Strengthening Positioning, Navigation and Timing (PNT) to drive world economy and society





# **RELIANCE ON PNT** (GNSS)ACROSS **ECONOMY**

Position, Navigation, and Timing (PNT) information is a crucial input into many technologies that underpin the modern economy.

## €2 TRILLION

Socio-economic benefits attributable to GNSS in the European territory (defined as the EU27 plus the UK, Norway and Switzerland

## 100,000 Highly-skilled Jobs

Attributable to GNSS industry during 1999-2027

#### **Domestic applications**

#### Home electronics:

Draw on GNSS synchronised electricity grid

#### Smart home technology:

Usually linked to a GNSS-derived user location

#### Email, news, social media:

Internet data centres synced using GNSS

#### Weather forecast:

Enhanced by GNSS radio occultation

#### Television broadcasts, landline phone:

Rely on GNSS synchronisation

#### Morning run, takeaway deliveries:

Tracked using GNSS

#### Social applications

#### Augmented reality games Travel guides:

 Mobile travel guides leverage GNSS

#### Personal trackers:

 Locate children, elderly loved ones. pets, and valuable objects

#### Location sharing:

 GNSS-based location services offer convenience

#### Transport applications

#### Airplanes, trains, boats:

 Safe and efficient operation enabled by GNSS

#### Pedestrians & cyclists:

Route planning and navigation

#### **Drivers:**

 Crowd-sourced congestion information

**GNSS** 

#### Public transport:

 Service and passenger information systems

### **Professional applications**

#### Fishermen:

GNSS provides compliance and location information

#### Road transport operators:

GNSS-enabled fleet management and navigation

#### Farmers:

 GNSS supports precision agriculture Construction:

Inputs from GNSS-aided surveyors

#### Travel guides:

 Mobile app travel guides leverage **GNSS** 

#### **Emergency applications**

#### Blue-light services:

 GNSS helps locate and dispatch the nearest emergency response service

#### Risk monitoring & disaster response:

 GNSS guided satellite imagery and positioning assist even when other infrastructure is unable

#### Commercial applications

#### Food prices:

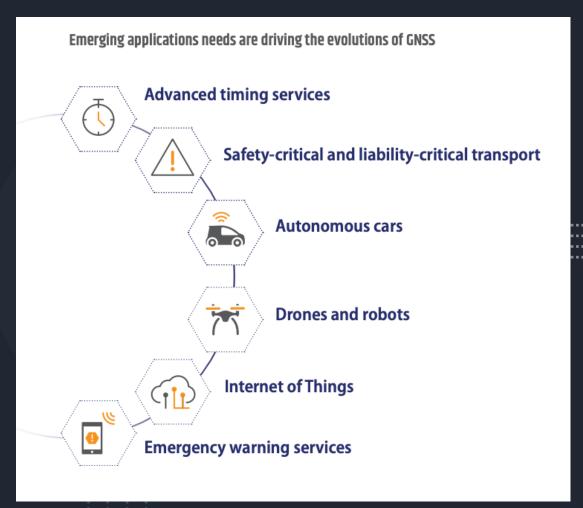
 GNSS enables efficient precision farming which keeps consumer prices low

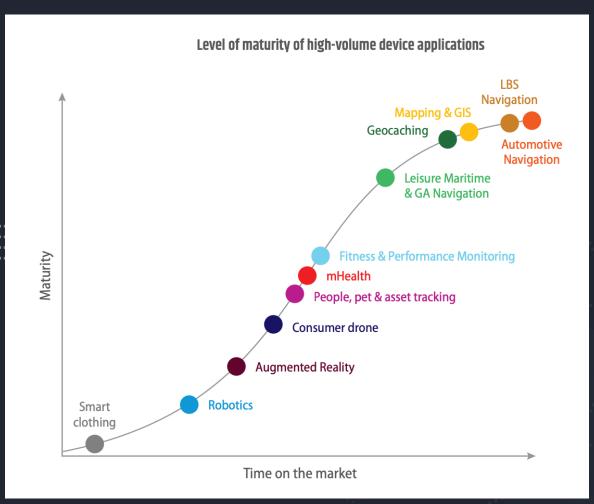
#### Supermarkets:

 GNSS-based fleet management enables and improves "just-in-time" stocking systems



# PNT MATURITY AND ITS CRITICAL ROLE IN DIGITAL AGE





# COST OF GPS/GNSS OUTAGE TO WORLD ECONOMY

According to the National Institute of Standards and Technology, GPS has generated.....

in economic benefits for the private sector. But what happens when there is a GPS outage?

The potential impact of a 30-day GPS outage:



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System (GPS) Final Report September /

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# **30-day GPS outage costs by industry**



# LIKELY VULNERABILITIES AND LIMITATIONS: GNSS AND BEYOND



- Covert
- Deception



#### **INTERFERENCE**

IntentionalUnintentional



#### GNSS SEGMENT ERRORS

- Erroneous Upload Data
- SV Faults



#### **MULTIPATH**

Combination of Line of Sight (LOS) and Non-LOS reflecting off nearby obstacles



# **CYBER ATTACKS**

Non-RF



#### **ATMOSPHERE**

- Scintillation
- Solar Activity

## **EXAMPLES OF GNSS INTERFERENCES**

- 2019: Aviation association Eurocontrol says it received 3,500 reports of GPS disruption in 2019, an all-time high. Jamming is widespread across the central and Eastern Mediterranean, likely due to electronic warfare between conflicting factions in Syria, Libya and elsewhere in the region.
- 2022: EU's Aviation Safety Agency warns of GNSS spoofing and jamming in aircrafts with noted incidents in flights over Europe
- 2022: Russian jamming of GPS signals over the Black Sea

"The concept of resilient PNT is context and application-specific, because achieving a state of resilient PNT for a user, a company, a critical infrastructure sector, or a nation are all different things. In other words, resilient PNT takes on different meanings depending on the scale or scope of the application, or the system that is being protected and backed up"

## PNT RESILIENCE SOLUTIONS

# SYSTEM OF SYSTEM APPROACH

No 'silver bullet ' to GNSS resiliency

→ solution needs to be 'system of system'

- Depending on application different systems will provide the answer
- Going from one 'system' to 'another' is not resilient

## **RESILIENT PNT SOLUTIONS**

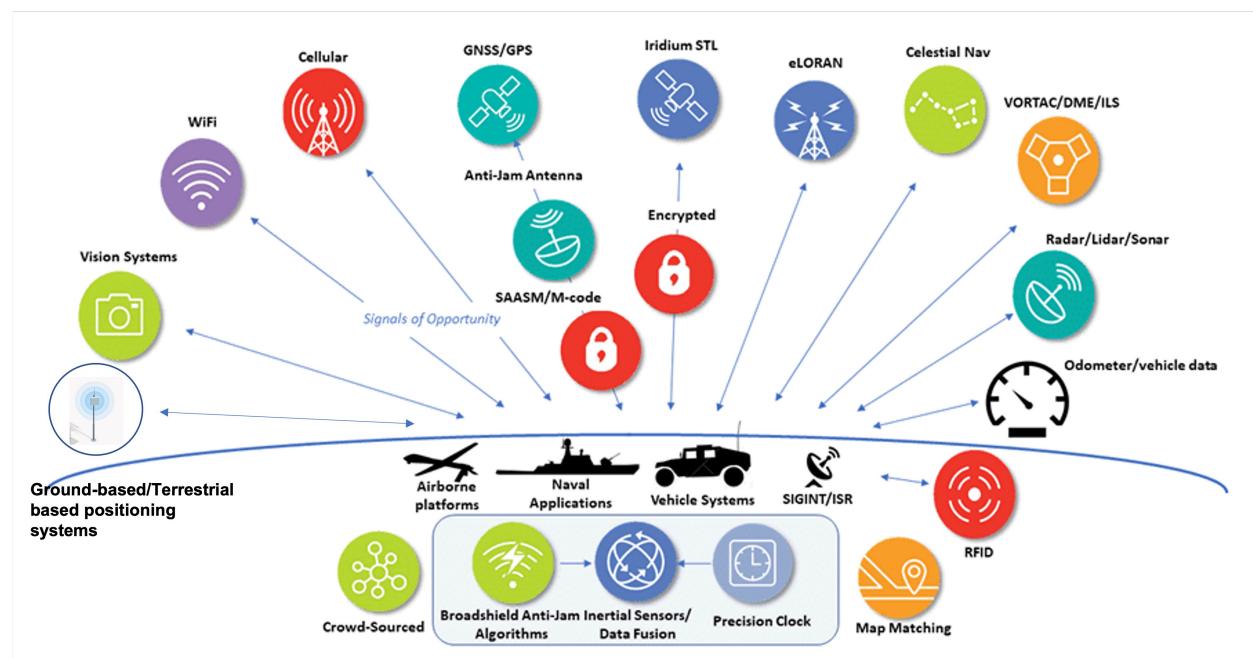
Fiber based system → Point to point but not suited for local distribution and mobility based applications

Terrestrial system (Dedicated & cellular) → Can provide high quality PNT services, low cost receiver, infrastructure based

Low Earth Orbit → space based, coverage in rural & more open spaces

**eLORAN (predecessor to GPS)** → primarily maritime applications, receiver SWAP considerations

Source: NIST Study



Source: Reference image from Orolia; interpreted by Geospatial World

# ALTERNATIVE/RESILIENT PNT SOLUTIONS FOR TOMORROW'S POSSIBILITIES

## KPIS IDENTIFIED FOR RESILIENT PNT BY JRC

- Can deliver positioning, and/or timing information independently from GNSS;
- Act as the backup in the event of a GNSS disruption or outage;
- Able to provide the coverage for the EU European territory including in-land waters;
- Resilient to GNSS failure modes and vulnerabilities (including GNSS frequency jamming and spoofing or unintentional interference);
- (If possible) extend PNT provision to the environments where GNSS cannot be delivered, i.e.: urban canyons, indoor, underground and underwater.
- Have TRL greater than 5 for position/navigation services OR greater than 6 for timing services.
- Provide minimum performance of the alternative PNT service for at least 1 day upon GNSS loss:
  - o Positioning Accuracy (Horizontal and/or Vertical 95%) < 100 m OR Timing Accuracy to UTC (3 sigma) < 1 microsec, and
  - Availability > 99%
- If the alternative PNT service provides a timing service, traceability to UTC shall be possible.

# KEY HIGHLIGHTS FROM EU-JRC FROM A-PNT TEST CAMPAIGN

### **REGULATORY INITIATIVES**

The European Commission (EC) has implemented multiple regulatory actions aimed at enhancing the resilience of PNT infrastructures and services in the EU. Those include:

- Introduction of new Galileo services with an enhanced resilience against spoofing attacks, as the Galileo OSNMA, plus those in the second generation of Galileo.
- The EU Space Regulation, requesting to protect EU Space ground infrastructure and stringent cybersecurity requirements for the EU Space Programmes.
- The Release of a new European Radio Navigation Plan, a reference document presenting the evolution of the landscape of PNT infrastructures in the EU to identify potential gaps and synergies in the various PNT sectoral domains.

### MAIN RECOMMENDATIONS

- Energy supply networks, transport infrastructures, telecommunications, and financial networks etc., are primary users of PNT services, and
  countries in Europe must consider the effect of the potential disruptions. Historically those included jamming, more sophisticated spoofing
  attacks or a malfunction in the GNSS system infrastructure.
- Initial assessment of alternate PNT systems shows that mature commercial A-PNT technologies, which can deliver positioning, and/or timing information independently from GNSS, already exist in the commercial market.
- EU companies have excellent record in time transfer and time generation. The test campaign highlighted the important role of the NMIs across
  Europe as most of tested technologies work with them directly and un-directly
- A resilient EU PNT requires system of system approach with mix of technologies following, which are supported by industry standards to
  ensure the required interoperability. All positioning technologies should operate within the European Terrestrial Reference Frame (ETRF) and
  timing related to time scale of UTC from an NMI.

Source: Assessing Alternative Positioning Navigation and Timing Technologies for Potential Deployment in the EU - JRC

# THANK YOU



