GNSS Under Attack

Workshop

Budapest – 5-6 Feb 2026

IntegriCom Hungary

IntegriCom Hungary

Workshop Introduction

- Part of a European Space Agency (ESA) initiative to strengthen space competencies in Hungarian companies.
- Designed for engineers, managers, and specialists who want to learn about GNSS
- Focus on vulnerability and resilience
- Organized by Integricom Hungary, but mostly driven by invited lecturers and with extensive support from BME

- Part A: non-technical overview (first few hours)
- Part B: technical exploration

Integricom Hungary

- Budapest-based engineering company specialised in high-integrity navigation and positioning systems founded in 2024
- New company, experienced team
  - GNSS / radio-navigation expertise
  - Collaboration with ESA, Eurocontrol, and European industry partners
  - Participation in numerous ESA satellite navigation projects
- Application domains: aviation (including drones), other modes of transport, autonomous mobility
- Typical Services:
  - Consulting & technical advisory
  - Algorithm design & software development
  - Data analytics for navigation & mobility systems

Workshop's Main Message(s)

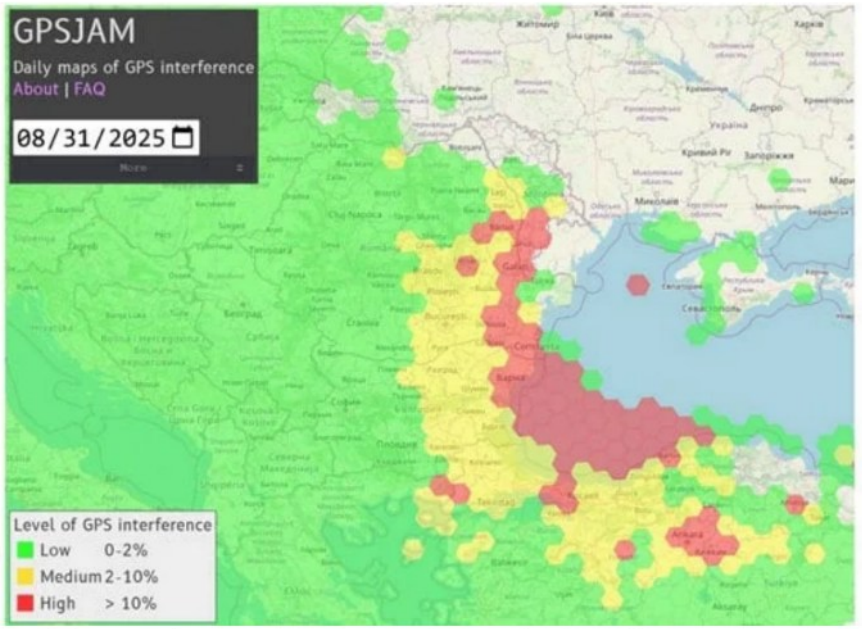
GNSS is vulnerable

- GNSS can be inaccurate
- GNSS can be unavailable
- GNSS can be deceiving
- GNSS can be attacked

Von der Leyen's plane jammed?

Plane carrying EU president hit by alleged Russian GPS jamming

By Jesse Khalil Published September 2, 2025



https://www.gpsworld.com/plane-carrying-eu-president-hit-by-alleged-russian-gps-jamming/

A screenshot of the interference pattern in Bulgaria displayed by GPSJam.org on Aug. 31. (Credit: GPSJam.org)

19 SEPTEMBER 2025

EU STEPS UP RESPONSE TO GNSS SPOOFING AND JAMMING

On 9 September 2025 in Strasbourg, Commissioner Andrius Kubilius addressed the European Parliament on the growing risks of interference with Global Navigation Satellite Systems (GNSS), warning of the urgent need to strengthen resilience against spoofing and jamming.

In his statement, entitled *"Serious threats to aviation and maritime transport from Global Navigation Satellite System interference: urgent need to build resilience against spoofing and jamming"*, he recalled a recent incident in which satellite navigation on board an aircraft carrying President von der Leyen was jammed, underlining how the threat is no longer theoretical but an everyday reality for aviation and maritime transport.

Satellite-based Positioning, Navigation and Timing (PNT) services such as Galileo, EGNOS and GPS

https://www.clecat.org/news/newsletters/eu-steps-up-response-to-gnss-spoofing-and-jamming

What is GNSS, and how (much) do we depend on it?

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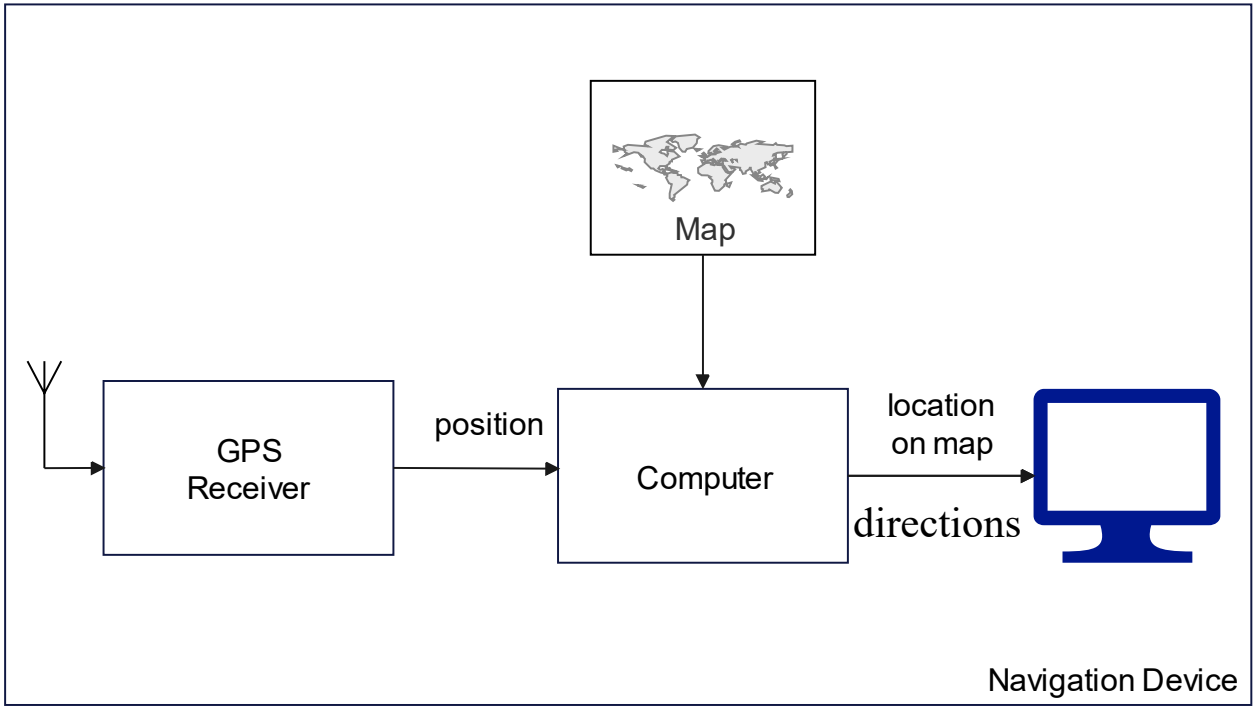
What is (a) GPS?

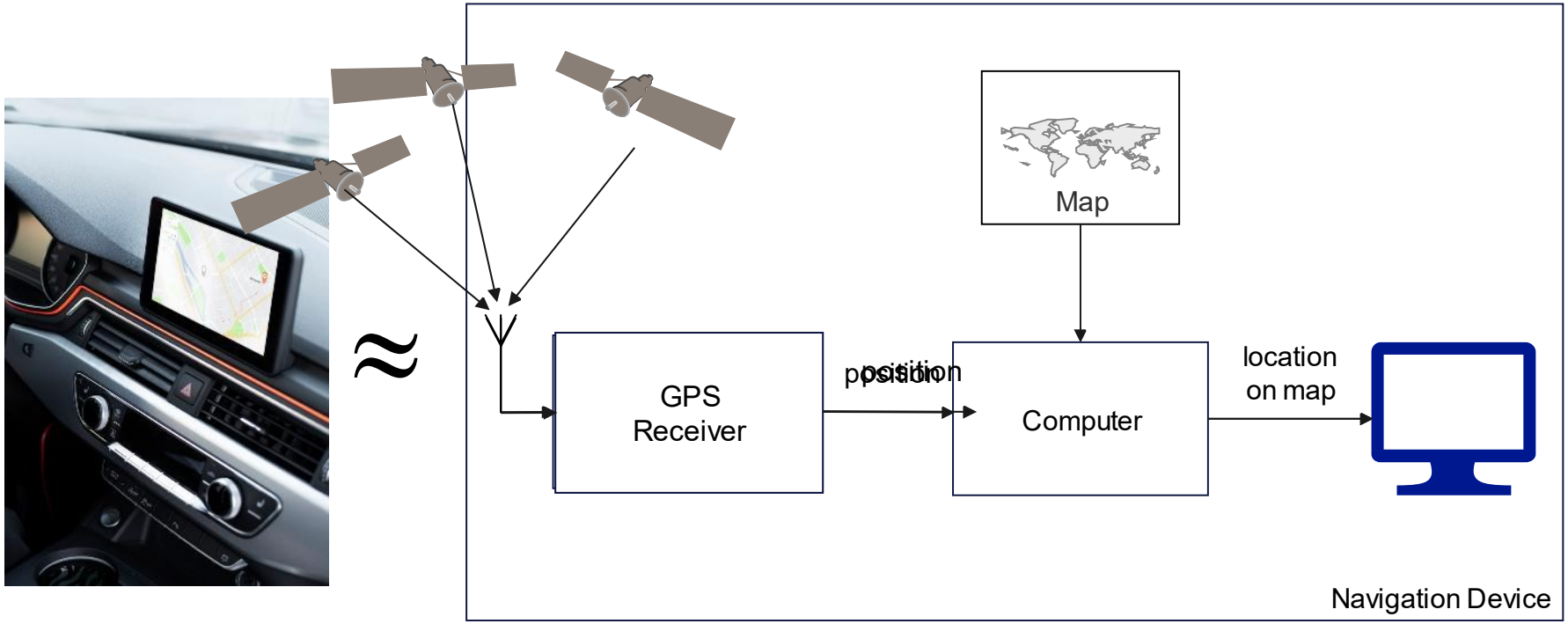
- Everyday speech:
  - "A" GPS is a *navigation* device
  - Brings you from A to B
  - Tells you where to turn to achieve this

What is (a) GPS?

≈


Map
GPS
Receiver
position
Computer
location
on map
directions
Navigation Device

Scope of GNSS for our workshop



- Position drives the navigation computer

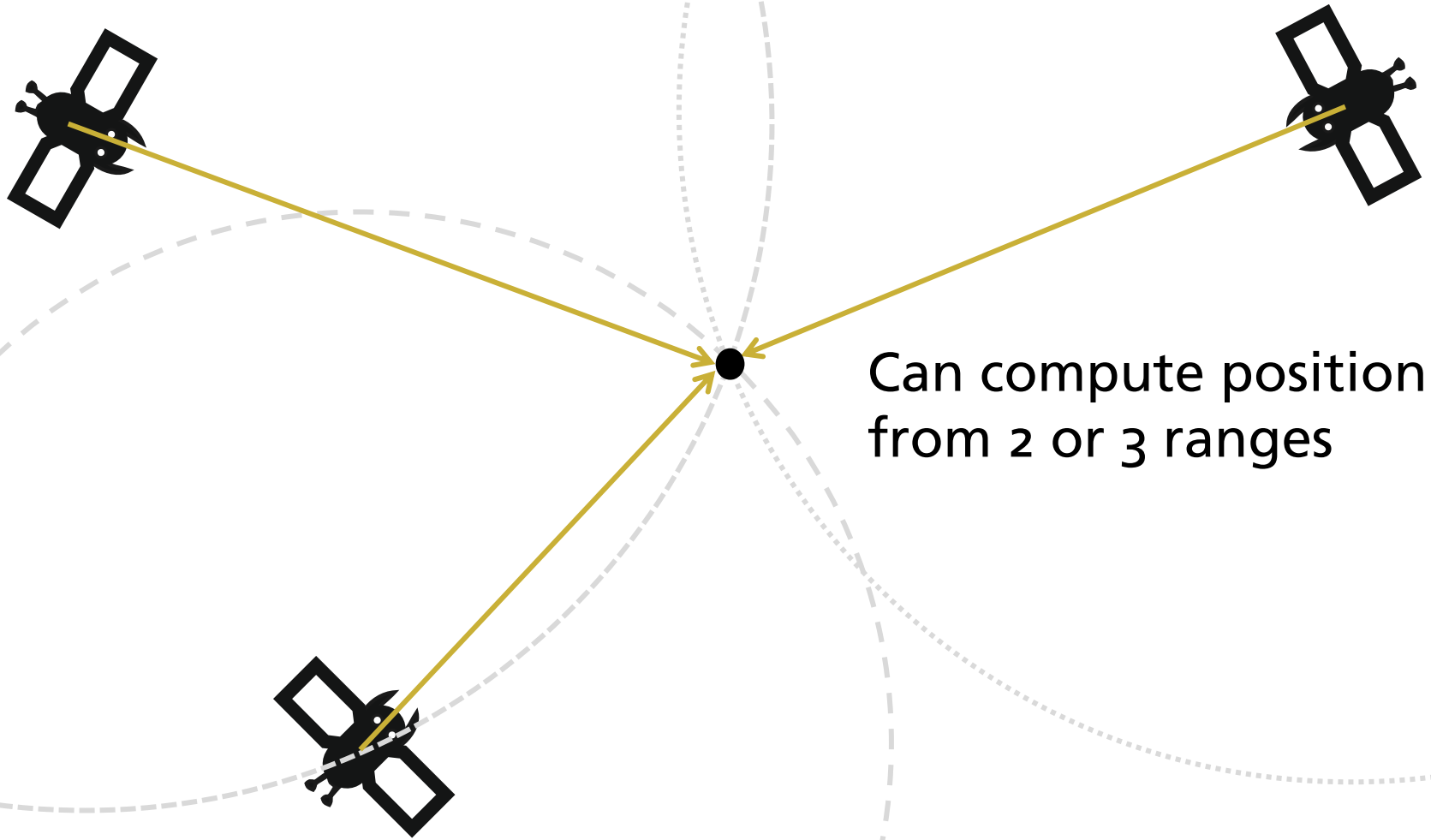
What is GNSS (or GPS)?

- GPS = Global Positioning System
- GNSS (Global Navigation Satellite System) is the generic term for satellite-based systems that provide positioning, anywhere on (or near) Earth.
- It includes multiple national and regional systems, such as:
  - GPS (United States)
  - GLONASS (Russia)
  - Galileo (European Union)
  - BeiDou (China)
- Provide Position (enabler for Navigation)

Working principle

- GNSS works by transmitting precise *time signals* from satellites.
- A receiver calculates its position by measuring *how long* these signals take to arrive from multiple satellites.
- (Radio)signals travel at known speed:
  - Distance determines the travel time
  - Travel time allows to compute the distance

Distances to position



Can compute position
from 2 or 3 ranges

Distances to time

Atomic clock

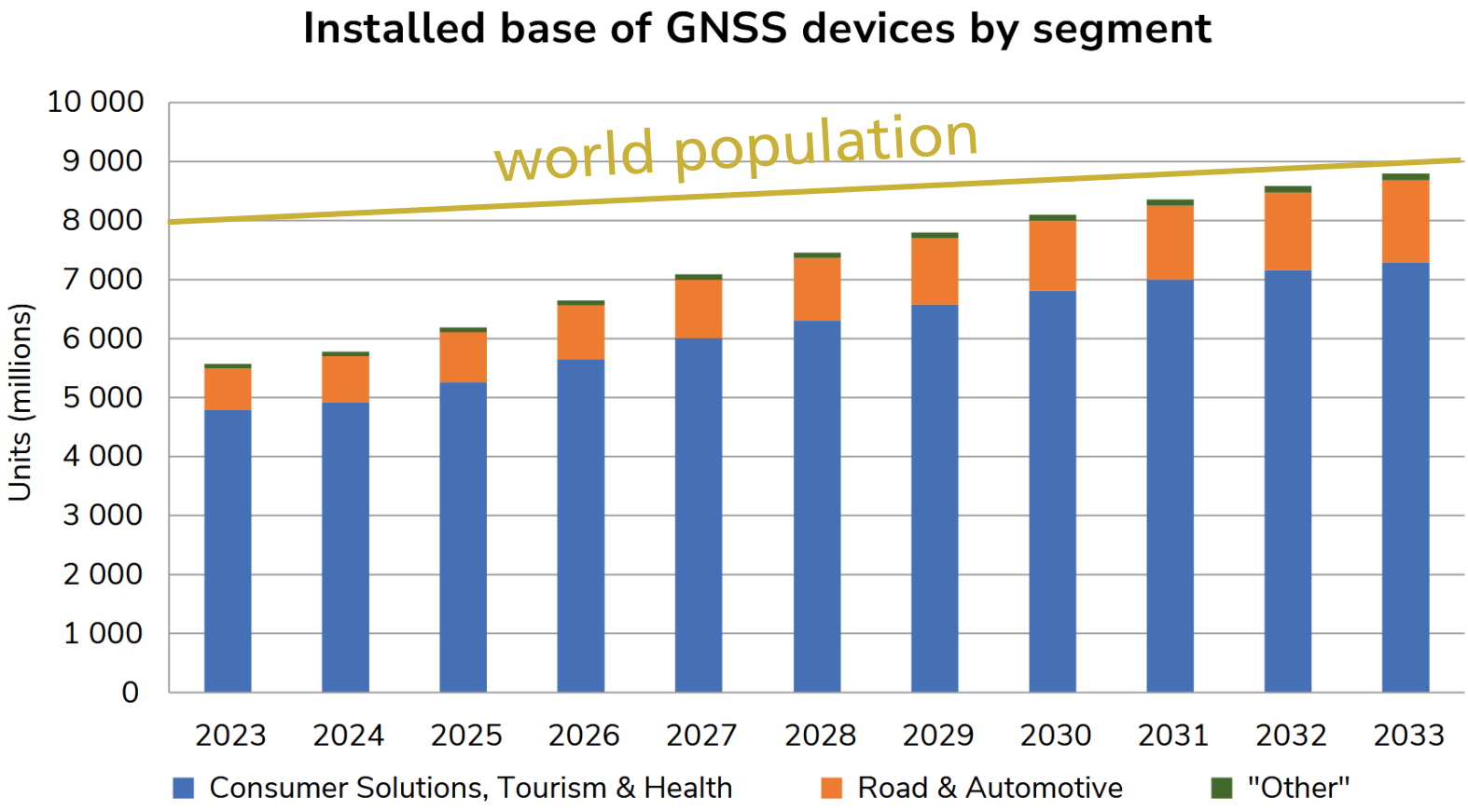
Can compute precise time from range when position is known

GNSS Is Everywhere

- Global Navigation Satellite Systems (GNSS) provide positioning, navigation, and timing (PNT) services worldwide.
- Every day, billions of people and systems rely on GNSS signals
- Nowadays it is *critical infrastructure*, comparable to electricity or the internet.

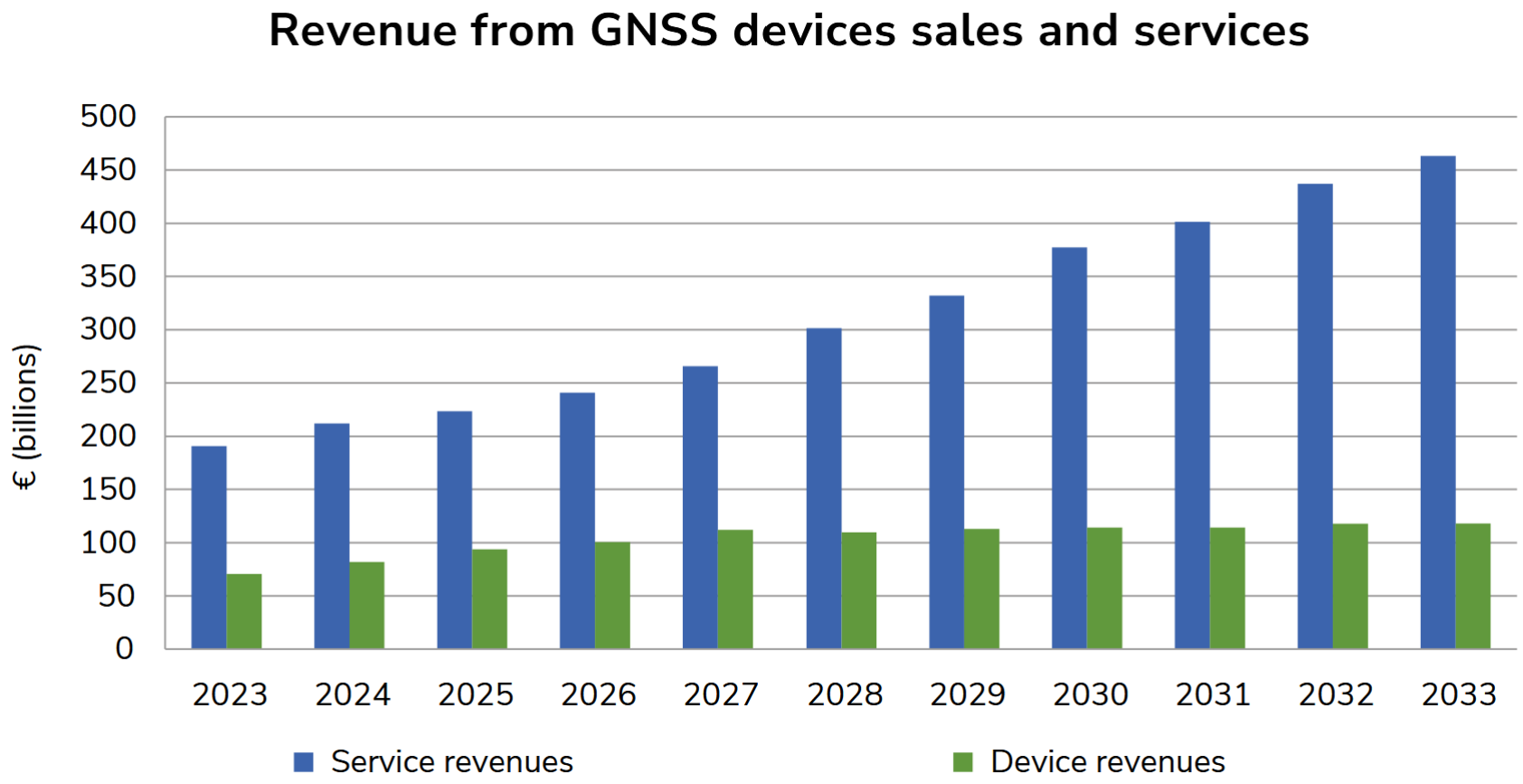
- Therefore: vulnerability is a problem

GNSS devices in numbers



Source: EUSPA GNSS market report 2024

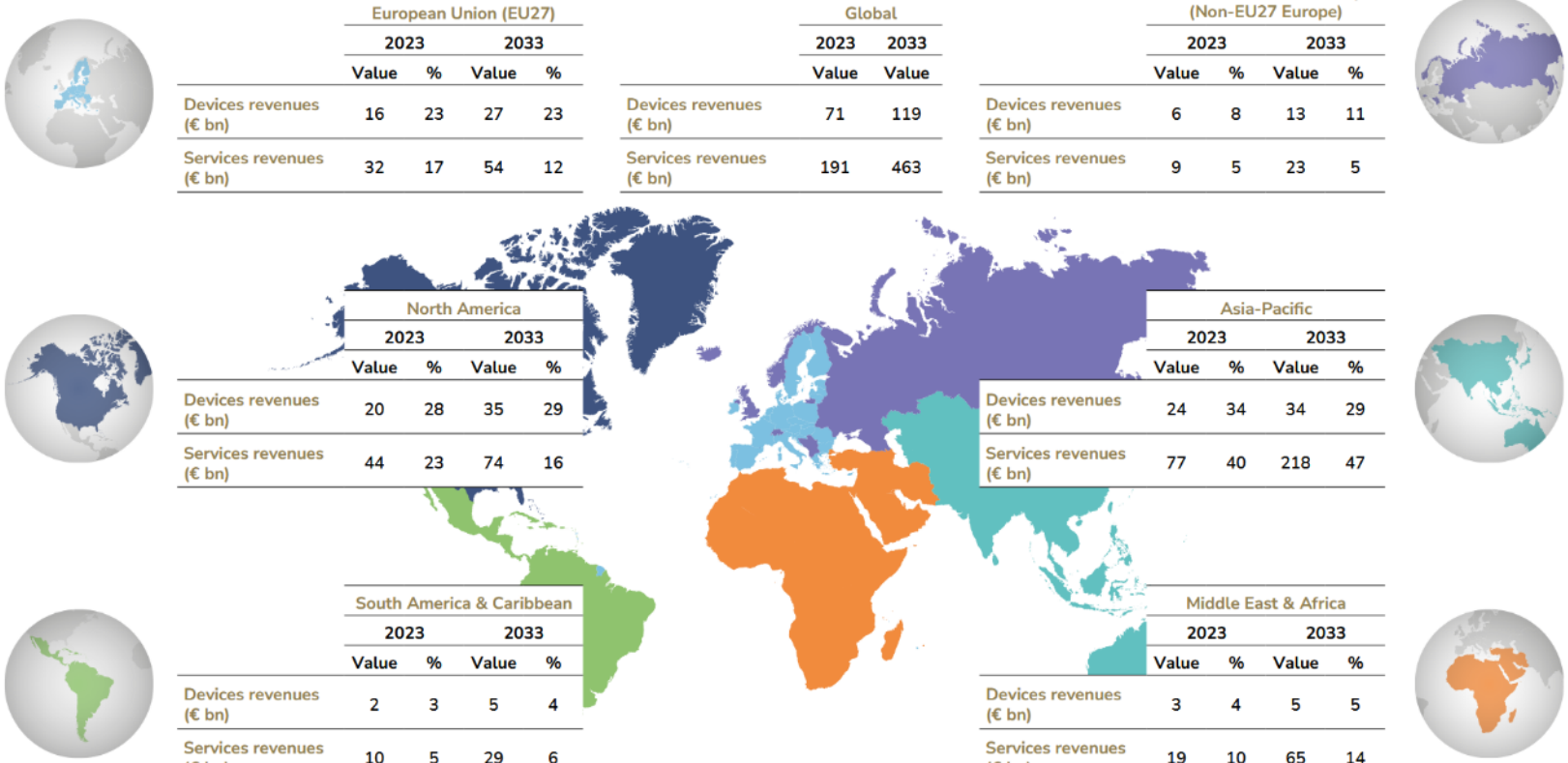
The Global Economy of GNSS



Source: EUSPA GNSS market report 2024

Everywhere?

GNSS demand world map



European Union (EU27)	2023		2033	
	Value	%	Value	%
Devices revenues (€ bn)	16	23	27	23
Services revenues (€ bn)	32	17	54	12

Global	2023	2033
	Value	Value
Devices revenues (€ bn)	71	119
Services revenues (€ bn)	191	463

Russia & Non-EU27 Europe (Non-EU27 Europe)	2023		2033	
	Value	%	Value	%
Devices revenues (€ bn)	6	8	13	11
Services revenues (€ bn)	9	5	23	5

North America	2023		2033	
	Value	%	Value	%
Devices revenues (€ bn)	20	28	35	29
Services revenues (€ bn)	44	23	74	16

Asia-Pacific	2023		2033	
	Value	%	Value	%
Devices revenues (€ bn)	24	34	34	29
Services revenues (€ bn)	77	40	218	47

South America & Caribbean	2023		2033	
	Value	%	Value	%
Devices revenues (€ bn)	2	3	5	4
Services revenues (€ bn)	10	5	29	6

Middle East & Africa	2023		2033	
	Value	%	Value	%
Devices revenues (€ bn)	3	4	5	5
Services revenues (€ bn)	19	10	65	14

GNSS is trusted

- Perceived Authority: Users often perceive the navigation voice or visual display as an infallible authority, leading them to follow instructions even when they contradict visible road signs or common sense.
- Automation Bias
  - Perceived as objective hence true
  - Efficiency and convenience reinforce trust and dependency over time (cognitive shortcut)

Trust not always justified…

JANUARY 12, 2026

Tourists End Up Stuck on Ski Slope After Following GPS Directions

Three female Taiwanese tourists recently made news headlines in Andorra after driving onto a snowy ski slope while following GPS directions.

News

SHARE

https://www.odditycentral.com/news/tourists-end-up-stuck-on-ski-slope-after-following-gps-directions.html

“Death by GPS”

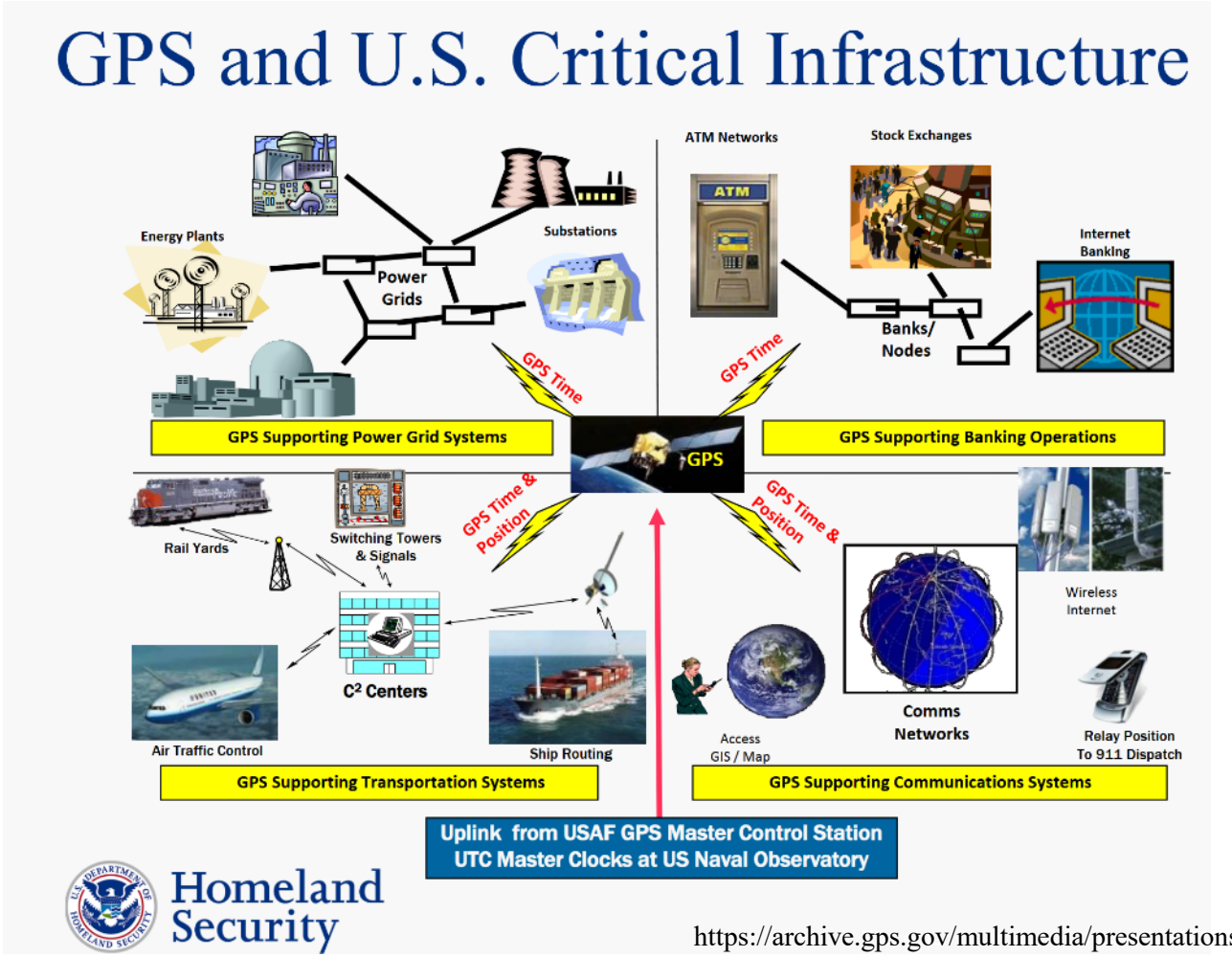
- When GNSS lies convincingly, users often comply (even when reality disagrees!)

Deaths of four young men in Spain reopens navigation system debate: 'We blindly trust the GPS'

Their car plunged off a road which, if it snows, is usually closed to traffic. At the time of the accident it was already snowing, but the road was still open and the GPS system recommended it

https://www.surinenglish.com/spain/blindly-trust-the-gps-20250325083457-nt.html

Critical Infrastructure Depending on GNSS



https://archive.gps.gov/multimedia/presentations/2014/11/ICG/dhs.pdf

Key Sectors That Depend on GNSS

- Transport & logistics
  - Aviation navigation and landing
  - Maritime shipping and port operations
  - Road transport, fleet management, ride-hailing
- Telecommunications & digital services
  - Precise GNSS timing synchronizes mobile networks and internet
- Finance
  - Timestamping of financial transactions
- Energy
  - Power grid synchronization and monitoring
- *Industry & agriculture*
  - *Precision farming*
  - *Construction, surveying, automation, robotics*

What dependency means

Without GNSS, many systems would degrade or stop within hours.

Jamming and spoofing

- Jamming blocks satellite navigation : signals: no position, no time!

- Spoofing feeds users *believable* but *false* location data or erroneous time

Aviation example 1

FCC Fines Operator of GPS Jammer That Affected Newark Airport GBAS

August 31, 2013 By Inside GNSS

The Federal Communications Commission (FCC) has proposed a hefty fine for a New Jersey truck driver whose alleged use of a GPS jammer caused harmful interference to the new ground-based augmentation system (GBAS) at Newark Liberty International Airport (EWR).

https://insidegnss.com/fcc-fines-operator-of-gps-jammer-that-affected-newark-airport-gbas/

Aviation example 2

NASA report: Passenger aircraft nearly crashes due GPS disruption

By Dana Goward Published July 8, 2019

Photo: IlkerErgun/Shutterstock.com

Temporary GPS recovery led to premature GPS-based clearance, followed by loss of navigation accuracy and a near-terrain conflict.

https://www.gpsworld.com/nasa-report-passenger-aircraft-nearly-crashes-due-gps-disruption/

Aviation example 3

https://eutoday.net/russian-gnss-interference-disrupted-123000-flights/

Aviation example 4

North Korea jams GPS signals, affecting ships, aircraft in South

Passenger planes are seen at Gimpo Airport in Seoul, South Korea, on Nov. 9, 2024. North Korean GPS jamming attacks affected dozens of civilian aircraft in South Korea, officials said.

https://www.voanews.com/a/north-korea-jams-gps-signals-affecting-ships-aircraft-in-south/7858015.html

Effects on aircraft navigation

- Navigation impact
  - Jamming blocks satellite navigation signals
  - Spoofing feeds aircraft believable but false location data
- Safety risk:
  - Pilots may lose accurate location awareness or unknowingly rely on incorrect information
- System and operational effects
  - Tracking, collision warning, and safety monitoring systems become less reliable
  - Flights may need to change routes, avoid certain areas, or revert to less efficient procedure
- Economic impact:
  - More delays, diversions, fuel use

Automotive example

Targeted jamming incident blinds GPS and BeiDou in east China's Nanjing

Reading Time: **2 minutes**

Why you can trust SCMP

Listen

Liu Zhen

Published: 7:00pm, 20 Dec 2025 | Updated: 8:54pm, 20 Dec 2025

Effects on car navigation

- Navigation impact
  - Jamming blocks satellite navigation signals
  - Spoofing feeds aircraft believable but false location data
- Safety risk
  - Drivers or automated systems may receive incorrect directions, positioning, or speed information
- System and operational effects:
  - Driver-assistance, collision avoidance, emergency services, and vehicle tracking become less reliable
  - Route guidance, fleet management, traffic optimization perform poorly
- Economic impact
  - Delays, higher fuel use, logistics inefficiencies, service disruptions...

Maritime spoofing example

New GPS ‘circle spoofing’ moves ship locations thousands of miles

By Dana Goward Published May 26, 2020

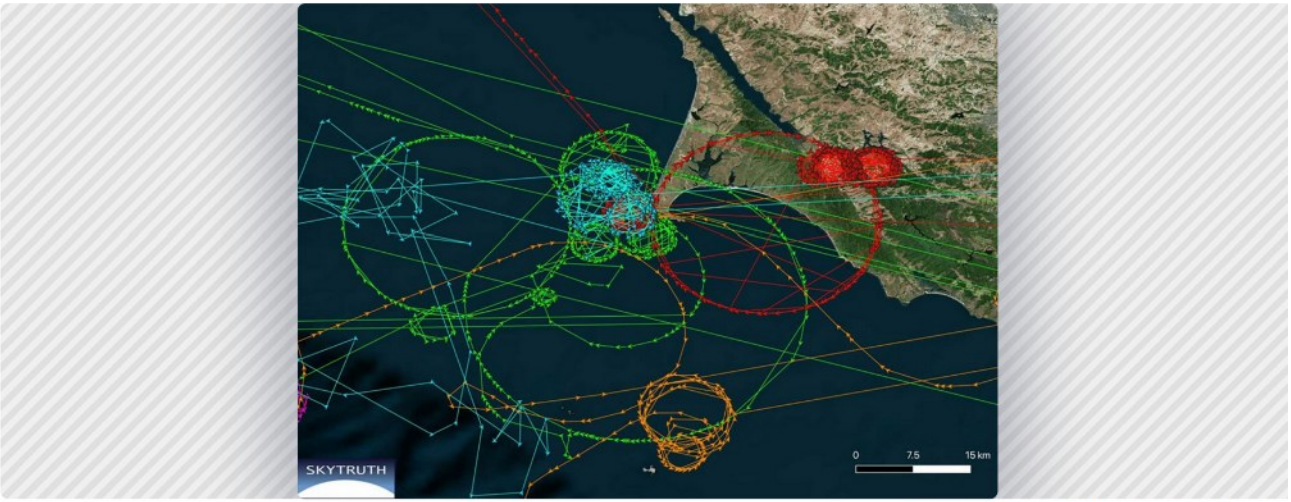


Image courtesy of Skytruth and RNTF

New research by Bjorn Bergman of the environmental non-profit SkyTruth has found ships in various parts of the world reporting locations thousands of miles away and circling at precisely 20 knots.

https://www.gpsworld.com/new-gps-circle-spoofing-moves-ship-locations-thousands-of-miles/

Effects on maritime navigation

Marine risks rise as GPS jamming spreads

by Claire Wilkinson

CYBER RISKS, MARINE, TECHNOLOGY, TERRORISM LATIN AMERICA
ALLIANZ, BEAZLEY, LOCKTON, MARSH & MCLENNAN

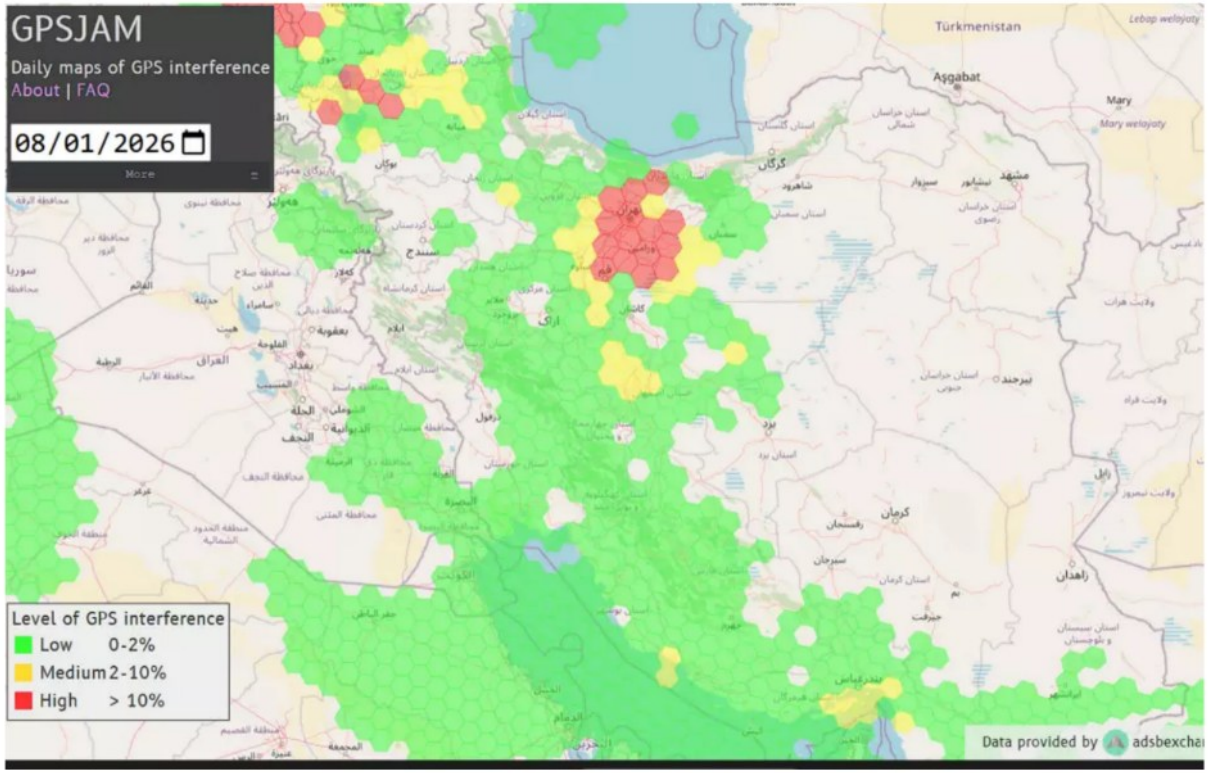
Dec 16, 2025

Ship collision and grounding risks are rising because of a surge in GPS jamming and spoofing, prompting coverage concerns for marine policyholders.

Effect on telecommunications

How Iran how Irani around it

ASIA / PACIFIC



A significant level of GPS interference was identified in Tehran on January 8, 2026 (shown in red on the map). © gpsjam.org

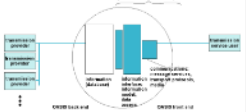
A Starlink terminal usually needs GPS in order to establish a geographic location so as to communicate with the network's satellites.

https://www.france24.com/en/iran-jammed-starlink-get-around-it

Power Grids heavily rely on GNSS timing

Electric Power Timing Applications[1]

Table 3. Timing Dependent Equipment

Equipment			
Transmission Line Fault Detection 	Equipment that determines the location on the transmission system of a fault, namely an event such as a short circuit, a broken wire, or an intermittent connection[i].	**Frequency Measurement** 	Equipment that measures the frequency, or rate of change of frequency, of the power grid. Also, equipment that computes the median of all the Frequency Response observations reported annually by Balancing Authorities or Frequency Response Sharing Groups for frequency events specified by the ERO. This will be calculated as MW/0.1Hz.[ii]
Synchrophasors/Phasor Measurement Units 	Measures the electrical parameters of an electricity grid with respect to universal time (UTC) such as phase angle, amplitude, and frequency to determine the state of the system[iii]	**Internet-based Market Transactions (OASIS, NTP, SNTP)** 	IP-based workstations, networks, and websites that use the network timing protocol (NTP) or simple network timing protocol (SNTP) to enable access to wide area energy market operation systems providing high-level market signals for transmission and distribution companies (ISO/RTO, Utility Operations).[iv]
Substation Control/ Re-Synchronization 	A type of control system at a transmission or distribution substation that transmits individual device status, manages energy consumption by controlling compliant devices, and allows operators to directly control power system equipment. Re-synchronization is the process of synchronizing an energized substation to the power grid.[v]	**Disturbance Monitoring Event Recorders** 	Devices capable of monitoring and recording system data pertaining to a Disturbance. Such devices include the following categories of recorders: Sequence of event recorders Fault recorders Dynamic Disturbance Recorders (DDRs)[vi]
Protective Relays 	A protective relay is an electromechanical or micro-processor controlled electronic system that senses an abnormal or fault condition and sends a trip to a circuit breaker in order to protect generators, transformers, and lines.[vii]	**Bulk Metering** 	Equipment that records the amount of power used in a particular area or sent down a particular line for power flow measurement and billing purposes.[viii]

[1] MITRE, "GPS Resiliency for Critical Infrastructure: Energy Sector Baseline Report (FINAL)," Version 1.1, November 24, 2013

Power Grid Example

GPS Jamming and Ukraine's Electrical Grid – Cisco Talos

by Editor | Apr 21, 2024 | Blog

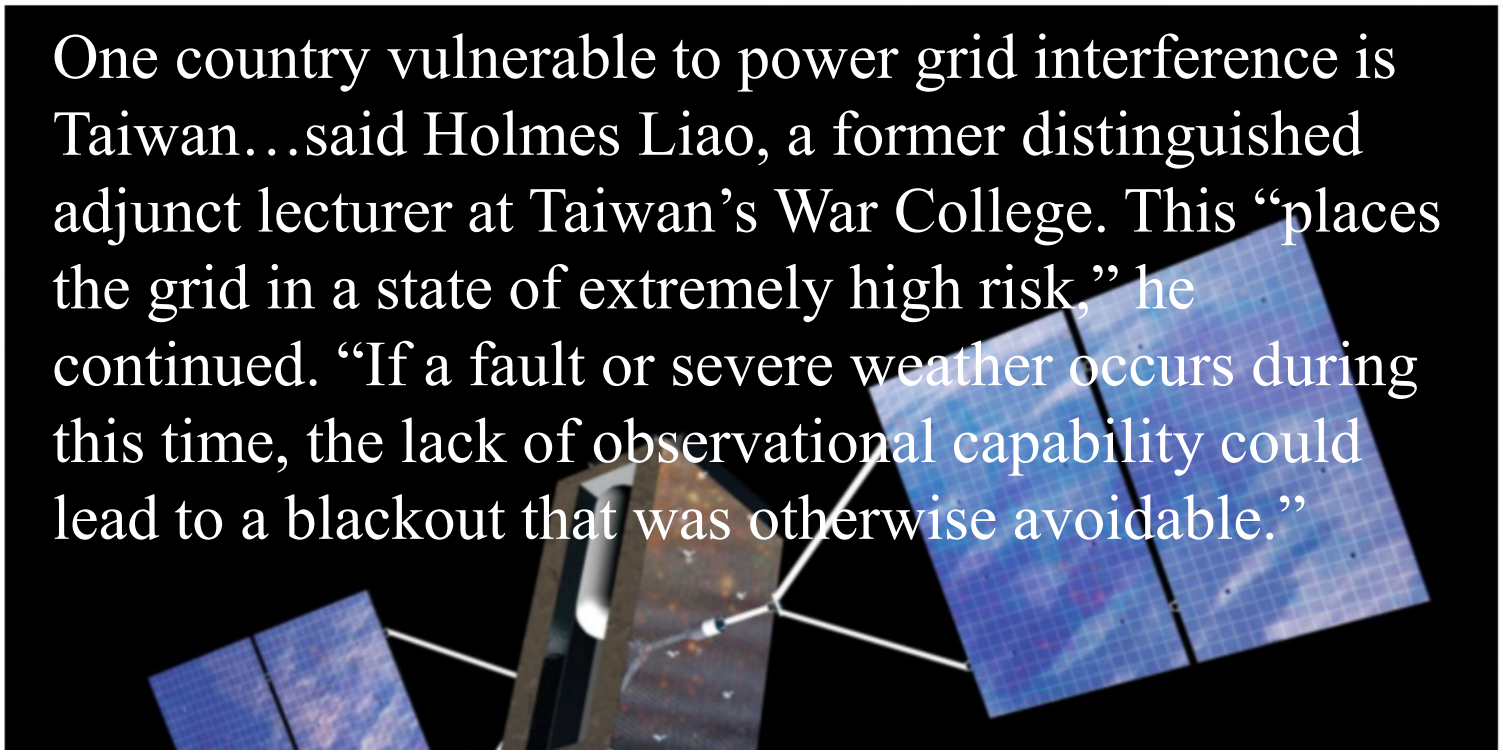
https://rntfnd.org/2024/04/21/gps-jamming-and-ukraines-electrical-grid-cisco-talos/

GPS: the first front in electronic warfare

Ukraine's energy infrastructure has been shaken by Russia's growing efforts around GPS interference, underscoring how the geolocation technology is being weaponised

by **Paddy Stephens** — December 31, 2025 in **News**

One country vulnerable to power grid interference is Taiwan…said Holmes Liao, a former distinguished adjunct lecturer at Taiwan's War College. This "places the grid in a state of extremely high risk," he continued. "If a fault or severe weather occurs during this time, the lack of observational capability could lead to a blackout that was otherwise avoidable."



https://resiliencemedia.co/gps-the-first-front-in-electronic-warfare/
https://resiliencemedia.co/gps-the-first-front-in-electronic-warfare/Special vulnerabilities in Taiwan

Effect on power grids

- Power grids rely on satellite signals for precise time synchronization, not location
- Jamming blocks timing signals; spoofing delivers incorrect but believable time data
- System and economic impact
  - Protection systems, fault detection, and monitoring may operate incorrectly or shut down equipment
  - Increased outage risk, service disruptions, recovery costs, and downstream effects on critical services
  - Grid components may fall out of sync, increasing the risk of miscoordination and instability

Impact on satellites

ends to
s
Bolster

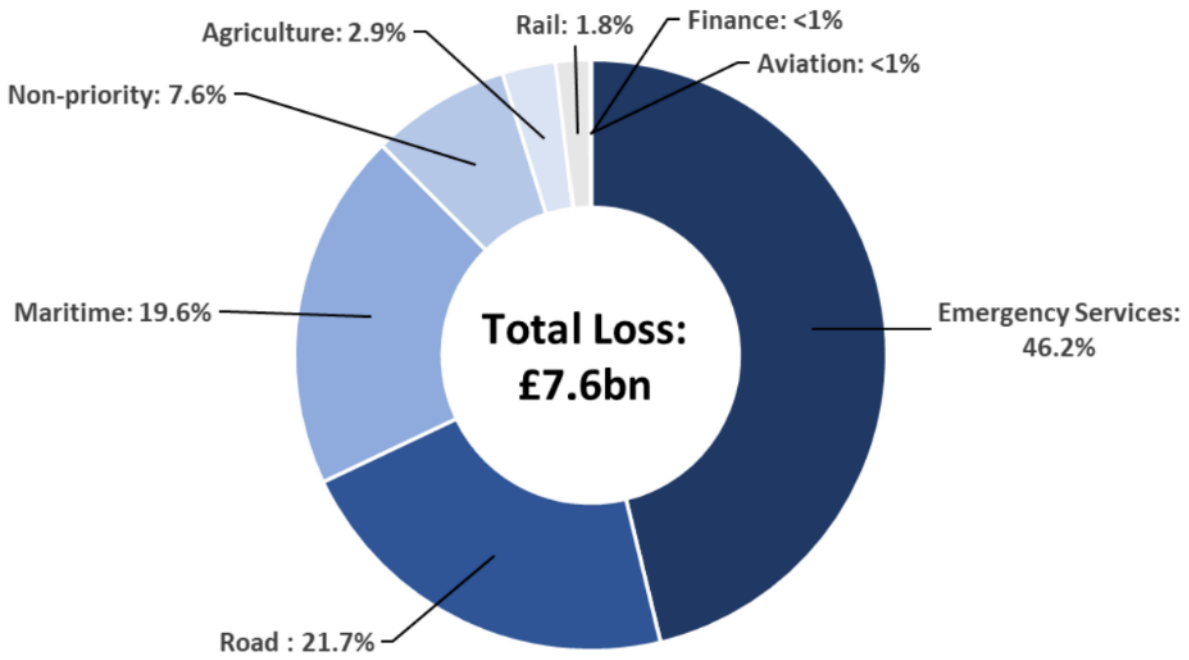
Russia's Pole-21E electronic countermeasures systems are designed to radiate energy in attempts to confuse cruise missiles, guided bombs, and other satellite-guided systems.
Russian Ministry of Defense

https://www.airandspaceforces.com/gps-jamming-extends-to-leo/

Estimated Economic loss of losing GNSS

The economic loss of losing GNSS for seven days has been estimated at **£7,644.5m**. A separate analysis of a 24-hour outage identified as estimated loss of **£1,424.4m during a 24-hour outage**.

Figure 19 Share of 7-day economic loss, by sector



Source: London Economics

Even More Final Words

https://techhq.com/news/un-agencies-say-gps-interference-is-getting-worse-heres-whats-at-risk/

Workshop Practicalities

- Signatures
- Lunch
- Schedule
- Feedback

- https://infinidome.com/gps-jamming-map/