of NAVISP Element 1 Innovation Office

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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

More GNSS satellites
More GNSS signals

- 3-Dimensional Dead Reckoning

- E-LORAN
- Others

- Inertial Measurement Units
- LIDAR
- Others

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

- 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

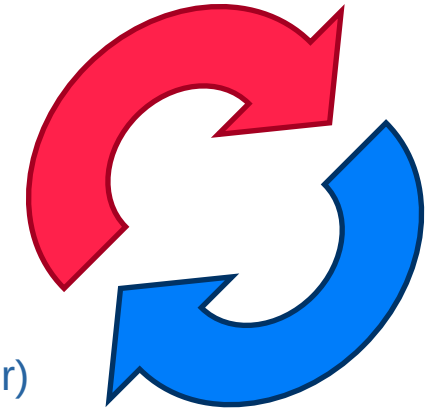
Digital broadcasting

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

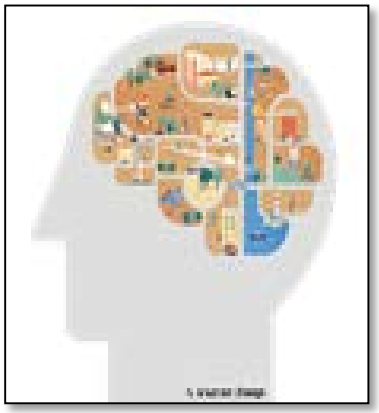
Social inclusion

Drives new applications

Creates new challenges

Courtesy of Dr Paul Groves, UCL

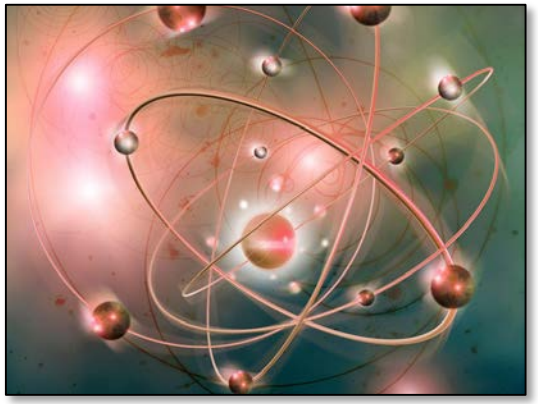
PNT Challenges



Artificial Intelligence PNT

PNT Innovations

PNT for Autonomy



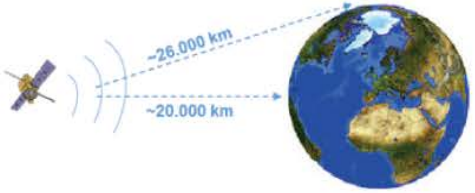
Quantum PNT

Resilient PNT

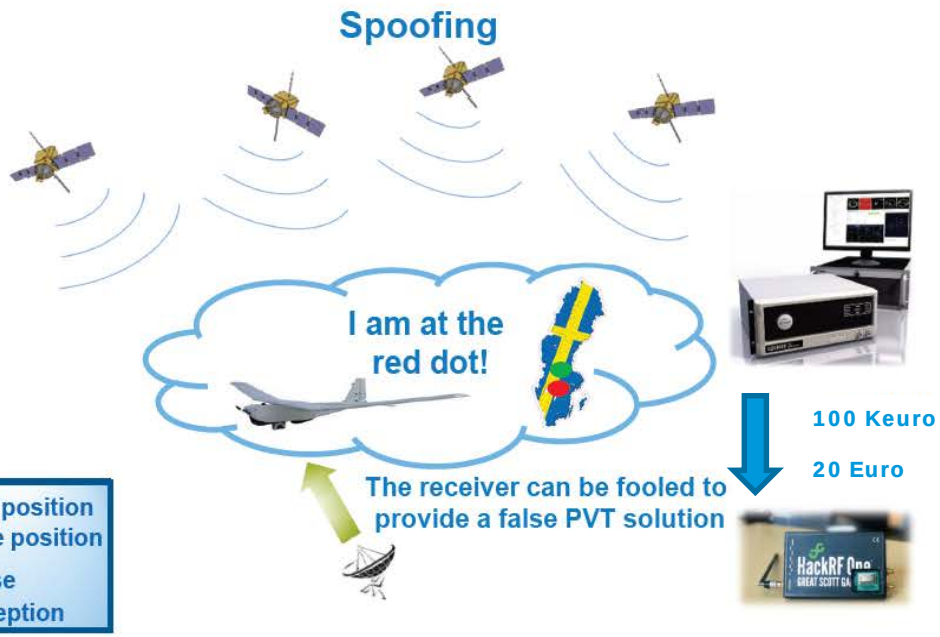
Courtesy of Prof Terry Moore
University of Nottingham

GNSS vulnerability

Threat



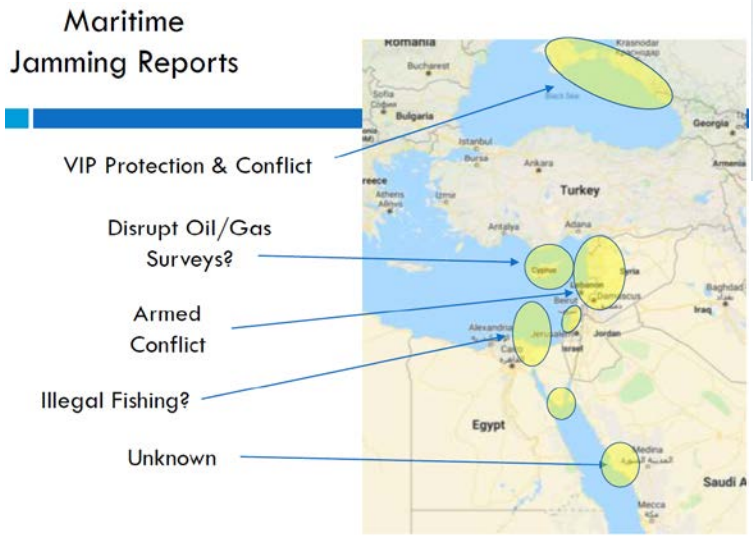
Main reason for the sensitivity towards jamming is the large distance to the satellites



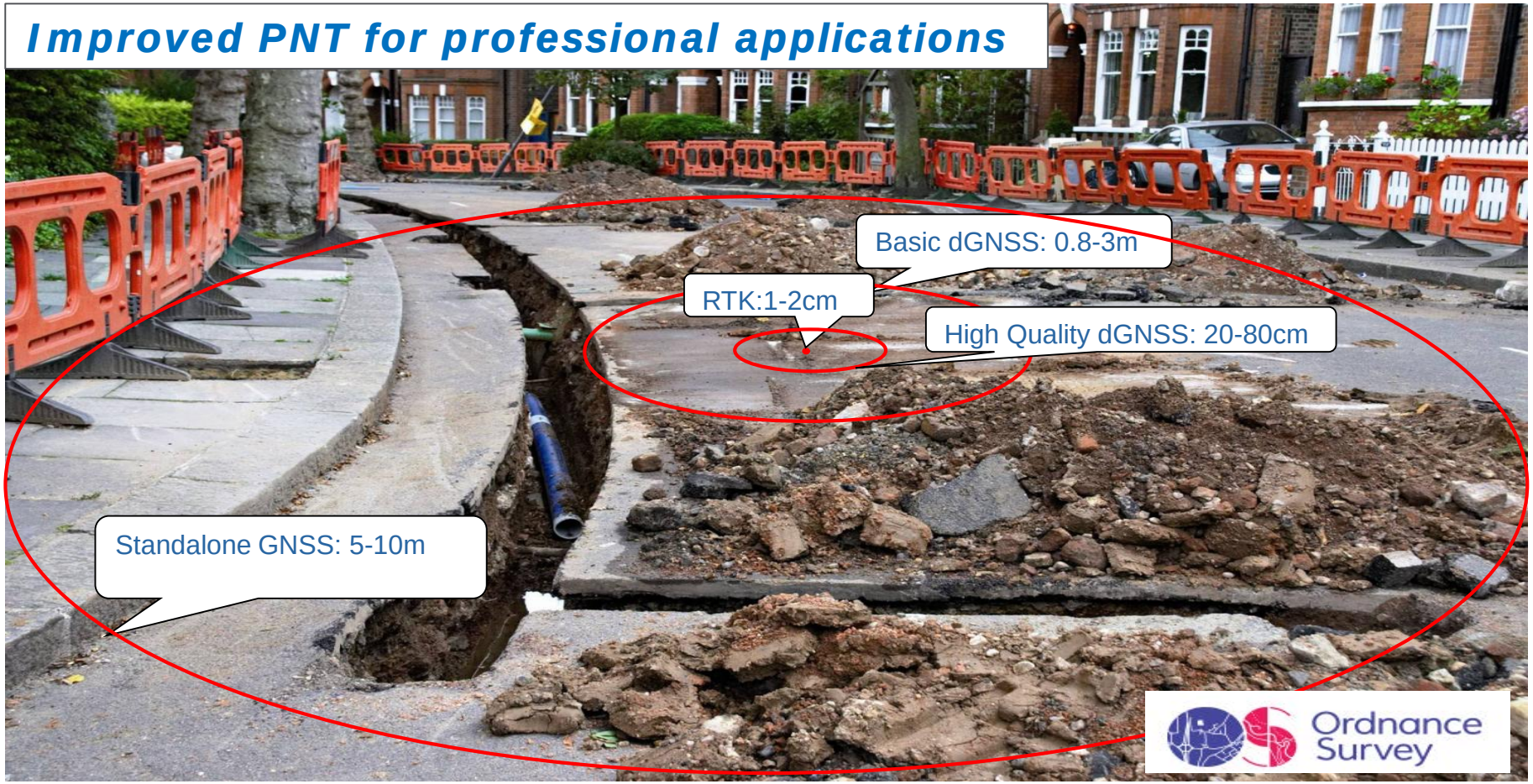
Critical infrastructures that depends on GNSS for its positioning or timing requirements should be equipped with interference monitoring, detection, and alert service, and should have alternative non-GNSS back-up solution

New concepts for improved PNT Resilience and Robustness

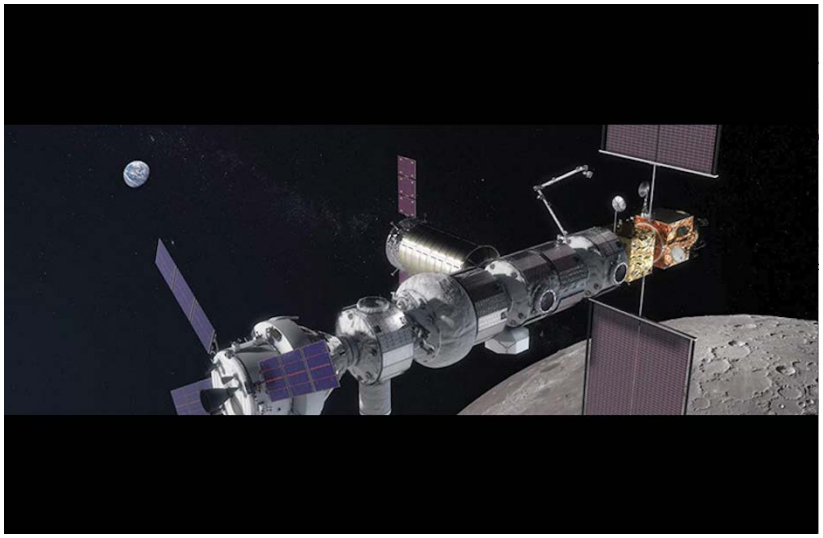
Protect
Toughen
Augment
against PNT Threats

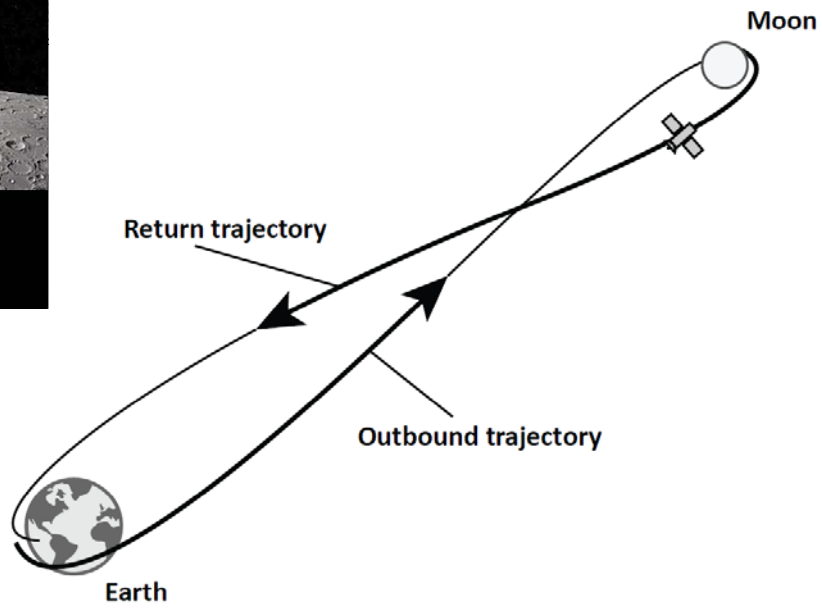


Improved PNT for professional applications

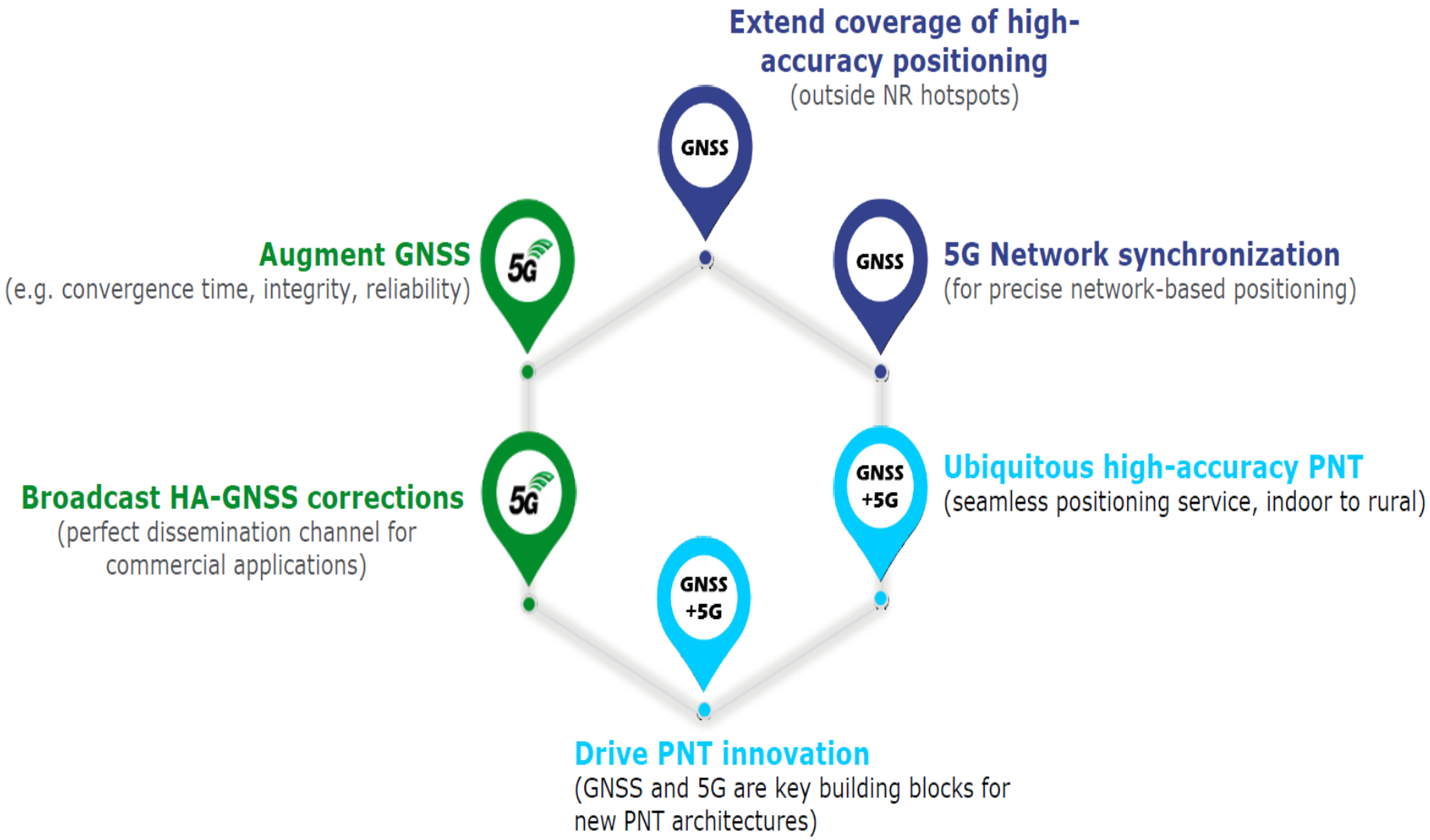


Highly Sensitive Spaceborne PNT Receivers in support of Interplanetary Navigation

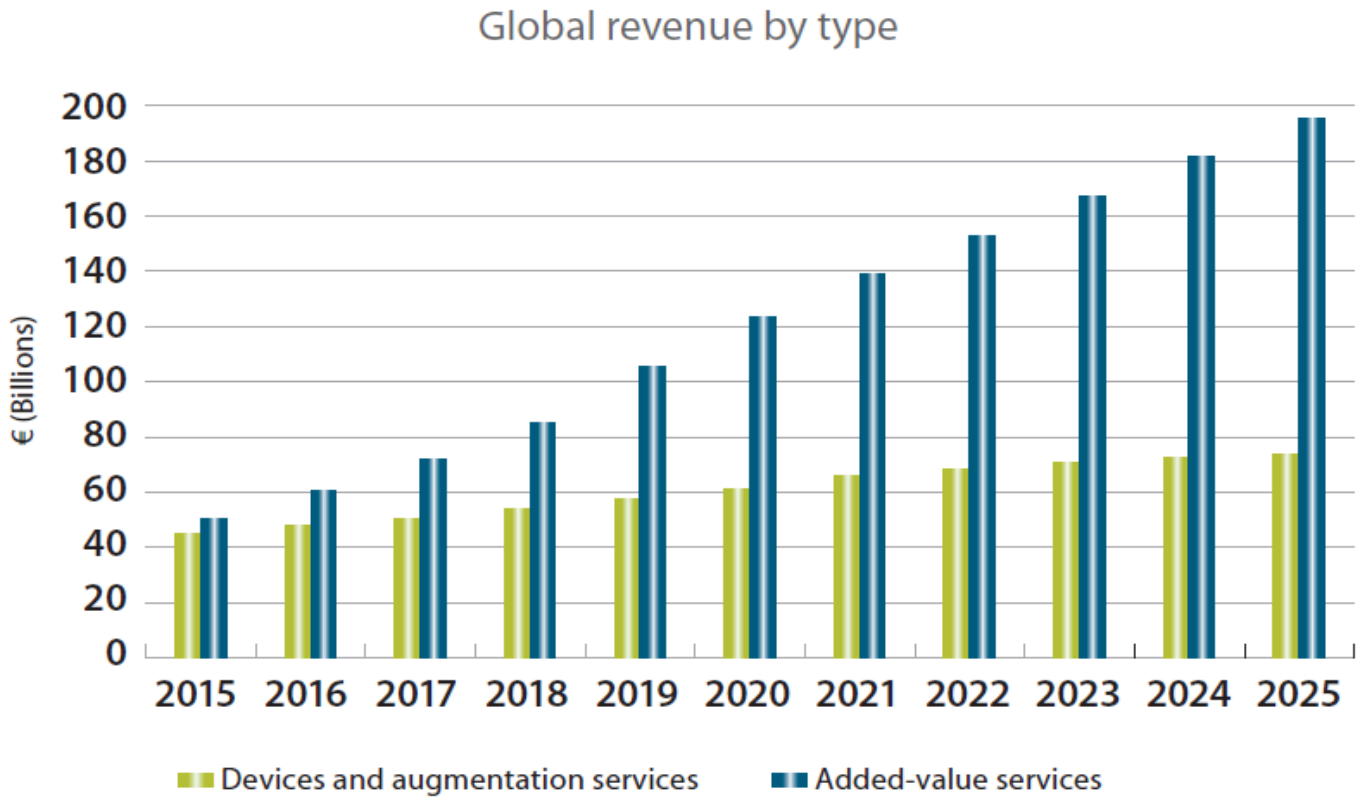




GNSS and 5G: A mutually-beneficial partnership

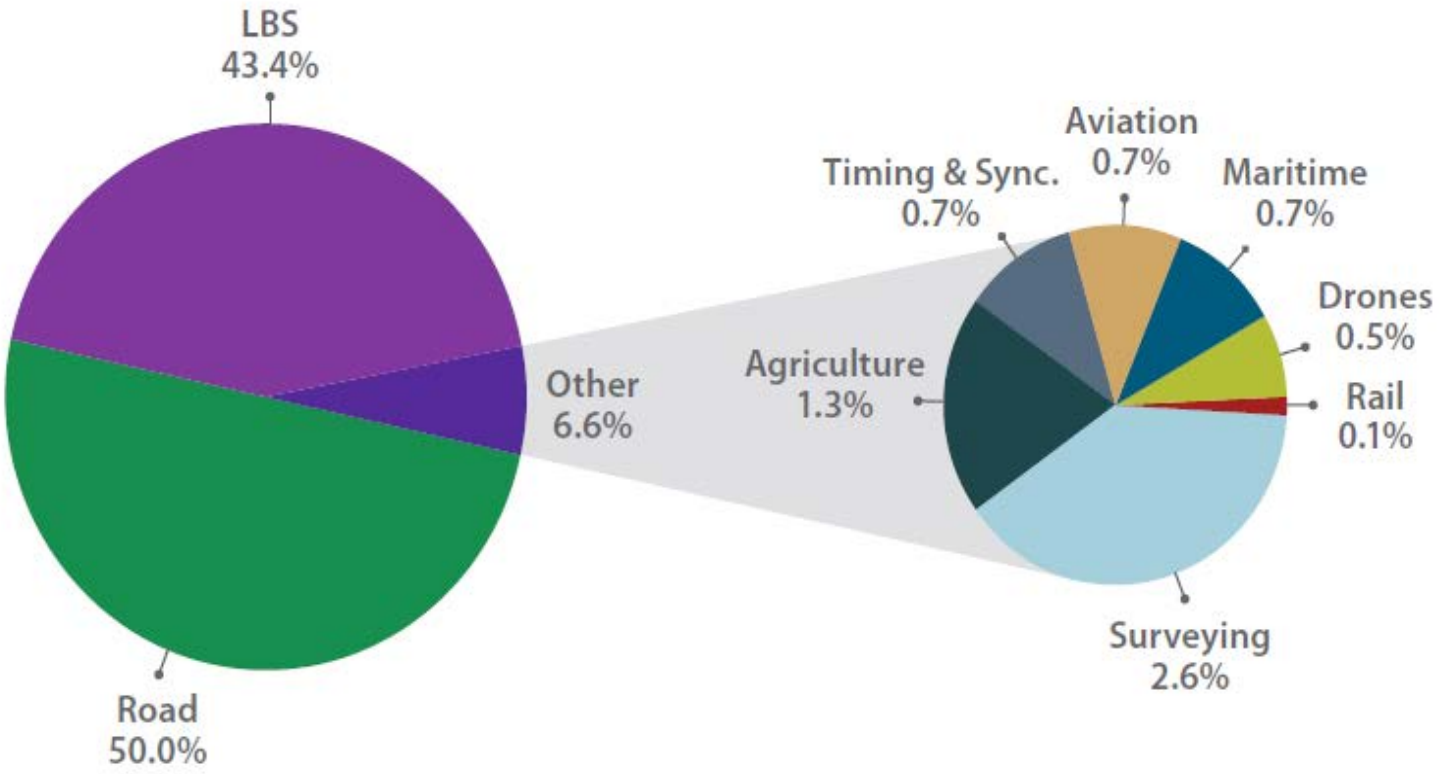


GNSS *Market Size Predictions 2017*



GSA

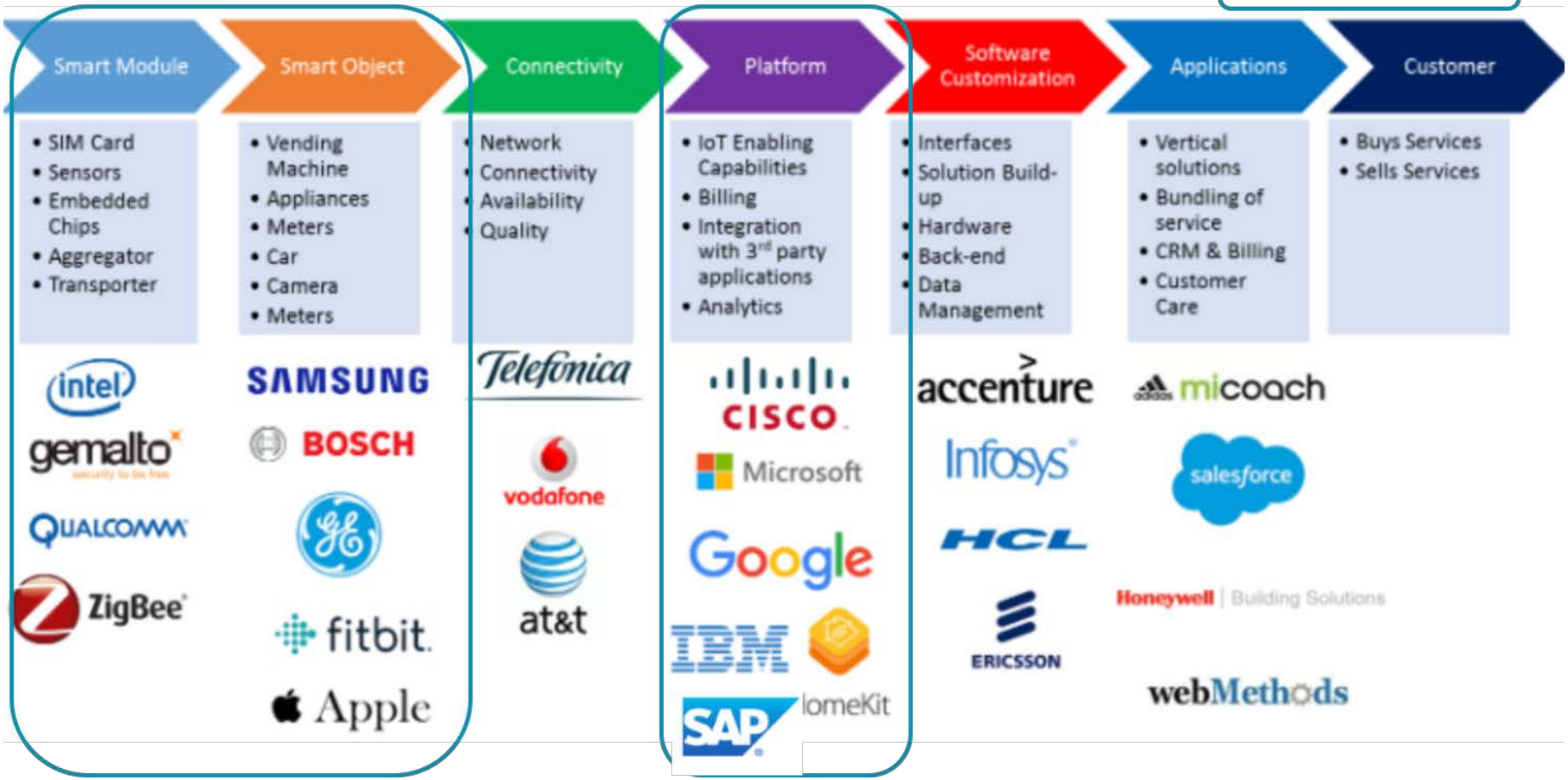
Cumulative Revenue 2015-2025 by market segment



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

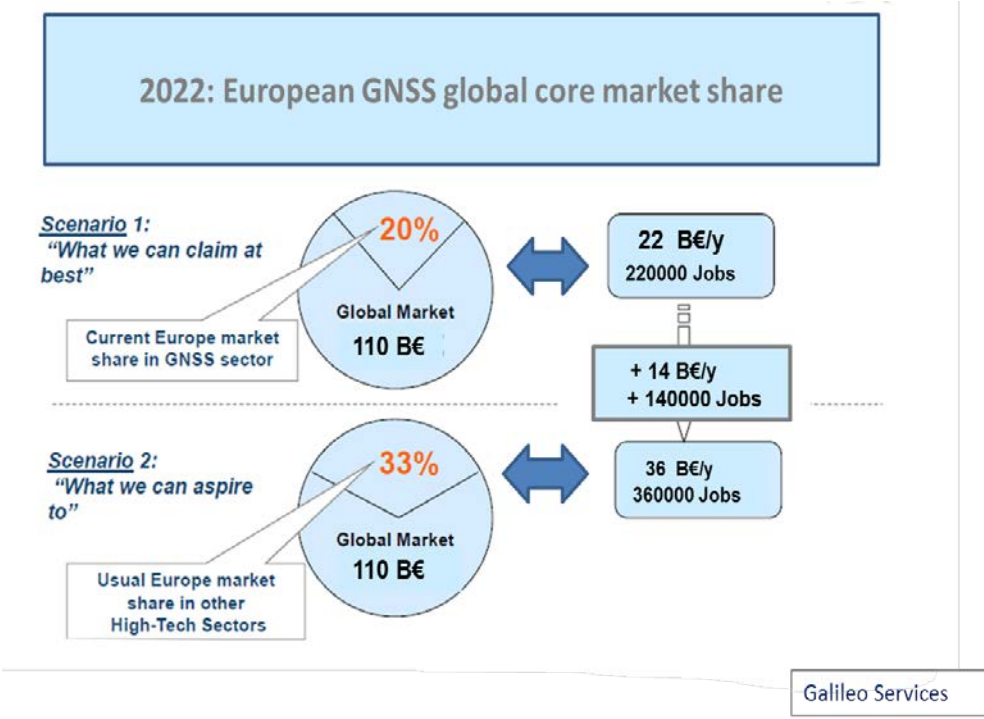
- European market share approximately around 20%, limited amount of European champions

2) Risk for sufficient and robust EU autonomy

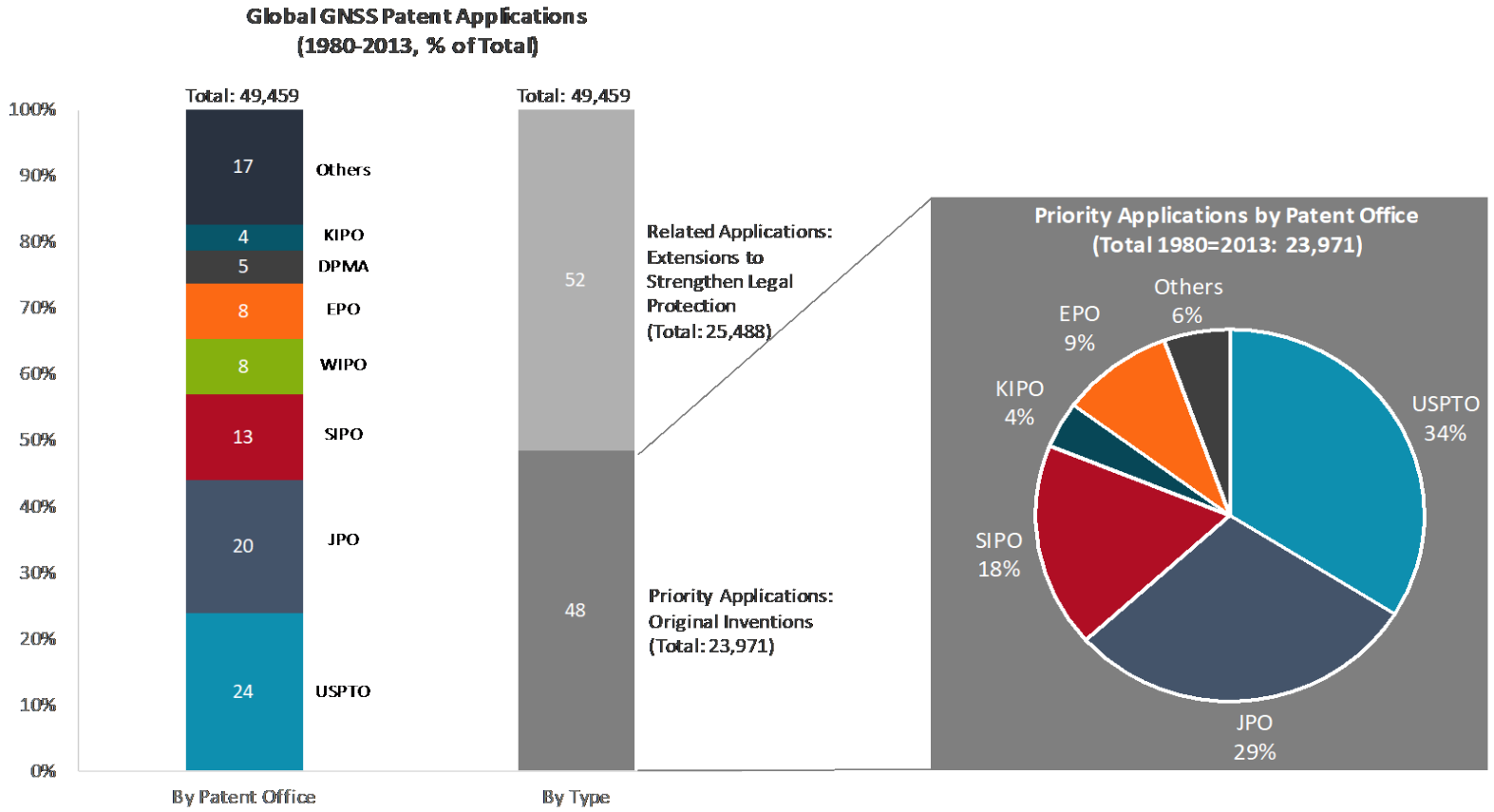
- Dependence on GNSS increases together with the Market
- Galileo may not be used as intended
- European Autonomy is dependent on robust performance and wide usage of Galileo, with equip/apps made in EU and full integration into the broader space and terrestrial services and applications landscape

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



Note: USPTO= US Patent Trademark Office, JPO= Japan Patent Office, SIPO= State Intellectual Property Office of the People's Republic of Chin, WIPO= World Intellectual Property Organization, EPO= European Patent Office, DPMA= Deutsches Patent- und Markenamt, KIPO= Korean Intellectual Property Office
Source: EC, 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

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

NAVISP Financial Status: Contributions

Contribution to the financial envelope covering NAVISP phase I:

Participating States	**Element 1** M€, 2016 e.c.	**Element 2** M€, 2016 e.c.	**Element 3** M€, 2016 e.c.	**Total** M€, 2016 e.c.
Austria	0.40	1.40	-	1.80
Belgium	0.50	-	1.48	1.98
Czech Republic	1.00	1.00	0.20	2.20
Denmark	0.50	0.50	0.50	1.50
Finland	1.15	0.50	0.28	1.93
France	2.00	4.00	-	6.00
Germany	2.63	2.63	-	5.26
Ireland	-	1.00	-	1.00
Italy	-	2.50	-	2.50
Netherlands	0.50	0.50	-	1.00
Norway	0.70	2.00	2.30	5.00
Poland	-	2.10	-	2.10
Portugal	-	1.00	-	1.00
Romania	0.67	0.67	0.67	2.01
Spain	-	6.00	-	6.00
Sweden	-	0.71	-	0.71
Switzerland	0.98	1.52	-	2.50
United Kingdom	5.00	20.00	5.00	30.00
Canada		2.00		2.00
Covered	16.03	50.03	10.43	76.49
Uncovered	17.47	9.97	23.07	50.51
TOTAL	**33.50**	**60.00**	**33.5**	**127.00**

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**

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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: **NAV**igation Innovation and Support Programme **A**dvisory **C**ommittee

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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

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Roger Mckinlay (Chair)

- Challenge Director – Quantum Tech. for UK Research and Innovation.
- Previous member of the National Quantum Technologies Programme Strategic Advisory Board and Panel member of 2016 Blackett Review on Quantum technologies.
- Occupied several technical, management and strategy positions in the oil and gas, civil aviation, defence, security, maritime and rail industries.
- Past president of the Royal Institute of Navigation.
- Fellow of the Institution of Engineering and Technology, Fellow of the Royal Aeronautical Society, Fellow of the Institute of Directors, Fellow of Royal Institute of Navigation.

Stefano Debei (Member)

- Professor in Mechanical Thermal Measurements Space Robotics, Universita' degli Studi di Padova, Italy.
- Director of Centre for Studies and Activities for Space "G.Colombo" .
- Technical Manager of BepiColombo's instrument SYMBIOS-SYS
- Co-principal investigator of DREAMS, environmental and meteorological experiment for Exomars 2016
- Technical responsible for the wide-angle camera in Rosetta OSIRIS telescope.
- Member of NASA's Mars Exploration Programme Analysis Group (MEPAG).
- Author of more than 200 publications. 3751 citations.

Peter Grognard (Member)

- Managing Director of the Von Karman Institute for Fluid Dynamics.
- Till 2017, Managing Director of the new Thales Alenia Space site in Leuven developing new generation of spacecraft & launcher electronics.
- Founder and manager of Septentrio until 2014. Septentrio receivers have played a fundamental role in the Galileo programme.
- Previously, satellite navigation business development manager at the Interuniversity Microelectronics Center in Belgium
- 1994-1998 S&T attaché at the Embassy of Belgium in Washington
- 1992-1994, member of the Belgian Delegation to ESA.

Bernd Eissfeller (Member)

- Director of Space Applications, Institute of Space Technology & Space Applications, and Professor of Navigation at Faculty of Aerospace Engineering, Universität der Bundeswehr, München(D). Germany.
- Member of several advisory groups to the EC: CSI WG, CS-WG, and WG Evolutions. Member of Program Board Communication & Navigation at DLR Organizer of the Munich Satellite Navigation Summit
- Member of the US ION, Member of German Institute of Navigation (DGON)
- Formerly, at Kayser Threde GmBH, pioneering R&D on GNSS integrity monitoring.
- More than 250 scientific and technical publications.

Luis Mayo (Member)

- Managing Partner Enif Strategy Consulting S.L., Madrid, Spain
- Formerly, Chairman and CEO of Tecnobit, the Aerospace and Defence branch of Grupo Oesia.
- Formerly, CEO of Grupo GMV. Under his leadership, GMV became the world leader among the suppliers of satellite control centers
- Member of the Board of Directors of Galileo Sistemas y Servicios S.L., Galileo Industries S.A. and ESNIS GmbH.
- Contributor to the Spanish National Space plans' definition. Member of the Advisory Committee for Space Matters of the Spanish Centre for National Defence Studies. Full member of the French Air and Space Academy.

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

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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

NAVISP Industry D

Second NAVISP Industry Days in Januray 2020 (TBC) Save the Dates!

RY DAYS ESTEC
GENDA

NEWTON 1 '60'/ESTEC@ESA
NEWTON 2 '81'/ESTEC@ESA

nuary
14:00
Welcome (Paul Verhoef/P.Michel)
NAVISP programme (P. Mancini)
Keynote Speech (R. Mc Kinlay)

15:15
Coffee break

15:45
Element 1 Session: Innovation
Chair: G. Solari
Keynote speech on PNT innovation:
Bernd Eissfeller
Projects presentations
Q&A

18:00
Cocktail

18 January
09:00
Element 2 Session: Competitiveness
Chair: A. Flumara
Keynote speech: Louis Mayo
Projects presentations
Q&A

11:00
Coffee break

11:30
Element 3 Session: Support to Member States national objectives
Chair:
Keynote speech Andy Proctor
Projects presentations
Q&A

13:00
Lunch

14:00
NAVISP second phase (P.Mancini)
Conclusions

Solicited by

the increasing interest of Member States,

ESA is preparing NAVISP Phase II

in view of Cmin Space19+

doubling the funding request

from to 20 to 40 MEuro per year

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2020 NAVISP Element 1 Work Plan
List of Proposed Activities

Application of Machine Learning Technology for GNSS IoT Data Fusion
An innovative concept for the Risk Assessment of Geological Hazards using GNSS and Solid Earth tides modelling
Earth Moon GNSS spaceborne receiver for In Orbit Demonstration
Next Generation Network-assisted PNT Assurance
User antenna diversity algorithms for efficient multipath mitigation
Quantum metrology for secure PNT
Cooperative Positioning and Integrity Concept in Vehicle Platooning
Proof-of -concept of Hybrid 5G /GNSS positioning with local ad-hoc overlay
Next Generation motion sensor for hybrid GNSS/INS solutions in high-accuracy machine control applications
New concept for evolutive mitigation of RFI to GNSS
Interference Monitoring from Space
Hollow Corner Cube Retro-Reflectors for in-orbit PNT
Multi-layer PNT for SAR
Combining ELF signals with GNSS for improved PNT

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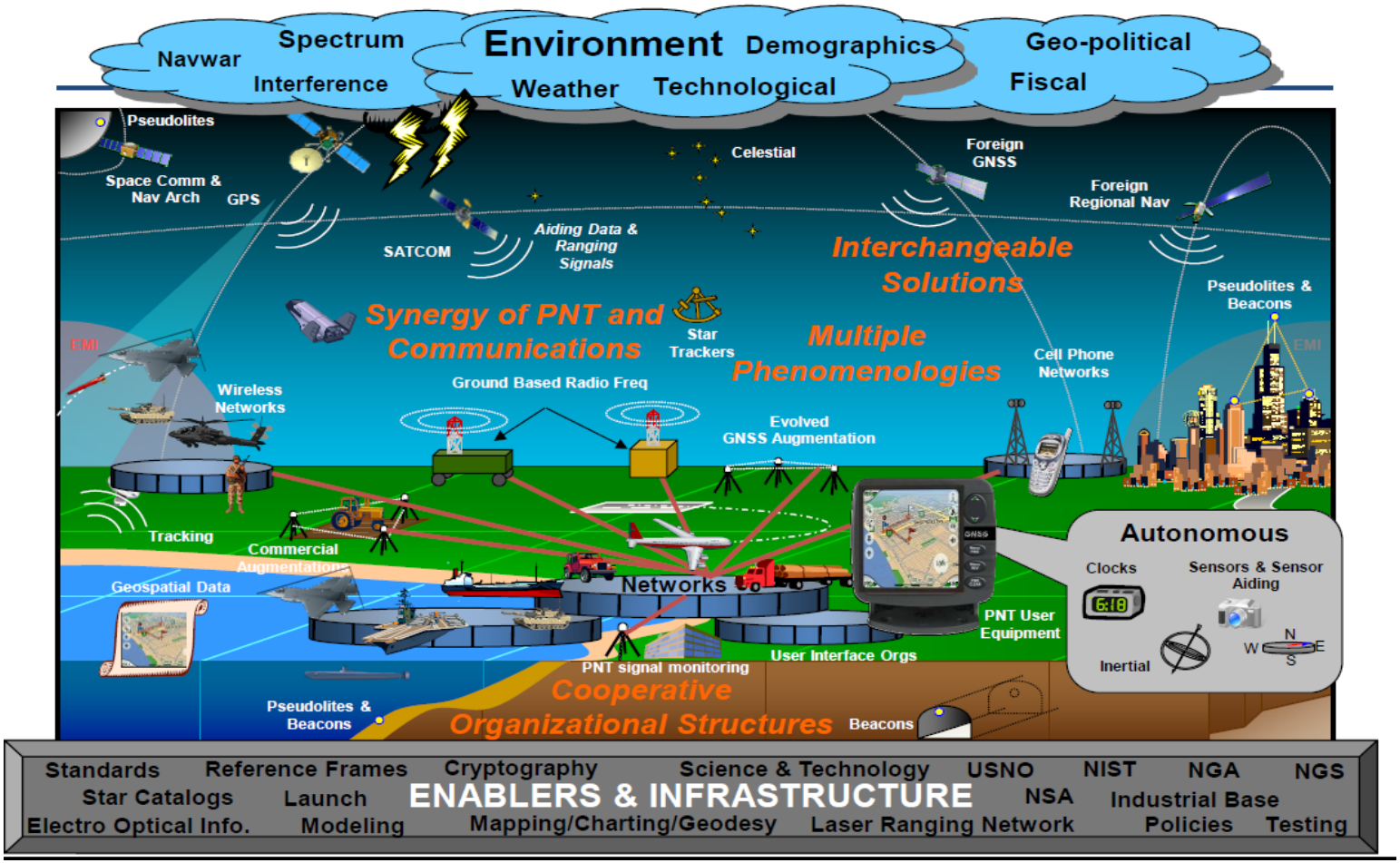
Future of Positioning, Navigation, and Timing



Karen Van Dyke
U.S. Department of Transportation

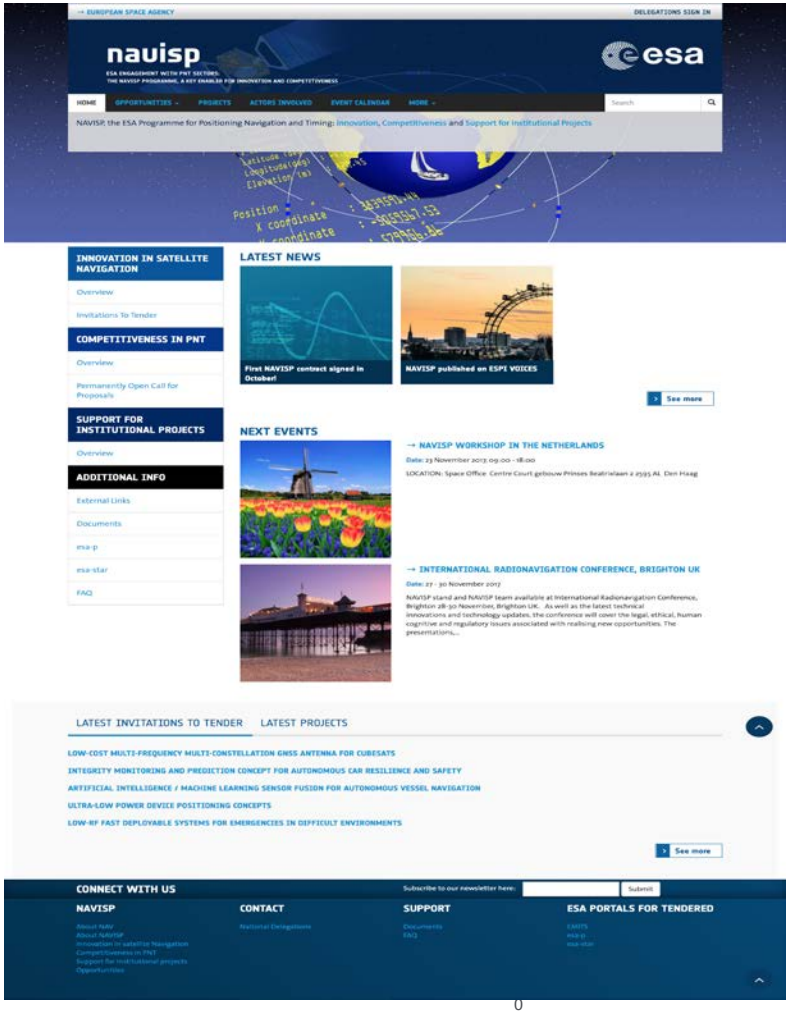
The NAVISP Portal

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



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