



Ministry of National Defence
Republic of Poland



Ministry of Digital Affairs
Republic of Poland



Ministry of Finance
Republic of Poland

RCB
Gov. Centre Sec.

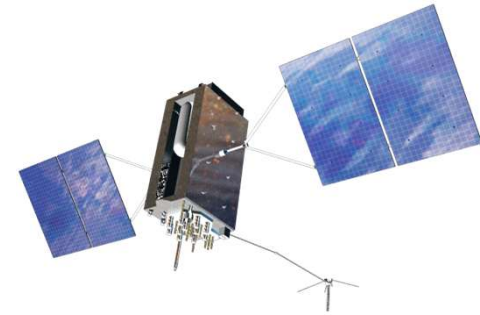


National Institute
of Telecommunications



From the **Polish PNT Shield** to a **European PNT Shield**

**Our mission is to turn detection into protection
from situational awareness and incident response to complementary PNT services**



Agenda:

- 1) The Importance of GPS/GNSS/PNT Technology**
Key role in critical infrastructure and daily life
- 2) GPS/GNSS/PNT Interference**
Jamming, spoofing and hybrid threats.
- 3) Protection, Defence and Attack**
Countermeasures, resilience and response strategies.
- 4) The concept of complementary PNT**
Polish PNT Shield: From National Resilience to European Complementary PNT

The Importance of GPS/GNSS/PNT Technology



The Baltic Sea is a critical theatre for the Russian economy because Russian Baltic ports handle a major share of the country's exports of oil, fuels and LPG – the core source of its hard-currency revenue. EU/G7 oil sanctions and the fact that, after Finland and Sweden joined NATO, the Baltic has effectively become a NATO-controlled sea and this has pushed Russia to rely on a dispersed "shadow fleet" of tankers, using advanced masking techniques such as AIS spoofing, ship-to-ship transfers and flags of convenience, supported by increasing GNSS jamming and spoofing that complicate monitoring, enforcement of sanctions and safe navigation.

The Importance of GPS/GNSS/PNT Technology



In the medium term, regardless of any de-escalation or “freezing” of kinetic fighting on land, at sea and in the air, Russia is likely to intensify below-threshold operations in the key modern domains of cyberspace and outer space, closely linked with the electromagnetic spectrum. These hybrid activities will aim to exploit Western dependence on GNSS/PNT, subtly degrade security and quality of life in EU and NATO countries, generate economic and social pressure, and thereby secure political concessions favourable to Moscow



The Importance of GPS/GNSS/PNT Technology

GPS/GNSS/PNT Interference
Protection, Defence and Attack
Complementary PNT



In addition, about 6% of European Gross Domestic Product (GDP) depends on Global Navigation Satellite Systems (GNSS). This corresponds to approximately €1 trillion.

↓
PTN as a foundation of the economy and critical infrastructure

World economy



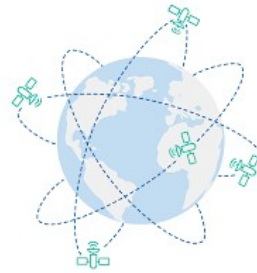
100 trillion €

EU



17 trillion €

GNSS



6% PKB UE 1 trillion €

Poland



0,8 trillion €

MON



Ministry of National Defence
Republic of Poland

0,03 trillion €

* <https://www.euspa.europa.eu/eu-space-programme/eu-space-market-and-users/gnss-and-eo-market-report>, GNSS Market Report 2015 (GSA) – 2015 „6% of European GDP depends on GNSS”, ESA – „Why Europe needs Galileo” - 2012–2015 „6–7% of European GDP ... dependent on satellite navigation signals”, European GDP ≈ 17 biliona euro (PL) = 17 trillion euros (EN) = 17×10^{12} €

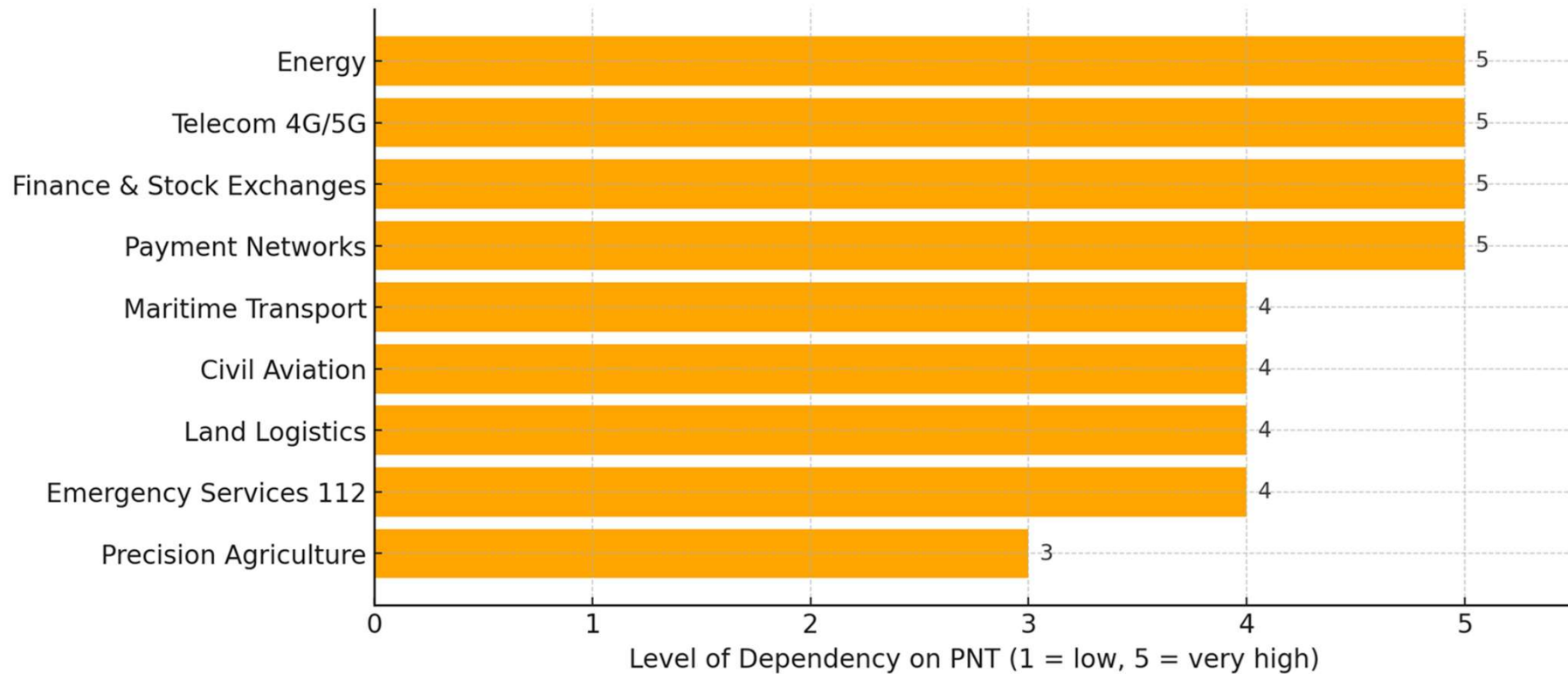


The Importance of GPS/GNSS/PNT Technology

GPS/GNSS/PNT Interference
Protection, Defence and Attack
Complementary PNT



The PNT Technology Interdependency Chain and Critical Risk Areas





The Importance of GPS/GNSS/PNT Technology

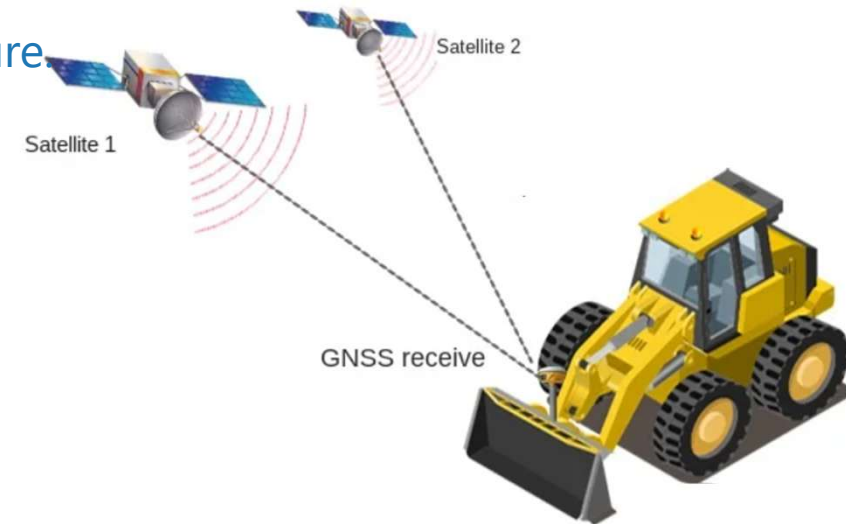
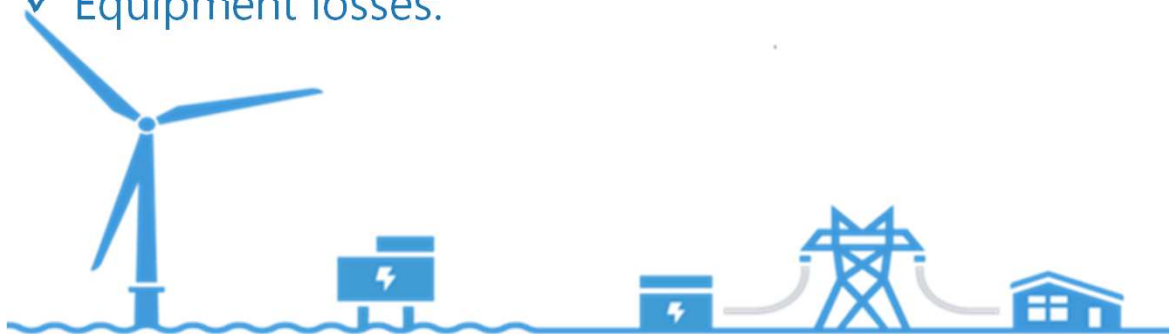
GPS/GNSS/PNT Interference
Protection, Defence and Attack
Complementary PNT



The PNT Technology Interdependency Chain and Critical Risk Areas

Practical effects of GNSS signal interferences

- ✓ Delays in the implementation of road, railway and construction projects.
- ✓ Inability to carry out surveying works in various sectors, including offshore wind farms (OWF).
- ✓ Inability to perform automated field operations in agriculture
- ✓ Inability to produce photogrammetric studies.
- ✓ Equipment losses.





The Importance of GPS/GNSS/PNT Technology

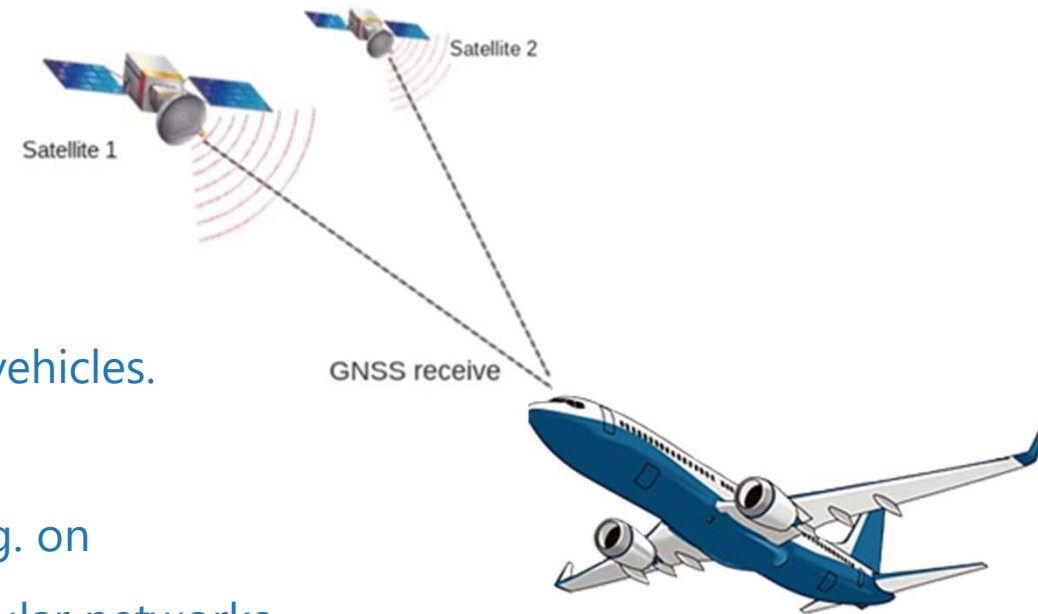
GPS/GNSS/PNT Interference
Protection, Defence and Attack
Complementary PNT



The PNT Technology Interdependency Chain and Critical Risk Areas

Practical effects of GNSS signal interferences

- ✓ Increased risk in air traffic.
- ✓ Increased risk in maritime and inland navigation.
- ✓ Problems in the functioning of emergency services.
- ✓ Threats arising from the operation of autonomous vehicles.
- ✓ Risk of disruptions in time synchronization systems.
- ✓ Very broad indirect impact of GNSS interference, e.g. on communication systems – desynchronization in cellular networks.

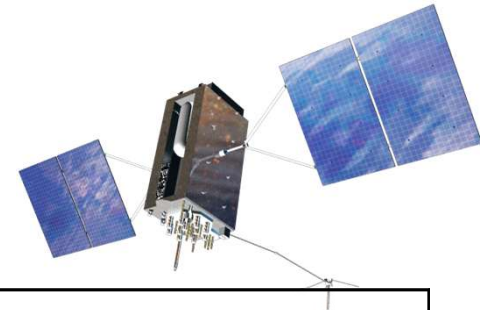




The Importance of GPS/GNSS/PNT Technology

GPS/GNSS/PNT Interference

Protection, Defence and Attack
Complementary PNT



Type of Interference	Source / Origin	
Anthropogenic (Man-made)	Unintentional	
	Intentional	jamming
		spoofing
Natural	Solar System: Coronal Mass Ejections (CME)	
	Interstellar Space: Broadband Emissions	

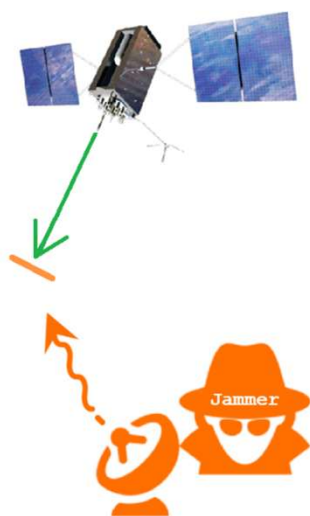
Jamming

- ✓ GNSS is highly vulnerable to interference.
- ✓ The cost of building a jammer is around €25.
- ✓ An electronics hobbyist can assemble one within a few hours.

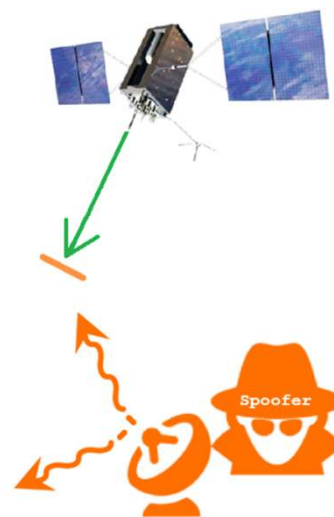
The Importance of GPS/GNSS/PNT Technology

GPS/GNSS/PNT Interference

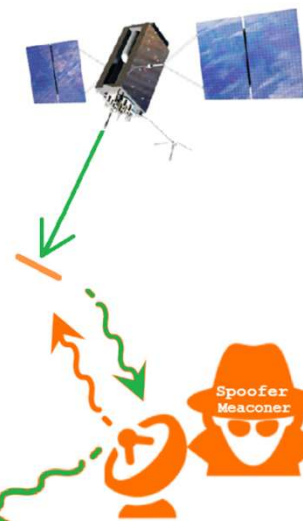
Protection, Defence and Attack
Complementary PNT



Jamming - Intentional transmission of signals in GNSS frequency bands. It prevents receivers from correctly acquiring satellite signals.



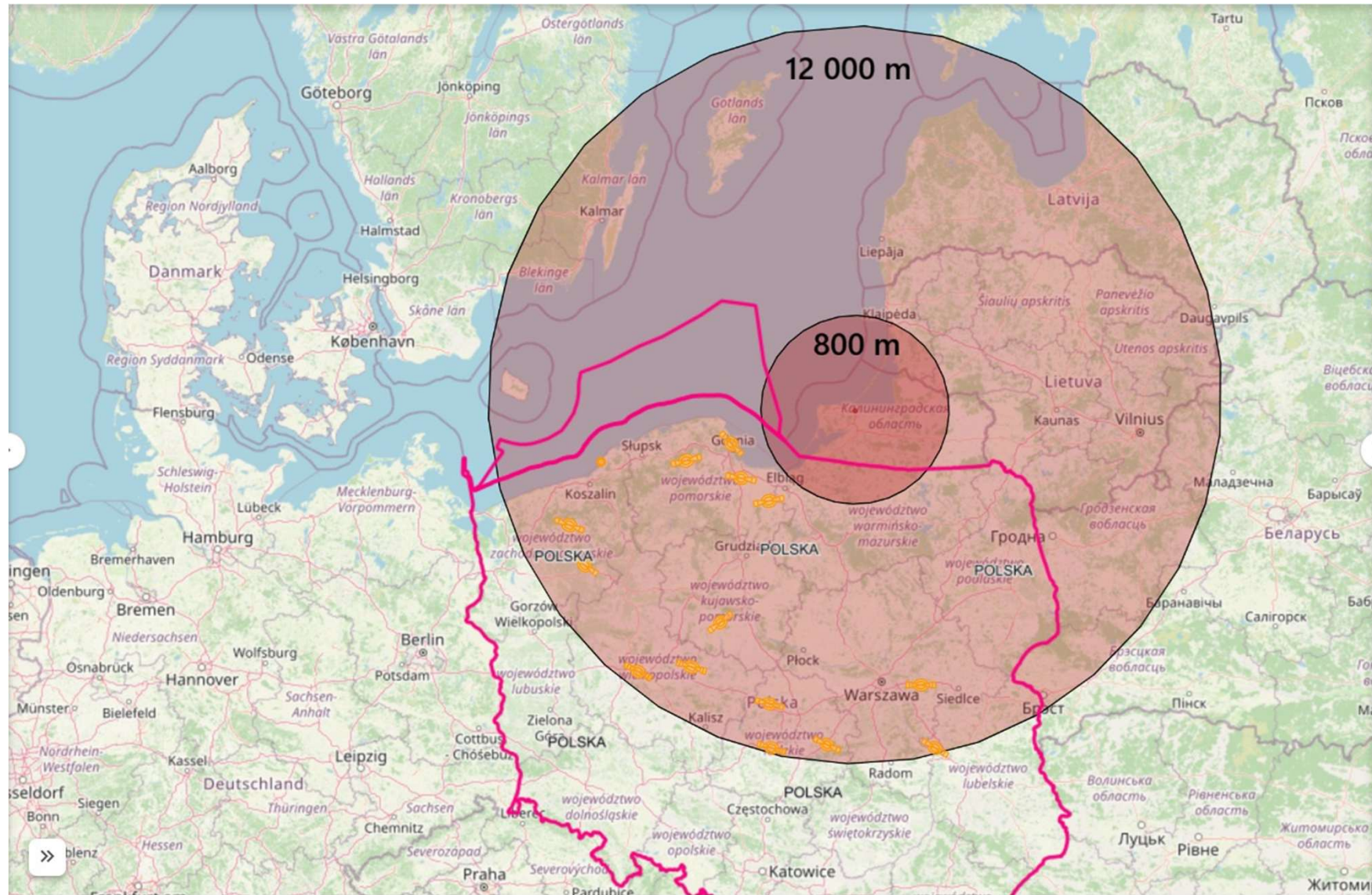
Spoofing - Transmission of false GNSS signals.



Meaconing - Intercepting GNSS signals in one location and retransmitting them with higher power in another area.

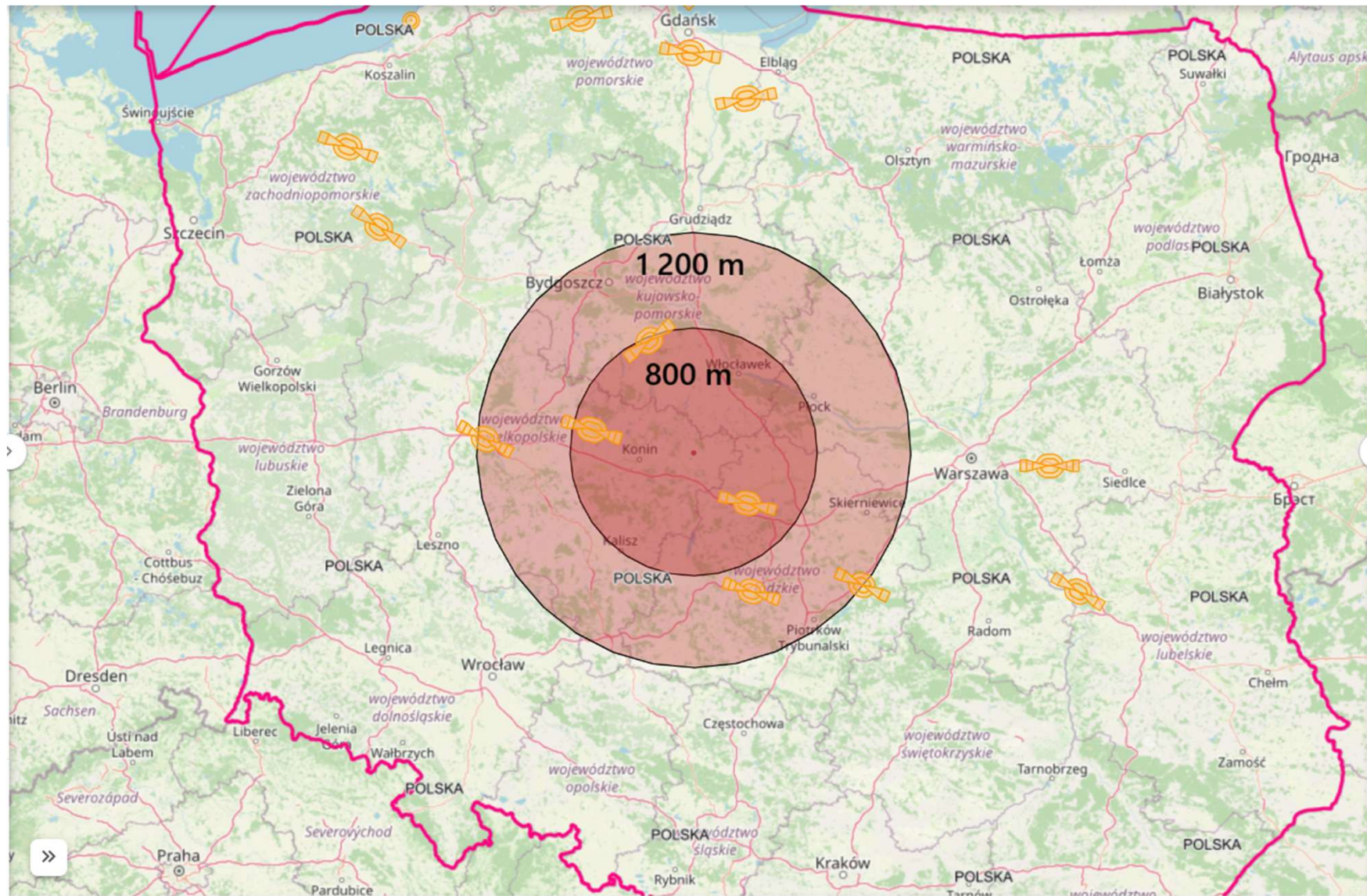
GPS/GNSS/PNT Interference

„> 1/2 of Poland's territory at cruising altitude within Kaliningrad Oblast range”



GPS/GNSS/PNT Interference

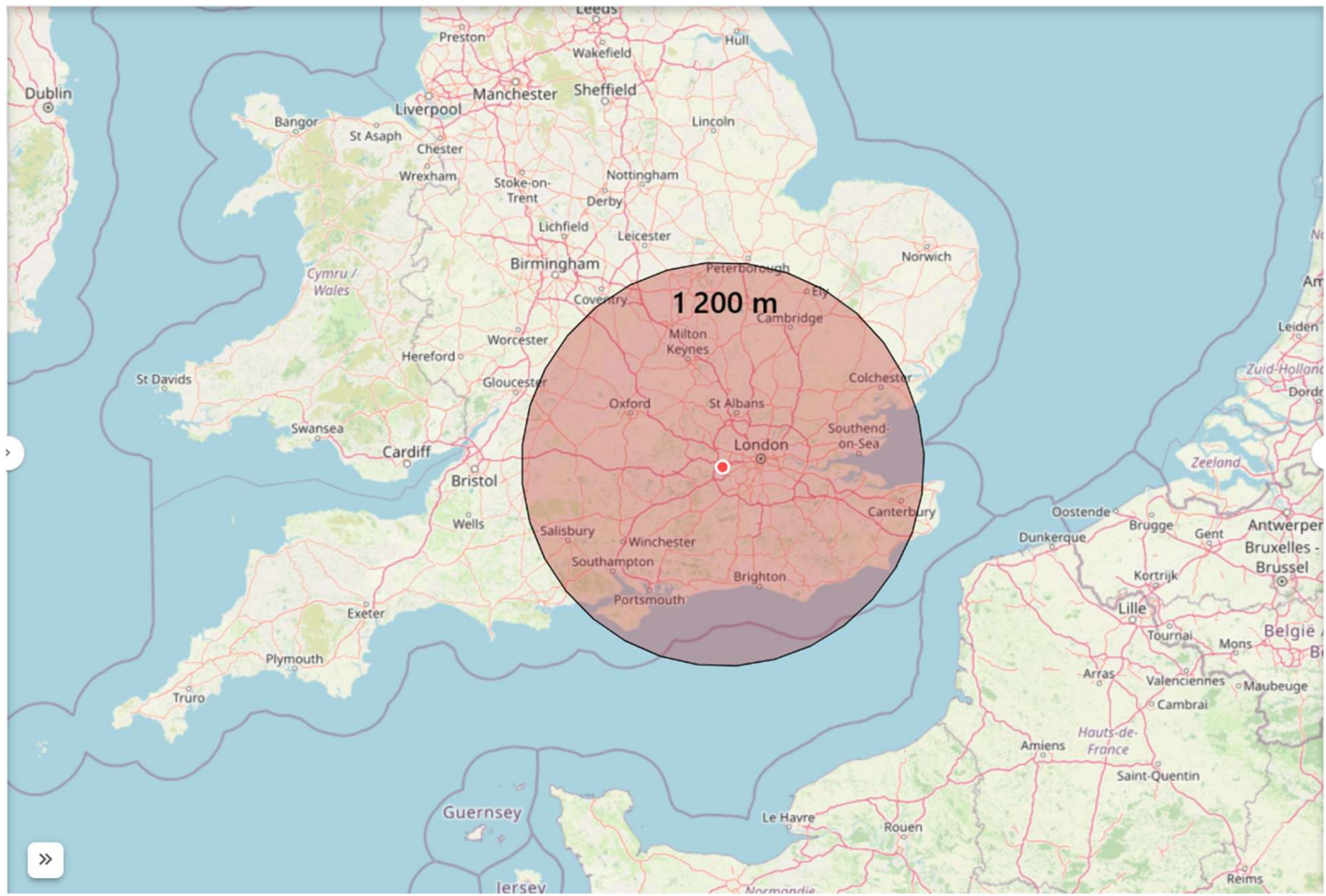
„> 1/2 of Poland's territory at cruising altitude within Kaliningrad Oblast range”



GPS/GNSS/PNT Interference

Heathrow London

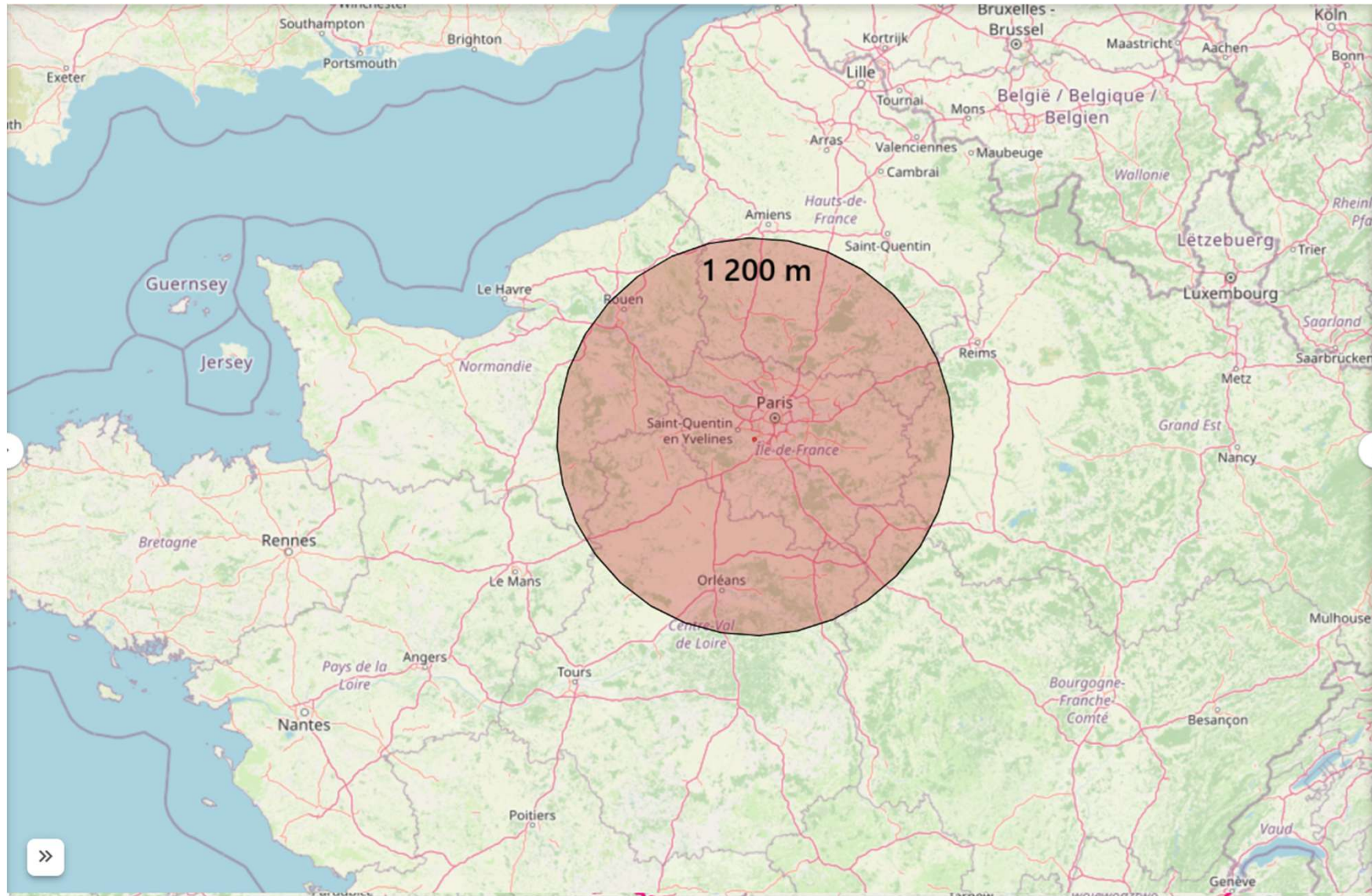
Number of Passengers
80 mln.



GPS/GNSS/PNT Interference

Roissy-Charles de
Gaulle

Number of Passengers
72 mln.



GPS/GNSS/PNT Interference

Heathrow London

Number of Passengers
80 mln.

Roissy-Charles de Gaulle Paris

Number of Passengers
70 mln.

Schiphol Airport Amsterdam

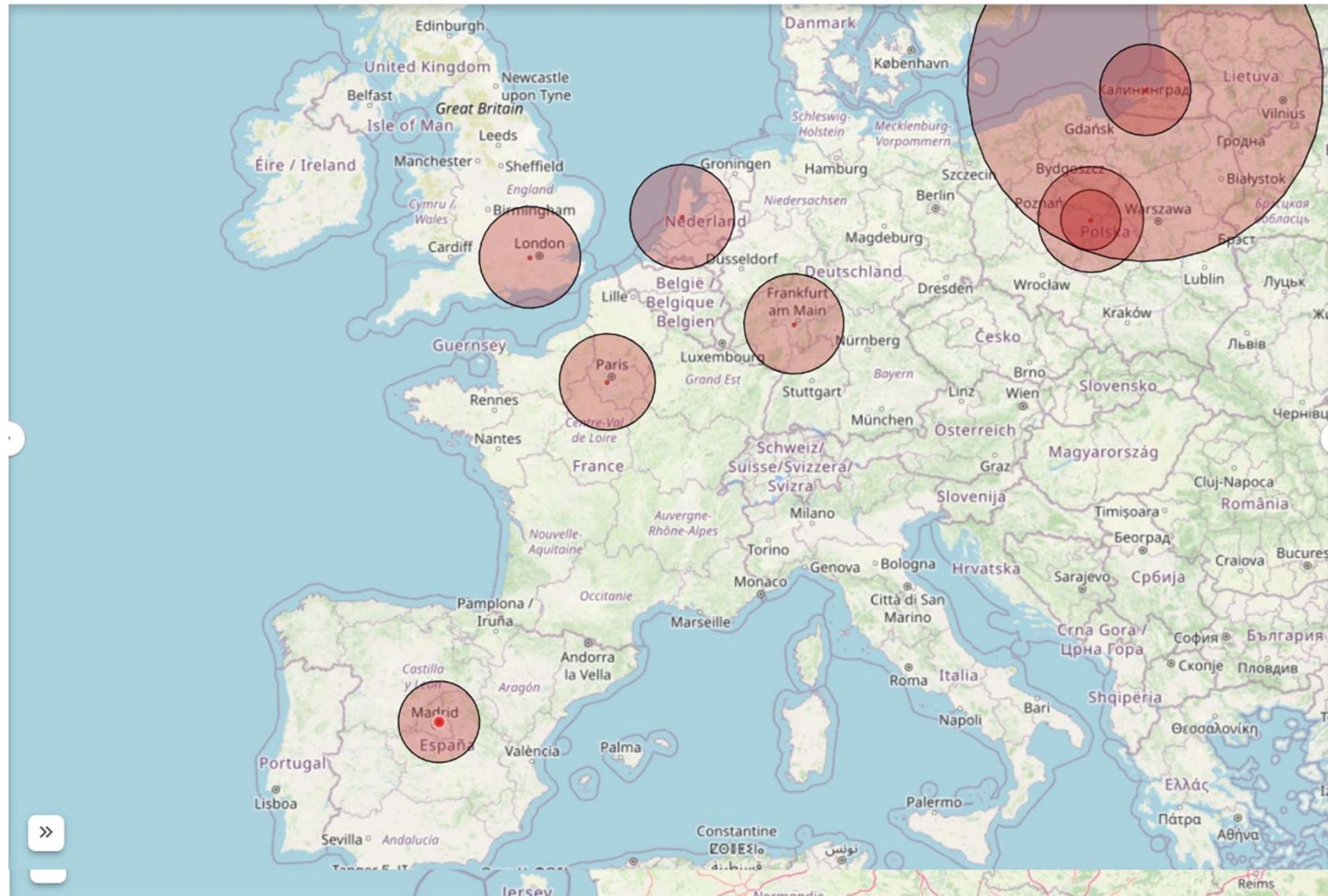
Number of Passengers
61 mln.

Frankfurt am Main Airport Frankfurt

Number of Passengers
60 mln.

Barajas Airport Madrid

Number of Passengers
60 mln.



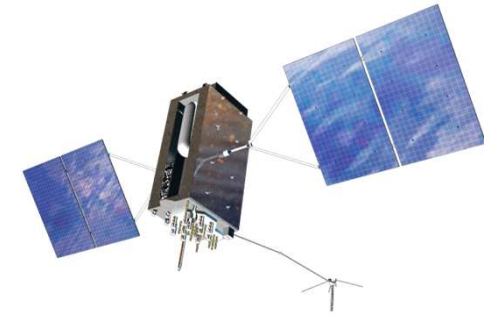


The Importance of GPS/GNSS/PNT Technology

GPS/GNSS/PNT Interference

Protection, Defence and Attack

Complementary PNT



Functionalities of the GNSS system we protect

Positioning

Navigation

Timing

Pillars of GNSS system security enhancement

Protection / Defence

Detection

Attack Data

Electronic Support (ES) – detection, identification and geolocation of interfering emissions.

"Hear the threat" – sensor network.

Complementary PNT

Positioning

Navigation

Timing

Electronic Protection (EP) – measures and procedures protecting own PNT capabilities.

"Protect yourself" – CRPA/MCARP antennas, atomic clocks, e-Loran, R-Mode, (Ground-based GPS), pulsar timing.

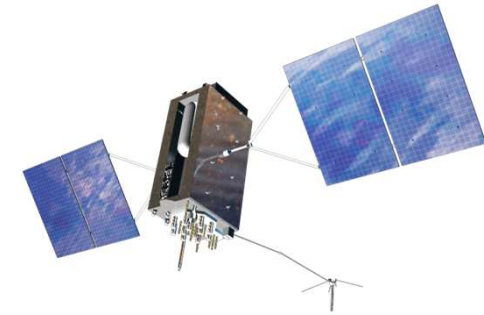
Attack

Space Electronic Warfare

Electronic Attack (EA) – the use of electromagnetic energy to degrade, deny or destroy an adversary's capabilities.



The Importance of GPS/GNSS/PNT Technology
 GPS/GNSS/PNT Interference
Protection, Defence and Attack
 Complementary PNT



Functionalities of the GNSS system we protect



Pillars of GNSS system security enhancement



Turn detection into protection

Polish PNT Shield

Protection / Defence

Detection

Attack Data

From situational awareness and incident response to complementary PNT services

European PNT Shield

Complementary PNT

Positioning

Navigation

Timing

From force protection to response capabilities

NATO PNT Shield

Attack

Space Electronic Warfare

The Importance of GPS/GNSS/PNT Technology

GPS/GNSS/PNT Interference

Protection, Defence and Attack

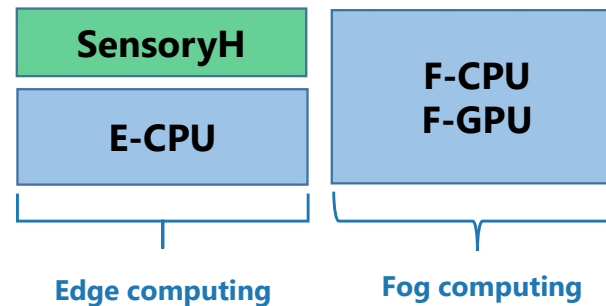
Complementary PNT



Ministry of Digital Affairs
Republic of Poland



RTGMS – Information Technology Architecture



Real-time GNSS Monitoring System for Poland (RTGMS) and ASG-EUPOS

Real-time GNSS Monitoring System for Poland

Map Monitoring — high level Monitoring — medium level Monitoring — low level Alert service Project Information

Status — low level

Data	Status	Station	City
<input type="checkbox"/>	<input checked="" type="checkbox"/>	BOLE	Bolesławice
<input type="checkbox"/>	<input checked="" type="checkbox"/>	SPOL	Siła Pod.
<input type="checkbox"/>	<input checked="" type="checkbox"/>	BRNO	Braniewo
<input type="checkbox"/>	<input checked="" type="checkbox"/>	BYDG	Bydgoszcz
<input type="checkbox"/>	<input checked="" type="checkbox"/>	GZYZ	Giżycko
<input type="checkbox"/>	<input checked="" type="checkbox"/>	GLDP	Gołdap
<input type="checkbox"/>	<input checked="" type="checkbox"/>	GMAL	Gorzów Wie.
<input type="checkbox"/>	<input checked="" type="checkbox"/>	INAR	Inowrocław
<input type="checkbox"/>	<input checked="" type="checkbox"/>	KATO	Katowice
<input type="checkbox"/>	<input checked="" type="checkbox"/>	KROS	Krosno
<input type="checkbox"/>	<input checked="" type="checkbox"/>	KSKE	Końskie
<input type="checkbox"/>	<input checked="" type="checkbox"/>	LODZ	Łódź
<input type="checkbox"/>	<input checked="" type="checkbox"/>	OLEC	Oleśnica
<input type="checkbox"/>	<input checked="" type="checkbox"/>	REDZ	Redzikowo
<input type="checkbox"/>	<input checked="" type="checkbox"/>	SLUP	Słupno

GNSS Stations Map

Legend: No disturbances (Green), Possible disturbances (Yellow), Disturbances (Red), No data (Grey)

- ultra-low latency,
- local buffering,
- scalability,
- the ability to handle thousands of data streams.

<https://rtgms.pl/>



The Importance of GPS/GNSS/PNT Technology

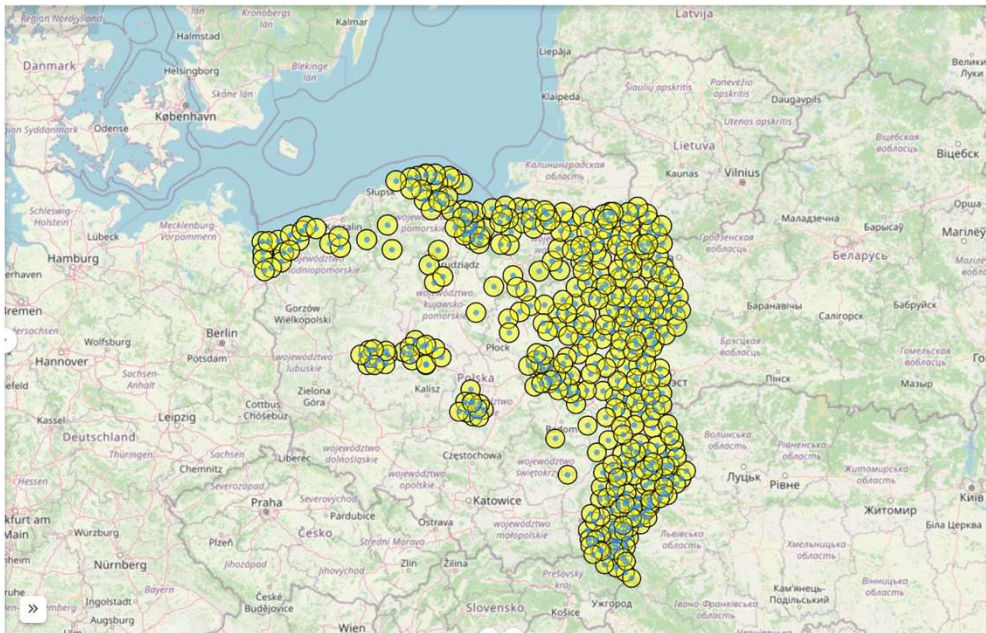
GPS/GNSS/PNT Interference

Protection, Defence and Attack

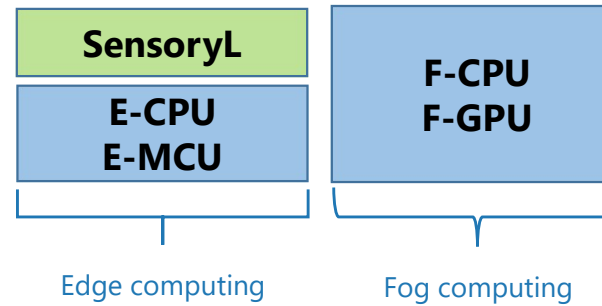
Complementary PNT



Ministry of Finance
Republic of Poland



SMZSG – Information Technology Architecture



GNSS Signal Interference Monitoring System (SMZSG) – Stage I

The Importance of GPS/GNSS/PNT Technology

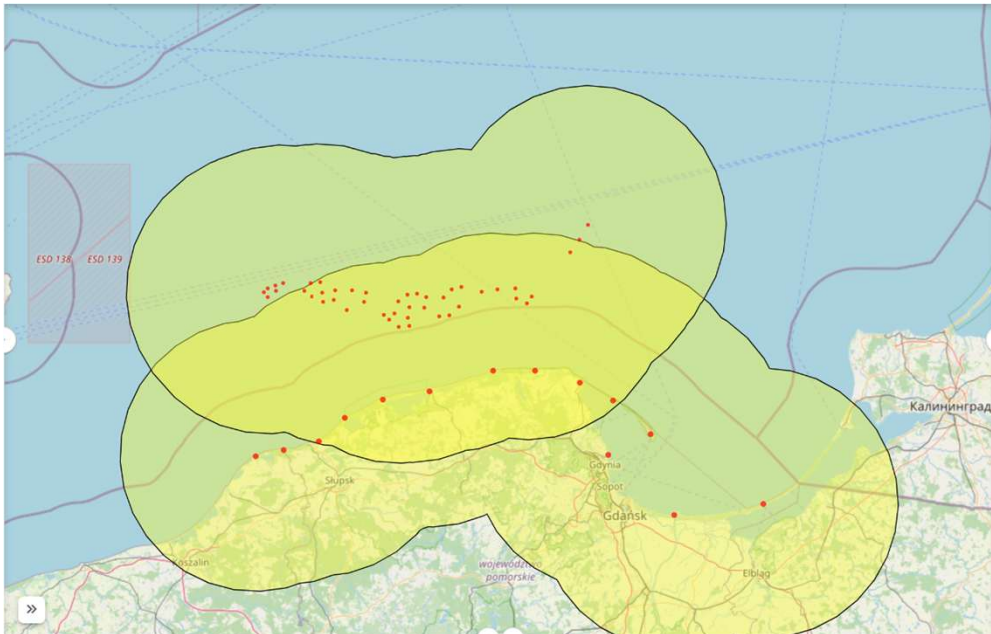
GPS/GNSS/PNT Interference

Protection, Defence and Attack

Complementary PNT

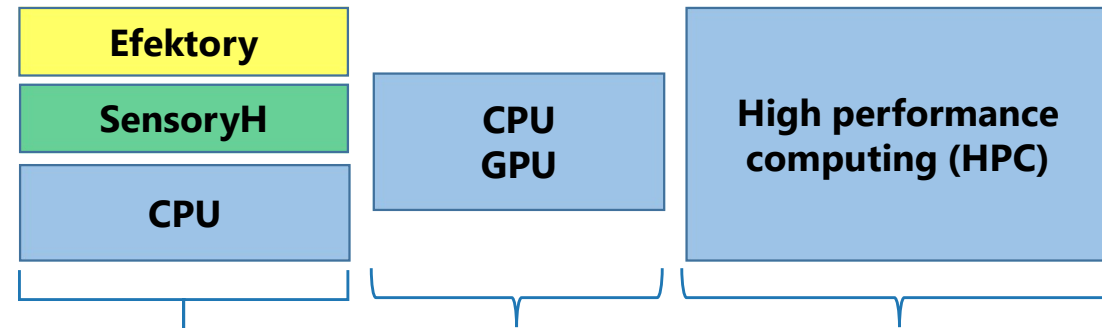


Ministry of National Defence
Republic of Poland



System for the Protection of Critical GPS/GNSS Services (SOUKG)

SOUKG – Information Technology Architecture



Edge computing

- Ultra-low latency
- Local buffering
- Data pre-selection
- Tens of thousands of parallel streams (SDR, GNSS)
- Demanding real-time applications

Fog computing

- Intermediate layer
- Aggregates multiple edge nodes
- Provides coordination, federation, and broader distributed resources.

Cloud computing

- Unlimited scalability
- Operational continuity
- Resource flexibility
- Machine Learning training
- Big Data analytics
- High-Performance Computing (HPC)
- Data archiving
- Platform services.

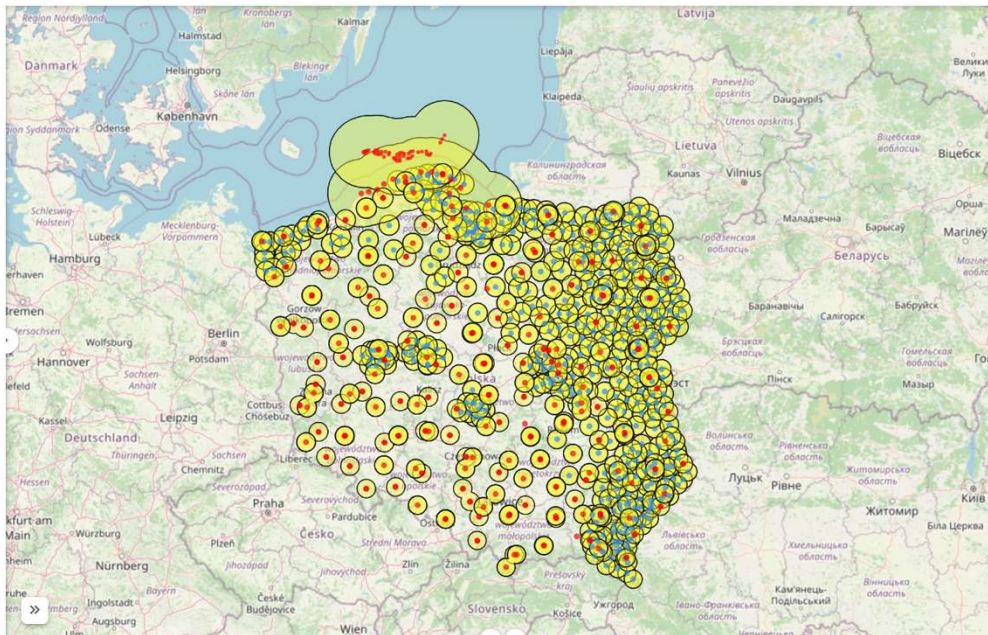
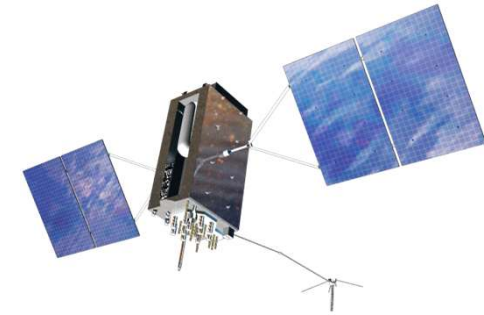


The Importance of GPS/GNSS/PNT Technology

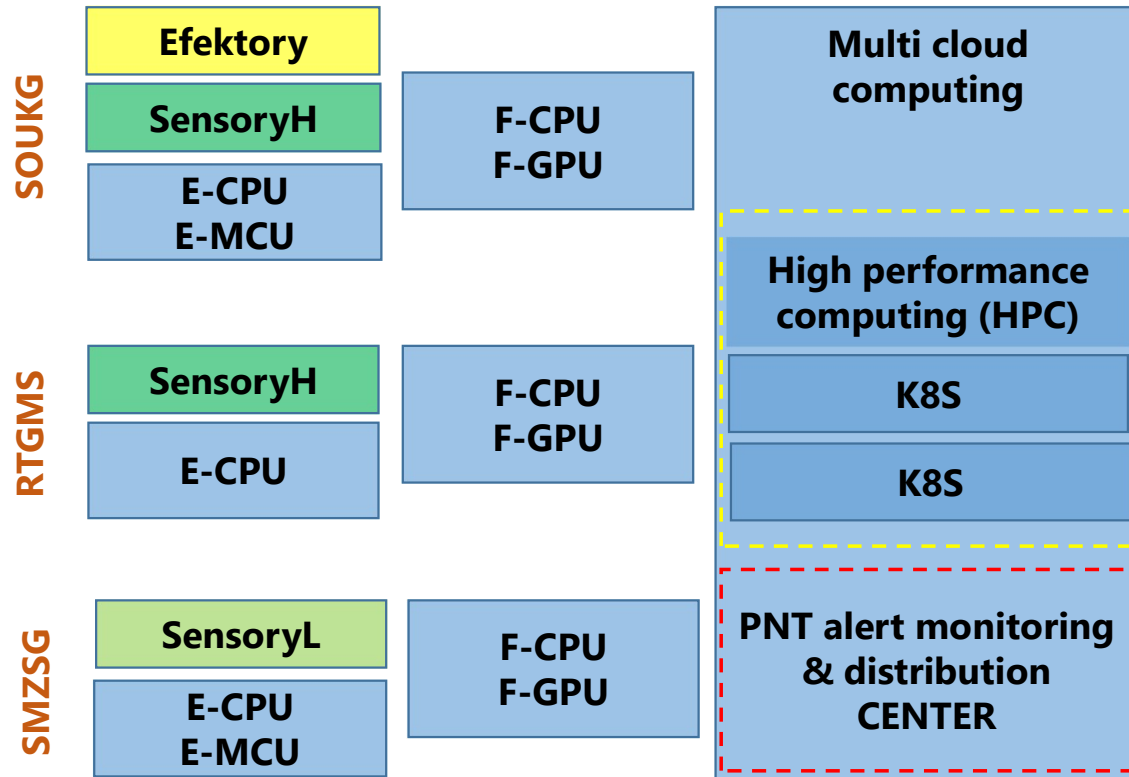
GPS/GNSS/PNT Interference

Protection, Defence and Attack

Complementary PNT



System for the Protection of Critical GPS/GNSS Services (SOUKG)
Real-time GNSS Monitoring System for Poland (RTGMS) and ASG-EUPOS
GNSS Signal Interference Monitoring System (SMZSG) – Stage I



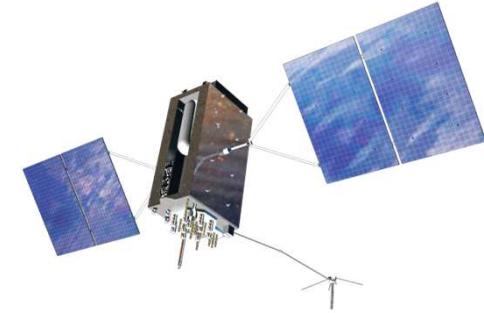
The Importance of GPS/GNSS/PNT Technology

GPS/GNSS/PNT Interference

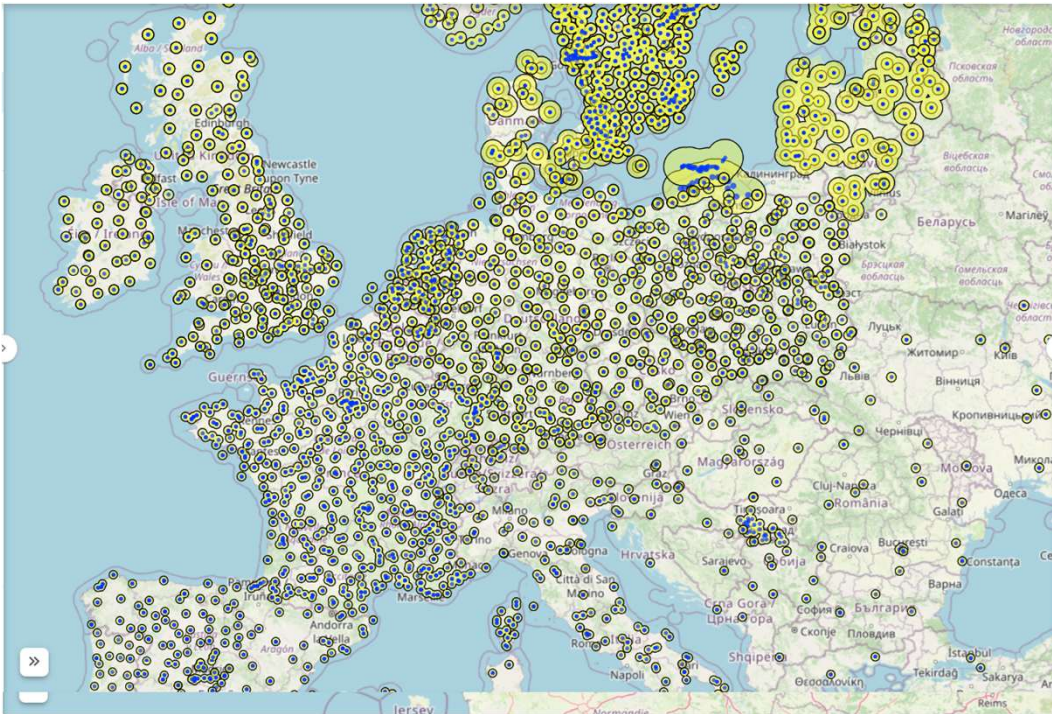
Protection, Defence and Attack

Complementary PNT

Functionalities of the GNSS system we protect



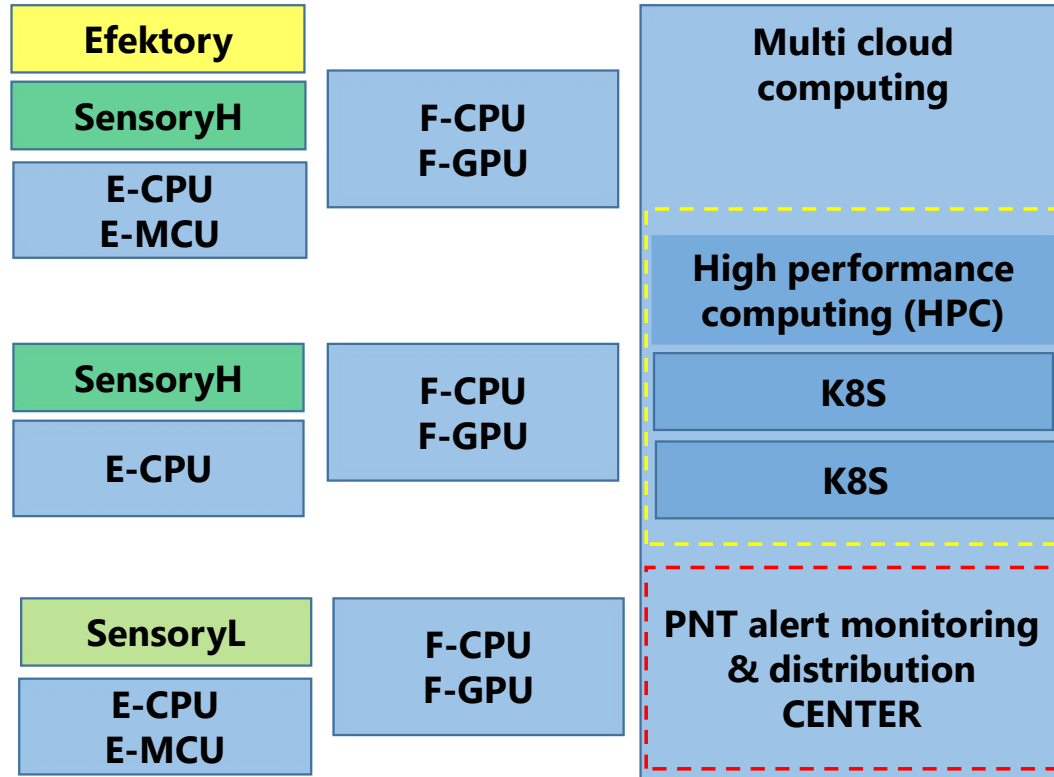
EU and NATO-wide scaling of the solution strengthening allied resilience



SOUKG

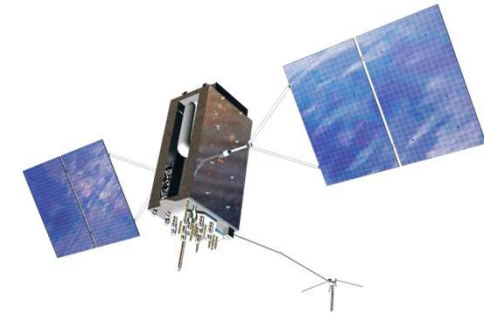
RTGMS

SMZSG



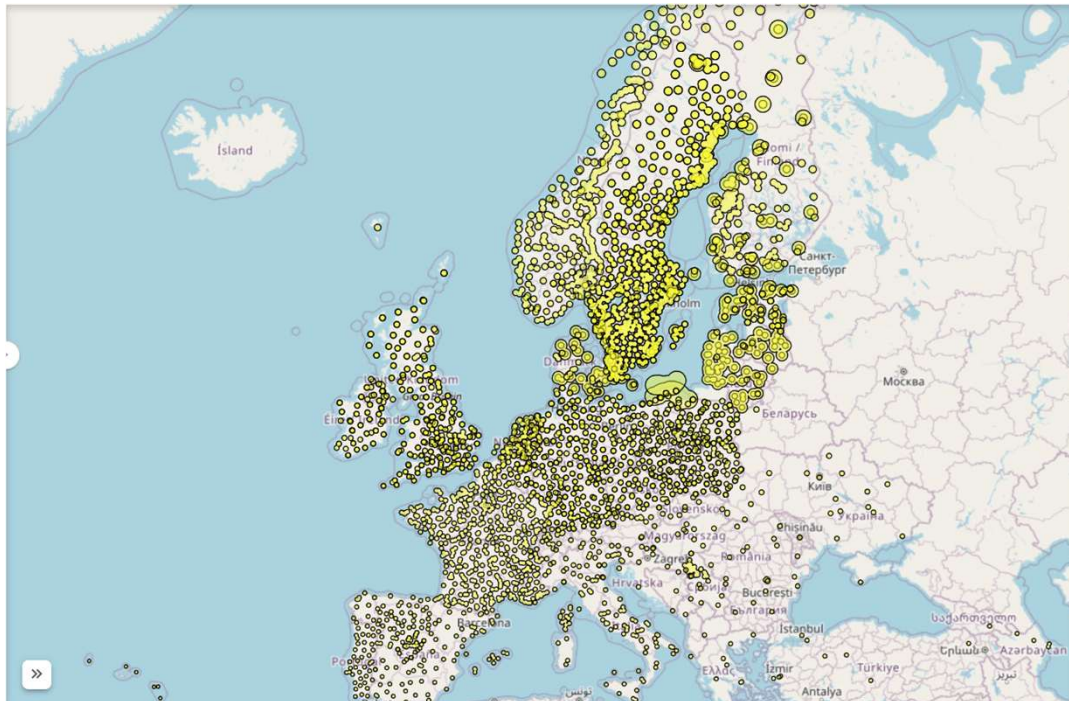


The Importance of GPS/GNSS/PNT Technology
GPS/GNSS/PNT Interference
Protection, Defence and Attack
Complementary PNT

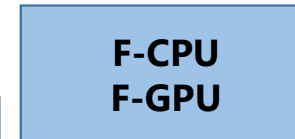
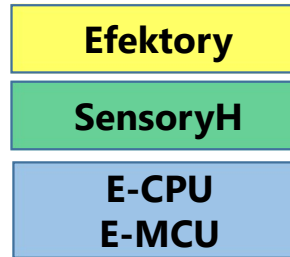


Functionalities of the GNSS system we protect

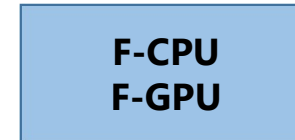
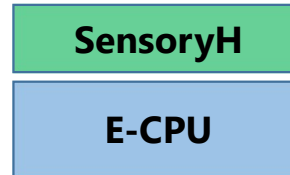
EU and NATO-wide scaling of the solution



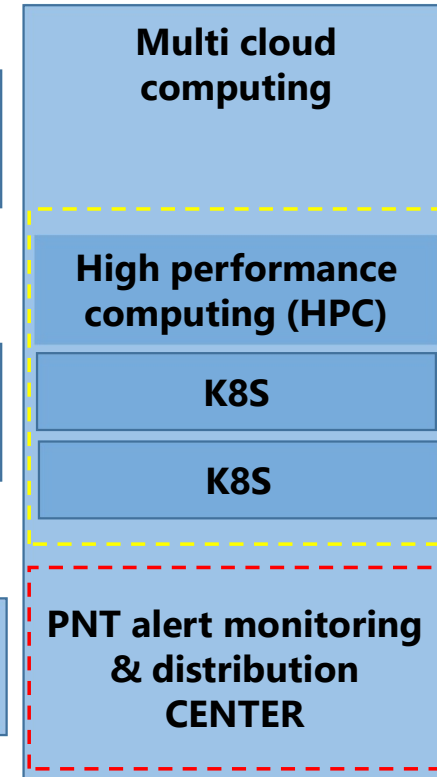
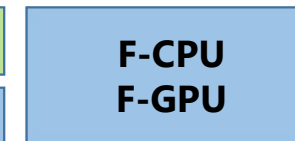
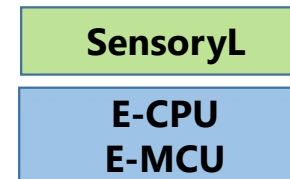
SOUKG



RTGMS



SMZSG



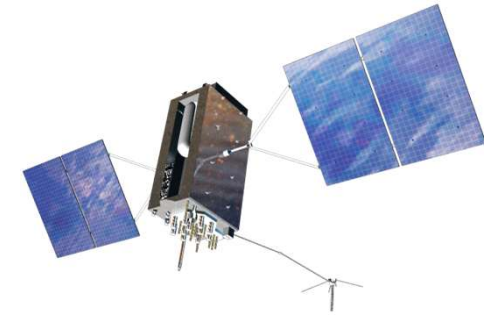


The Importance of GPS/GNSS/PNT Technology

GPS/GNSS/PNT Interference

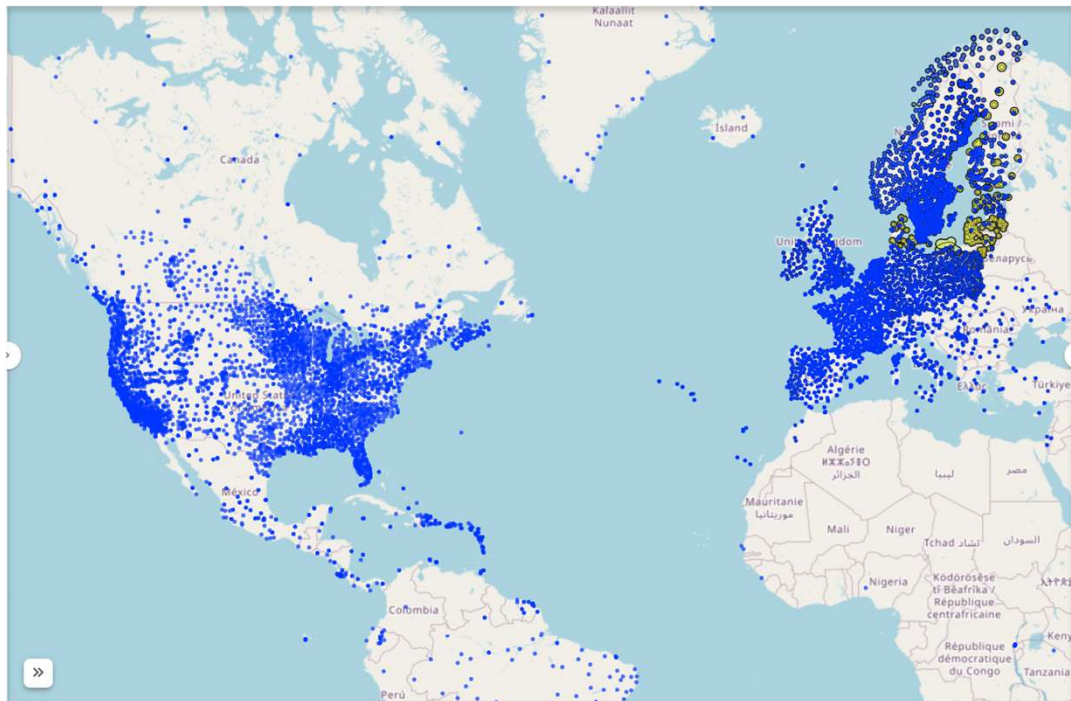
Protection, Defence and Attack

Complementary PNT



Functionalities of the GNSS system we protect

EU and NATO-wide scaling of the solution



SOUKG

Efektory

SensoryH

E-CPU
E-MCU

F-CPU
F-GPU

Multi cloud computing

RTGMS

SensoryH

E-CPU

F-CPU
F-GPU

High performance computing (HPC)

K8S

K8S

SMZSG

SensoryL

E-CPU
E-MCU

F-CPU
F-GPU

PNT alert monitoring & distribution CENTER

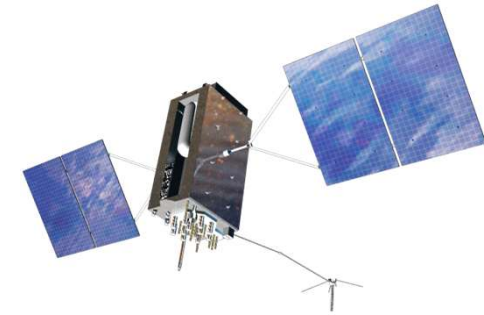


The Importance of GPS/GNSS/PNT Technology

GPS/GNSS/PNT Interference

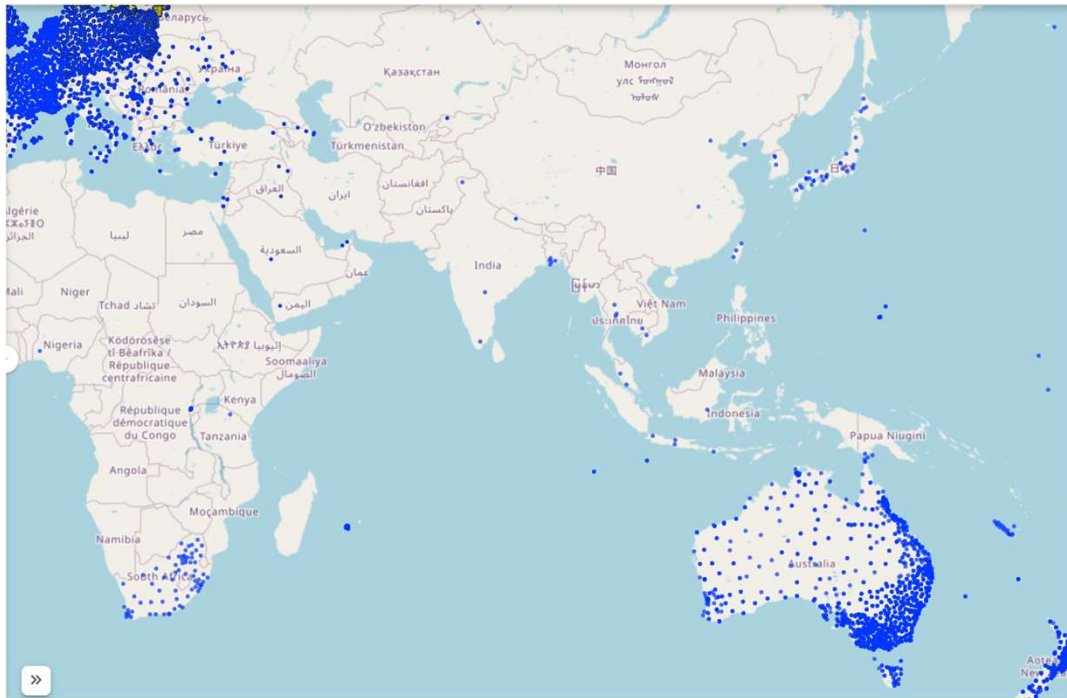
Protection, Defence and Attack

Complementary PNT

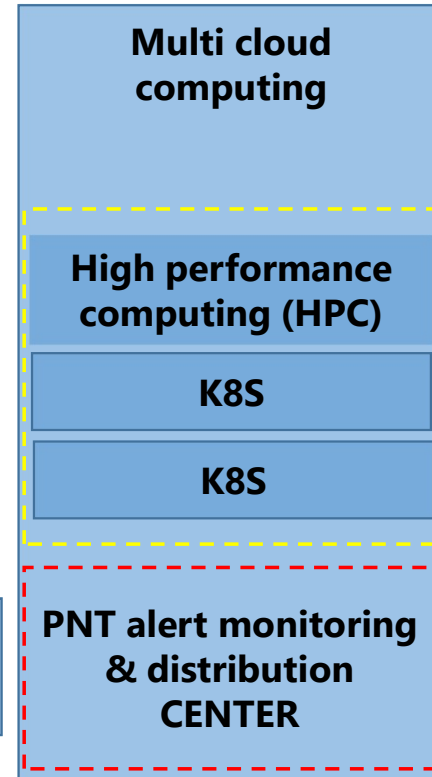
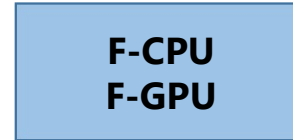
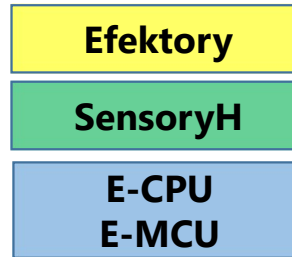


Functionalities of the GNSS system we protect

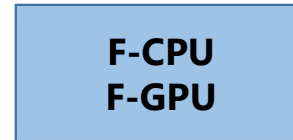
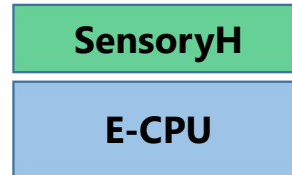
EU and NATO-wide scaling of the solution



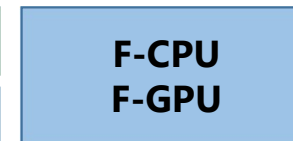
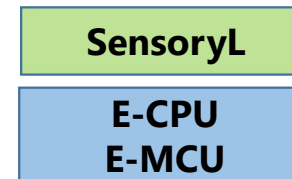
SOUKG



RTGMS



SMZSG

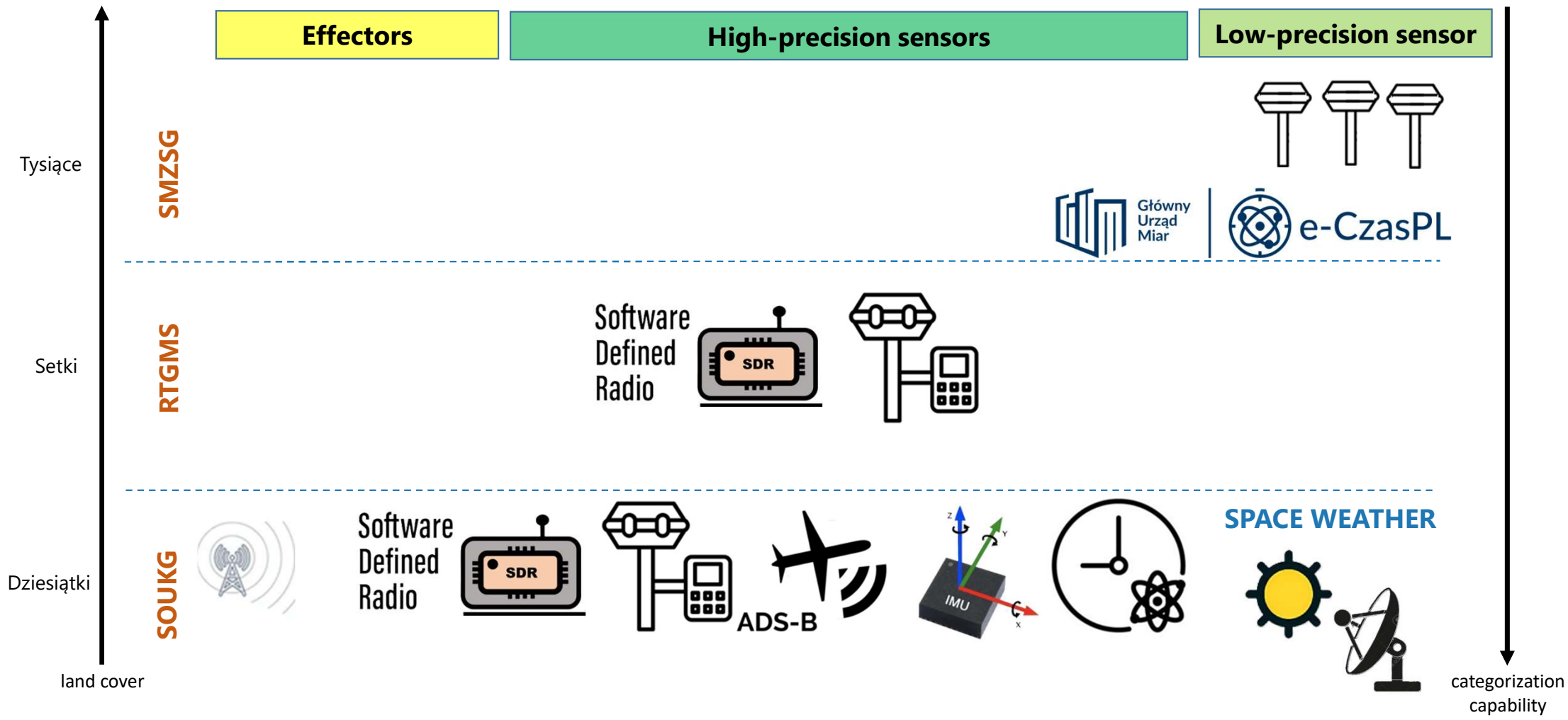


Polish PNT Shield

System for the Protection of Critical GPS/GNSS Services (SOUKG)

Real-time GNSS Monitoring System for Poland (RTGMS) and ASG-EUPOS

GNSS Signal Interference Monitoring System (SMZSG) – Stage I

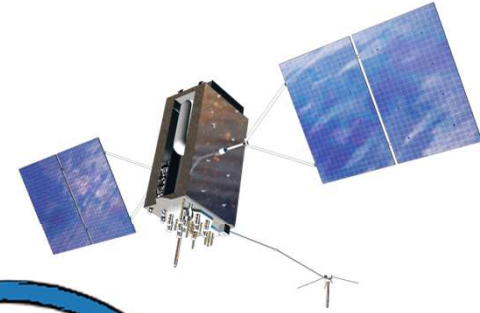


The Importance of GPS/GNSS/PNT Technology

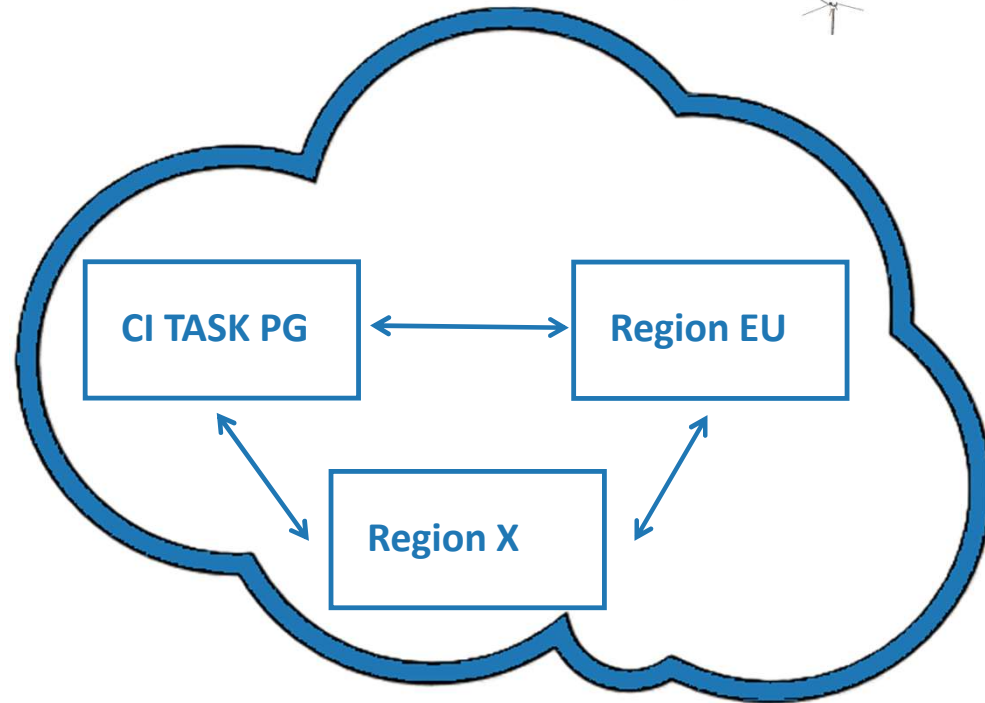
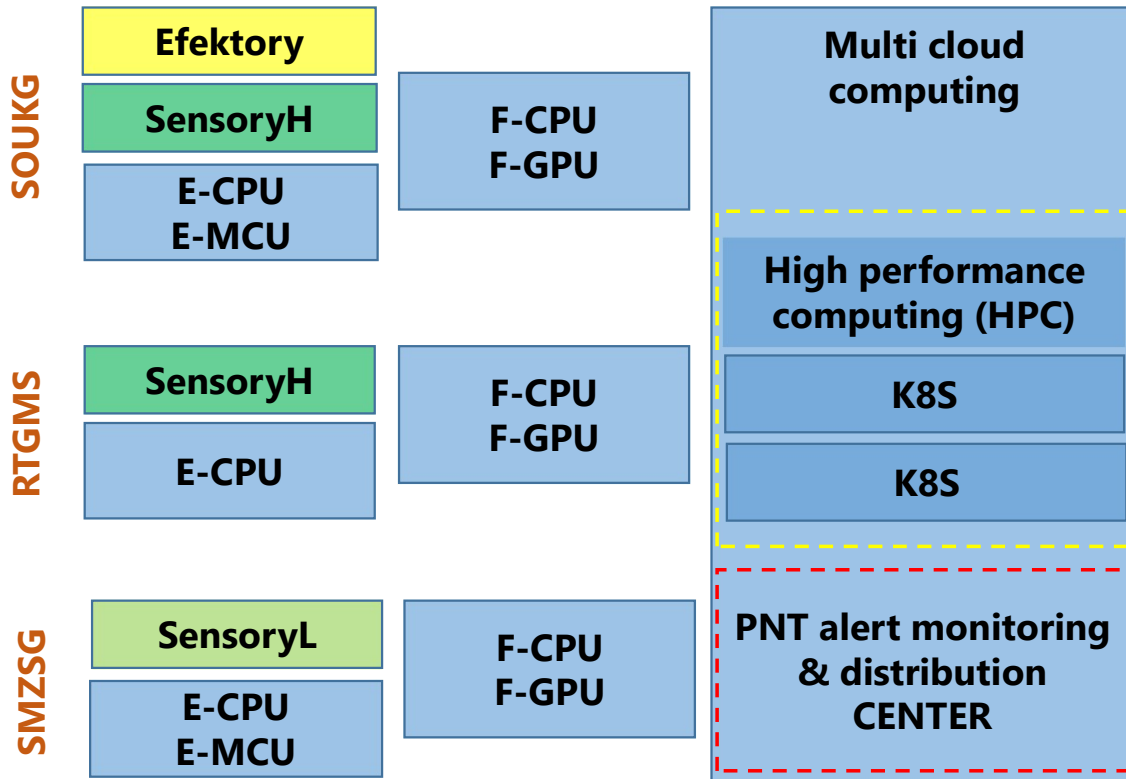
GPS/GNSS/PNT Interference

Protection, Defence and Attack

Complementary PNT



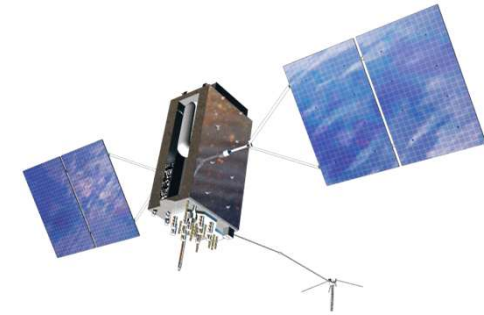
Protection: Detection and Attack Data



EU, NATO - Multi Cloud



The Importance of GPS/GNSS/PNT Technology
GPS/GNSS/PNT Interference
Protection, Defence and Attack
Complementary PNT



Complementary PNT under the Polish PNT Shield Programme

- 1) Objective: Develop redundant systems that provide alternative methods of positioning, navigation and timing (PNT) under the umbrella of the Polish PNT Shield.
- 2) Umbrella effect: Ensure resilience against interference and jamming, delivering a coordinated organisational framework for technical measures.
- 3) System-of-systems approach: The Shield will function as an operational layer, integrating diverse technologies and organisational processes.
- 4) Not a single solution: Complementary PNT will consist of a broad portfolio of solutions and technologies, rather than a single system.
- 5) Outcome: Guarantee uninterrupted and reliable PNT services in contested or degraded environments.



Ministry of National Defence
Republic of Poland



Ministry of Digital Affairs
Republic of Poland



Ministry of Finance
Republic of Poland

RCB
Gov. Centre Sec.



National Institute
of Telecommunications



European PNT Shield

The Polish PNT Shield has the technical and developmental potential to scale towards a European Shield for PNT and can be classified as Level B infrastructure (utilities, telecom and research).

- 1) To join the European Commission's EU UTC backbone initiative, integrating these European activities as a component of the Polish PNT Shield Programme.
- 2) To seek the scaling of solutions developed under the Polish PNT Shield Programme across EU and NATO member states.

https://joint-research-centre.ec.europa.eu/projects-and-activities/complementary-position-navigation-and-timing_en