



Department for  
Science, Innovation  
& Technology

# United Kingdom Resilient PNT Programme

## Framework for International Security and PNT Advantage



**Dr Mark Brammer, Wg Cdr RAF, Positioning Programme Lead  
UK National PNT Office**



# Overview of UK Programmes

- UK National Framework for PNT Resilience
- Resilient Time Programmes – Long Range Time over Fibre and GNSS-Independent Space
  - National Timing Centre – Resilient Enhanced Timescale Infrastructure
  - MOD Time
- CHAIN ODYSSEY – UK National eLoran Programme
  - Anchor system for UK and European Security
  - UK-France Partnership in eLoran and beyond
- URGENT COMPASS – UK Ministry of Defence Transportable eLoran
  - Low power small scale full eLoran system for deployed capability
  - Concepts in antenna and transmitter design
- PNT Interference Warning at National and International Level





Department for  
Science, Innovation  
& Technology

# A National PNT Risk

Assessed that 97% of UK CNI was dependent on GNSS services

- 90% of users relied on GPS

Risks to GNSS include:

- Loss due to system failure
- Loss due to hostile act
- Loss due to space weather

Economic Impact of 1 week's disruption - £7.4bn (\$9.6bn/€8.8bn)

## CHAPTER 4

## ACCIDENTS AND SYSTEMS FAILURES

### Loss of Positioning, Navigation and Timing (PNT) services

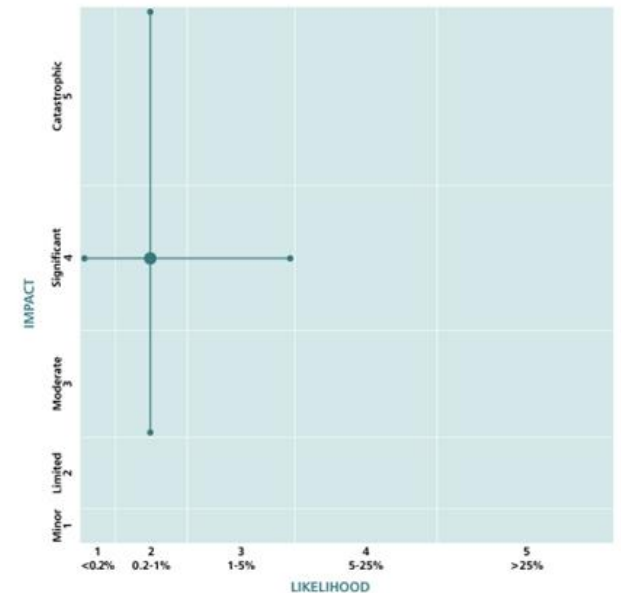
PNT services are a critical component of the UK's infrastructure. They facilitate a diverse range of essential functions across an increasingly interconnected society. For example, PNT is essential for telecommunications, transport navigation and providing precise timings. A loss of PNT services, either due to technological failures or malicious activity, would have catastrophic and cascading effects across the UK and globally.

#### Scenario

The reasonable worst-case scenario is based on a severe technical failure, due to either hardware failure or human error, in a Global Navigation Satellite System constellation leading to data corruption of that service. This would result in inaccurate position and timing data being delivered to users in space and around the world. The compound series of both technical failure and human error means the service would have no choice but to cease operations. There would be a significant disruption or complete cessation of transport (including aviation and maritime services), communications networks, financial services, energy and emergency services within a few hours of the incident taking place. There is also possible further disruption to other space-based services.

#### Key assumptions for this scenario

Sectors would revert to older technologies or alternatives to allow for ground services to resume during an extended outage.





Department for  
Science, Innovation  
& Technology

# Framework for PNT Resilience

A single National PNT Office responsible for coordination of all government PNT

A National Timing Centre established to create a resilient next-generation UTC(NPL) GNSS independent-time via space, fibre and high-precision terrestrial broadcast across multiple spectrums

System of Systems as a resilient and complete PNT alternative

**PNT Resilience**

PNT (Positioning, Navigation and Timing), is a technology vital to the functioning of Critical National Infrastructure and underpins many everyday activities in modern society.

**Why PNT matters**

PNT underpins the safe operation of Critical National Infrastructure and many everyday activities in modern society including:

- Our travel - cars, trains and planes
- Our telecommunications - phones and TV
- Our computers and internet
- Our emergency services - ambulance, police and fire
- Our personal navigation - maps on mobile phones
- Our finances - touch payments and mobile banking

**Why PNT is at risk**

The UK's PNT is almost completely provided through Global Navigation Satellite Systems (GNSS), primarily the US Global Positioning System (GPS), which is operated by the US Space Force.

There are many potential major disruptions to GNSS provided PNT, including hazards like severe space weather and catastrophic technical failure, and threats like cyber and physical attacks.

**What is PNT?**

- Positioning, the ability to determine location and orientation.
- Navigation, the ability to determine current and desired position.
- Timing, the ability to acquire and maintain accurate and precise time from a standard anywhere in the world.

**What will HMG do?**

Strengthen the resilience of the PNT services on which our Critical National Infrastructure and economy depend by scoping a new Government Policy Framework for Greater PNT Resilience.

**Government Policy Framework for Greater PNT Resilience will scope the proposals below**

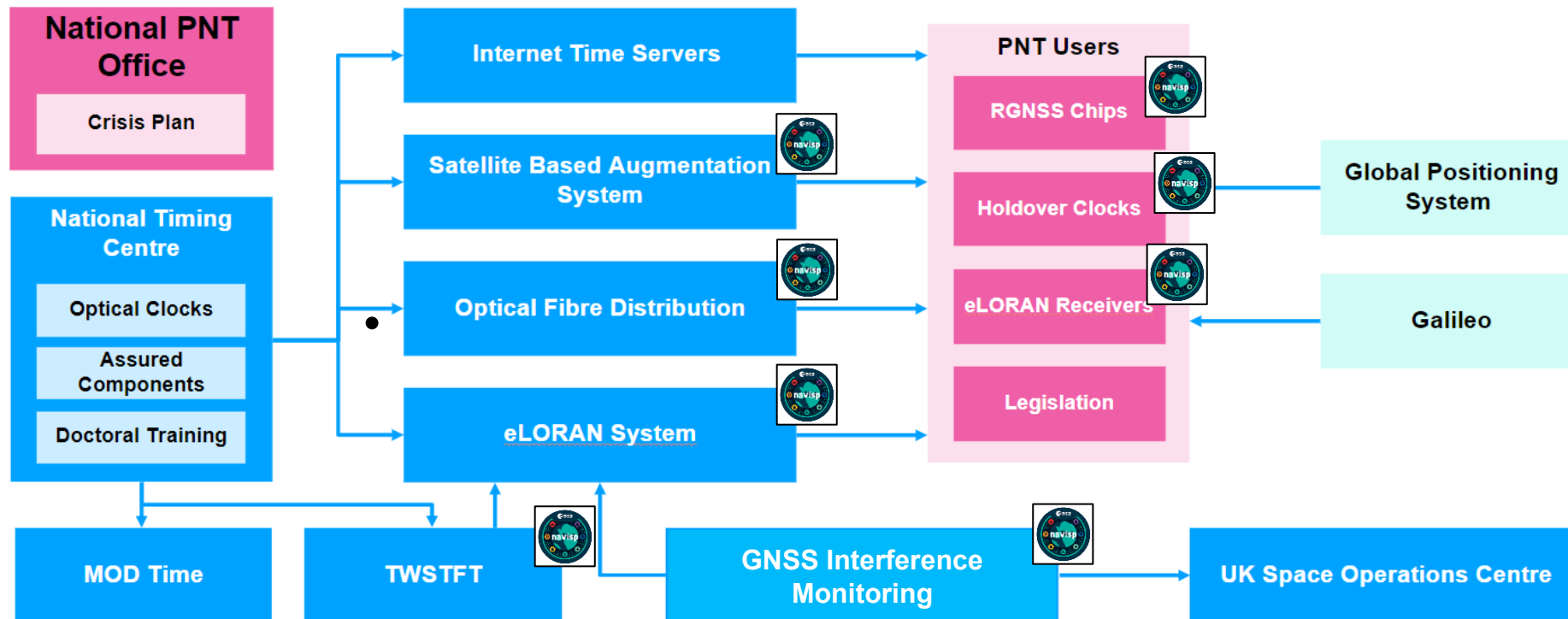
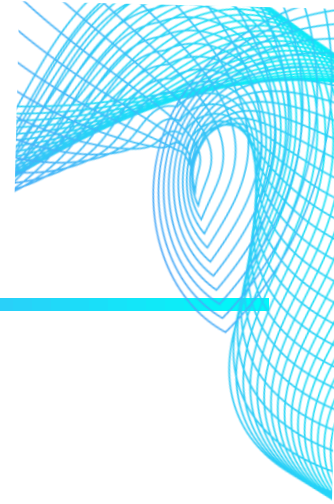
- National PNT Office
- Next Generation PNT
- PNT Crisis Plan
- PNT Growth Policy
- National Timing Centre
- PNT Skills
- MoD Time
- Satellite Based Augmentation System (SBAS)
- Enhanced Long Range Navigation (eLORAN)
- Infrastructure Resilience

HM Government





# National System of Systems and NAVISP

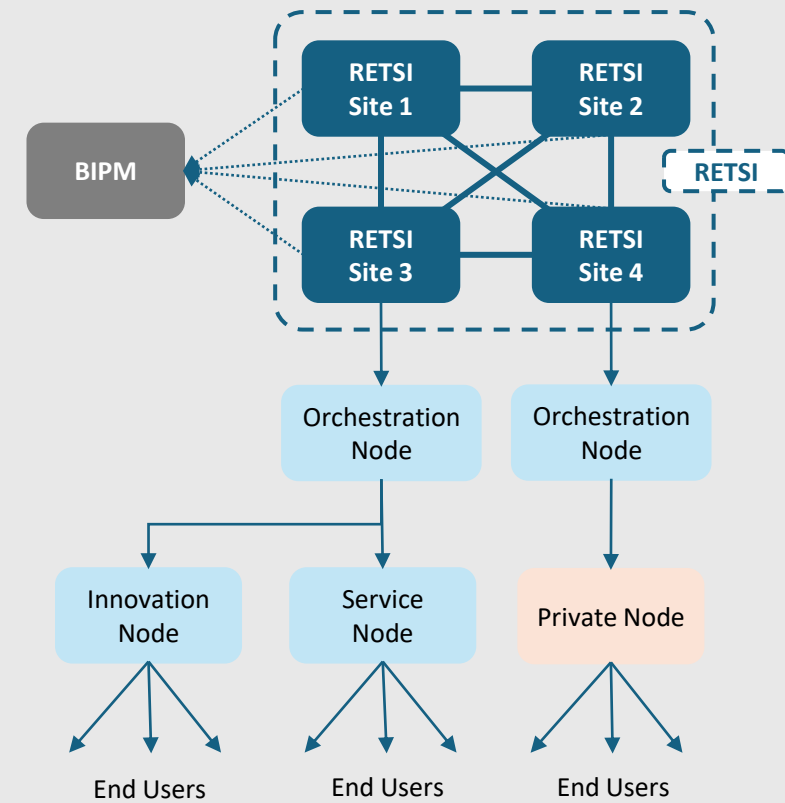


# UK National Timing Centre – Resilient Enhanced Timescale

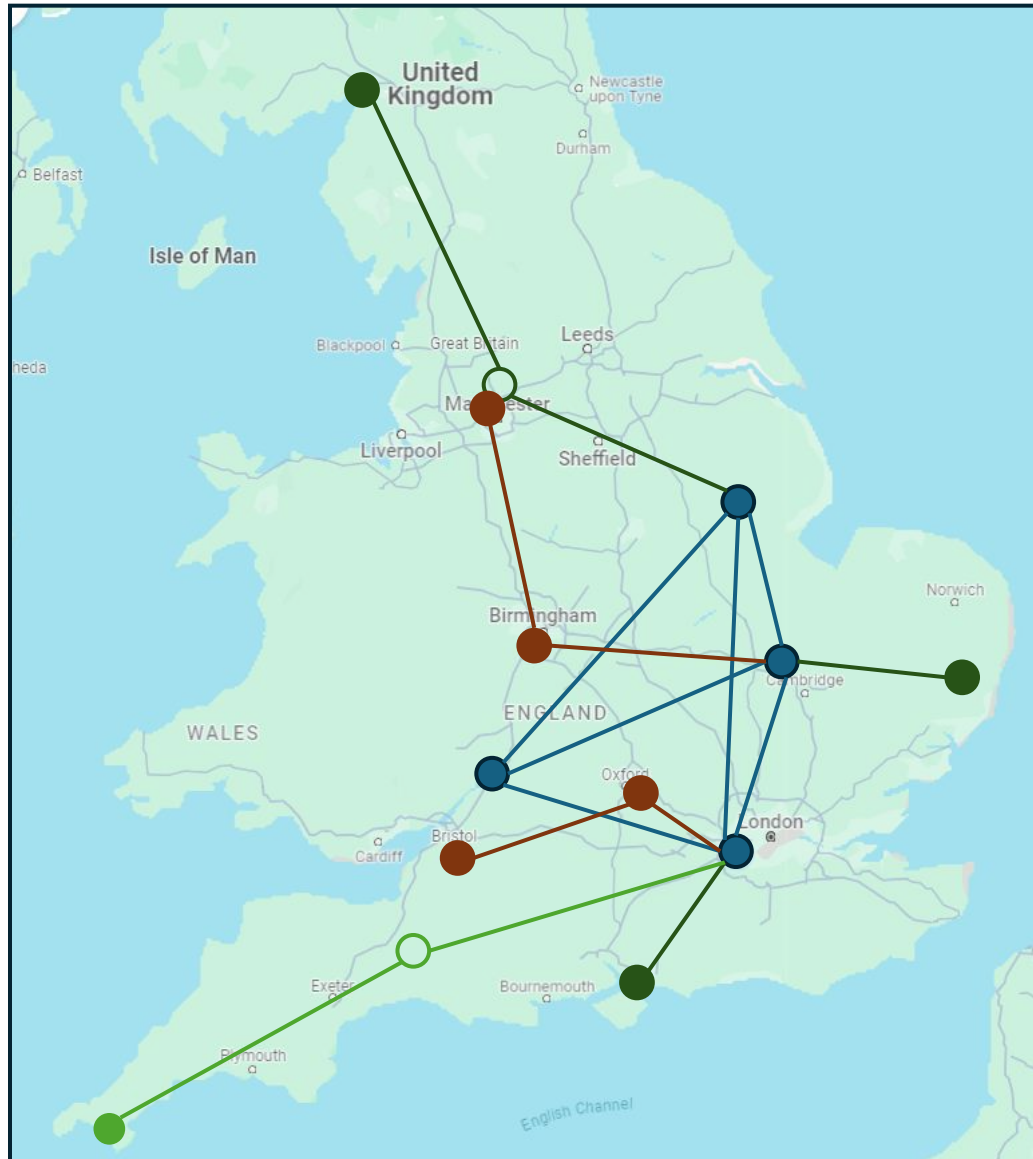
## National Timing Centre (NTC) Policy

- The NTC will provide resilient, terrestrial, sovereign, and high-quality Timing for the UK, and, when combined with eLORAN, back-up Positioning.
- The core of the NTC will be a Resilient Enhanced Time Scale Infrastructure (RETSI), a network of four sites with linked sets of atomic clocks.
- The four sites will be geographically distributed and physically and cyber secure and linked by a mesh network of secure optical fibre cable and TWSTFT.
- The NTC R&D Programme began in 2020 and has proven the technology. Funding is anticipated to reach Operational Capability by 2030

## Illustration of Resilient Enhanced Timescale Infrastructure and Distribution (not actual)



# “Ad-hoc” distribution → Distribution architecture



Requirements  
capture

High-level  
design

Detailed  
design

## Key considerations for design:

- Optimum routing / locations of intermediate nodes
- Upgradability
  - New users
  - More stringent performance requirements
  - Additional links for improved resilience
- **Interoperability with other European national networks**
- Secure

Map for illustrative purposes only.  
Most locations have not yet been fixed.





Ministry  
of Defence

# MOD TIME

Defence has a breadth of use cases and performance requirements similar to that of a modern Critical National Infrastructure and economy, with one exception:

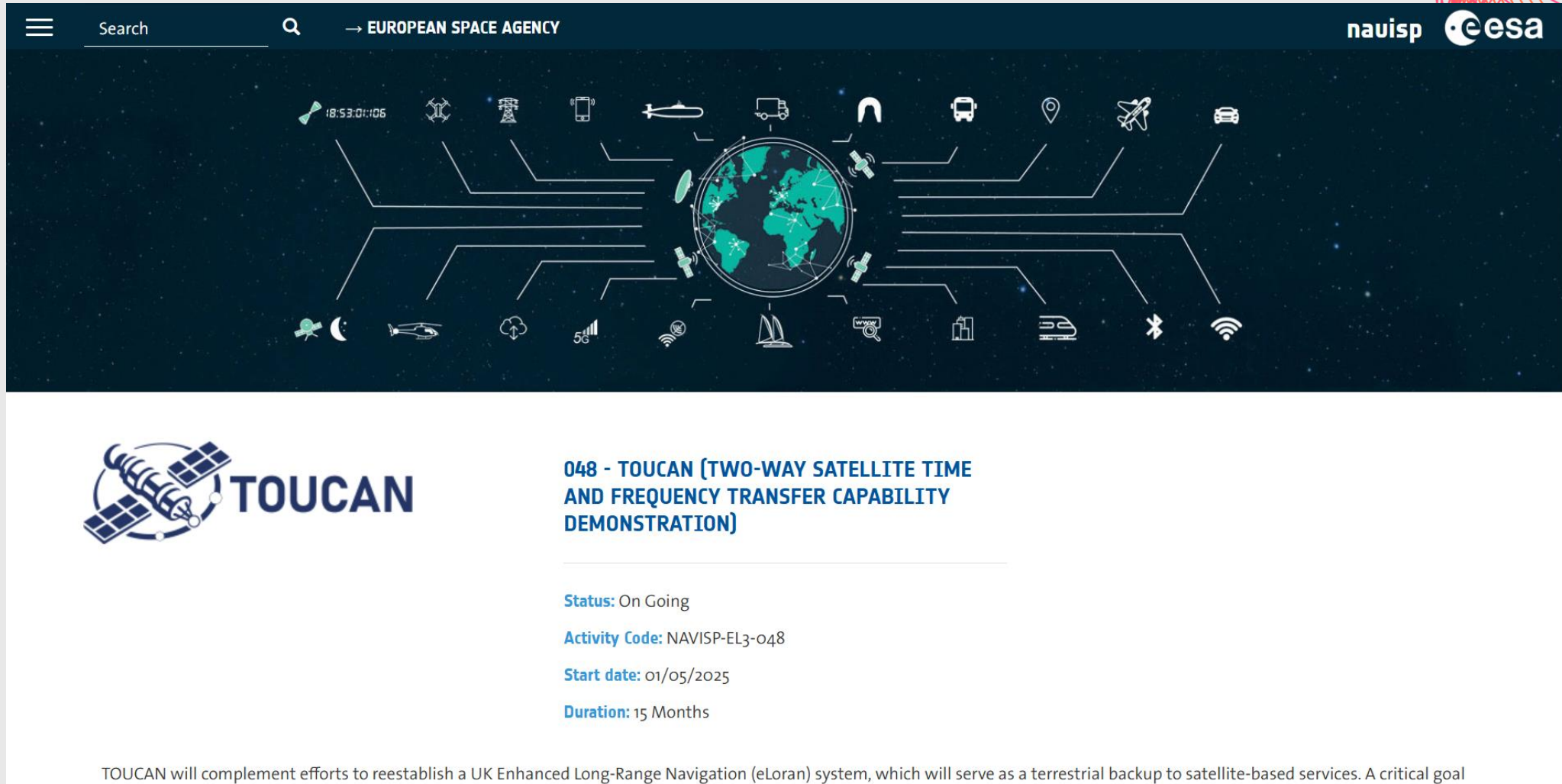
**Defence PNT is intended to be used in conflict**

Increasing regional and global conflicts as well as preparation of nations to engage in manoeuvre warfare reveal timing requirements once measured in minutes are now approaching single-digit nanoseconds and beyond

eLoran is one of several systems being developed to deliver MOD TIME



# ESA NAVISP – Pushing Boundaries of PNT



The screenshot shows the ESA NAVISP website interface. At the top, there is a search bar, a menu icon, and the text "EUROPEAN SPACE AGENCY" with a search icon. The "navisp" and "esa" logos are in the top right. The main content area features a central graphic of a globe with various icons representing different applications and services connected to it by lines. Below this, the "TOUCAN" project is highlighted with its logo and the following details:

**048 - TOUCAN (TWO-WAY SATELLITE TIME AND FREQUENCY TRANSFER CAPABILITY DEMONSTRATION)**

**Status:** On Going

**Activity Code:** NAVISP-EL3-048

**Start date:** 01/05/2025

**Duration:** 15 Months

TOUCAN will complement efforts to reestablish a UK Enhanced Long-Range Navigation (eLoran) system, which will serve as a terrestrial backup to satellite-based services. A critical goal



# CHAIN ODYSSEY

(Fixed eLoran Infrastructure)



Official Sensitive Rel FR and ROK



# eLoran – Going Where GNSS Can't Go



BLOG ▾ LIBRARY CONTACT DONATE



HOME JOIN NOW WHO WE ARE ▾ WHAT WE DO ▾ EVENTS PRESENTATIONS

## “Father of GPS” Calls for Immediate eLoran Build

by Editor | Jun 29, 2017 | Blog



Dr. Brad Parkinson at RNTF & ION meeting aboard USS Constellation, 27 June 2017, RNT Foundation photo.

Dr. Brad Parkinson, widely known as the “Father of GPS,” opened a presentation Tuesday night with a call for immediate





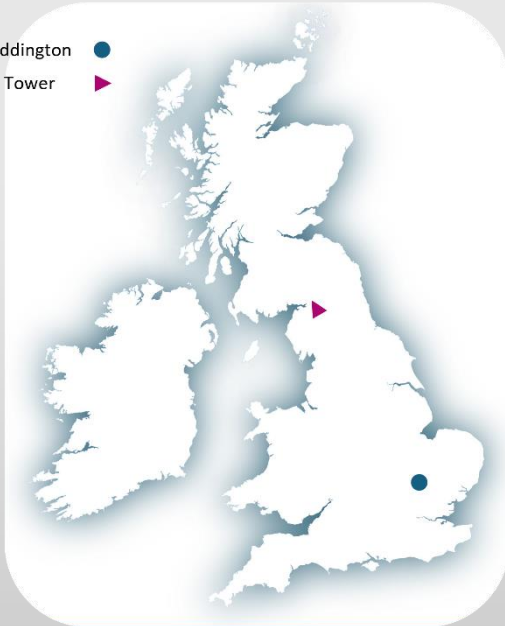
# CHAIN ODYSSEY DEVELOPMENTAL STAGES

**Map of current NTC and eLoran infrastructure**

Illustrative map, exact locations not shown.

Key

- NPL Teddington ●
- eLoran Tower ▲

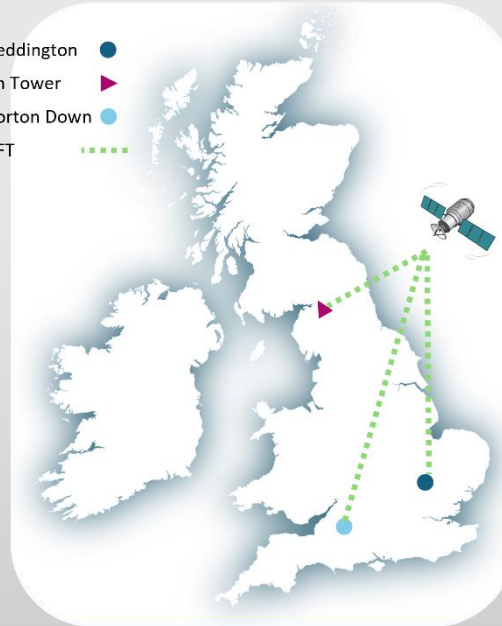


**Map of eLoran and TWSTFT initial operating capability**

Illustrative map, exact locations not shown.

Key

- NPL Teddington ●
- eLoran Tower ▲
- Dstl Porton Down ●
- TWSTFT - - -

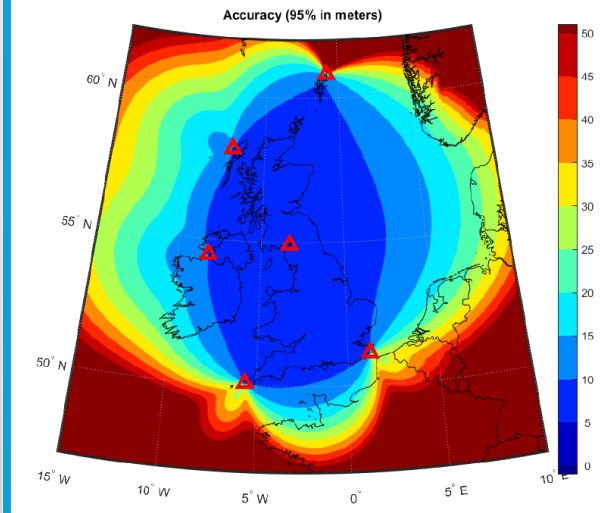
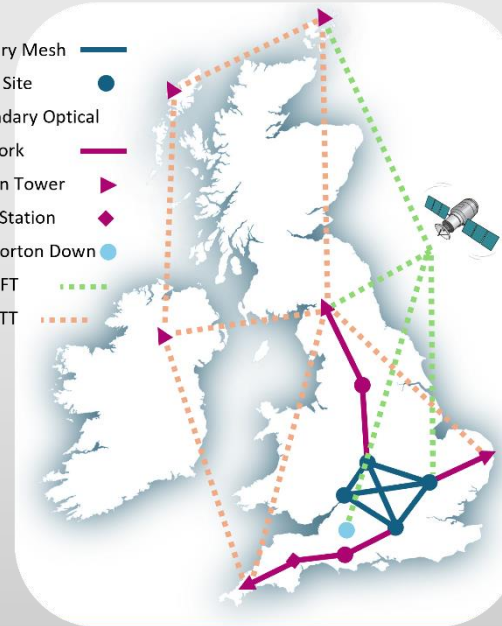


**Map of eLoran full operating capability and links to NTC**

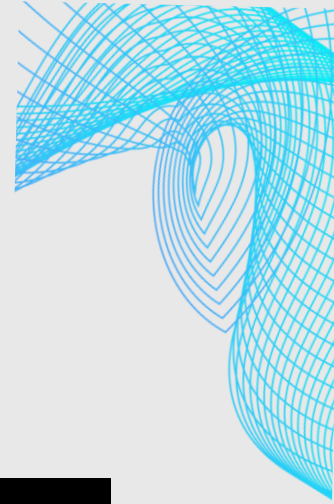
Illustrative map, exact locations not shown.

Key

- Primary Mesh —
- RETSI Site ●
- Secondary Optical Network —
- eLoran Tower ▲
- SBAS Station ◆
- Dstl Porton Down ●
- TWSTFT - - -
- TWLFTT - - -



# Beginning of European eLoran Alliance



## UK and France Renew Ties, Resilient PNT, eLoran a Key Part

July 10, 2025

By Dana A. Goward

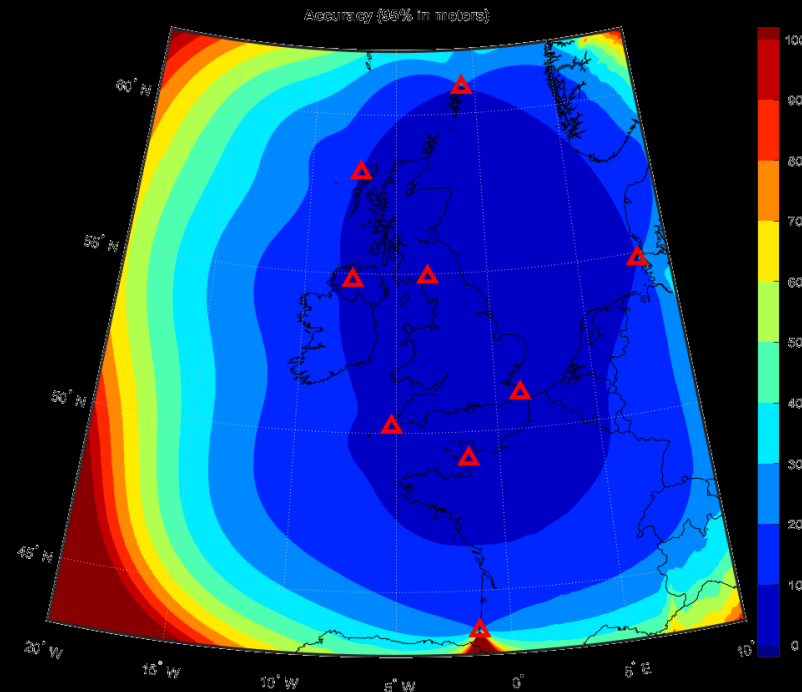


Conceptual graphic of UK eLoran signal coverage, Mitch Narins, Strategic Synergies, LLC.



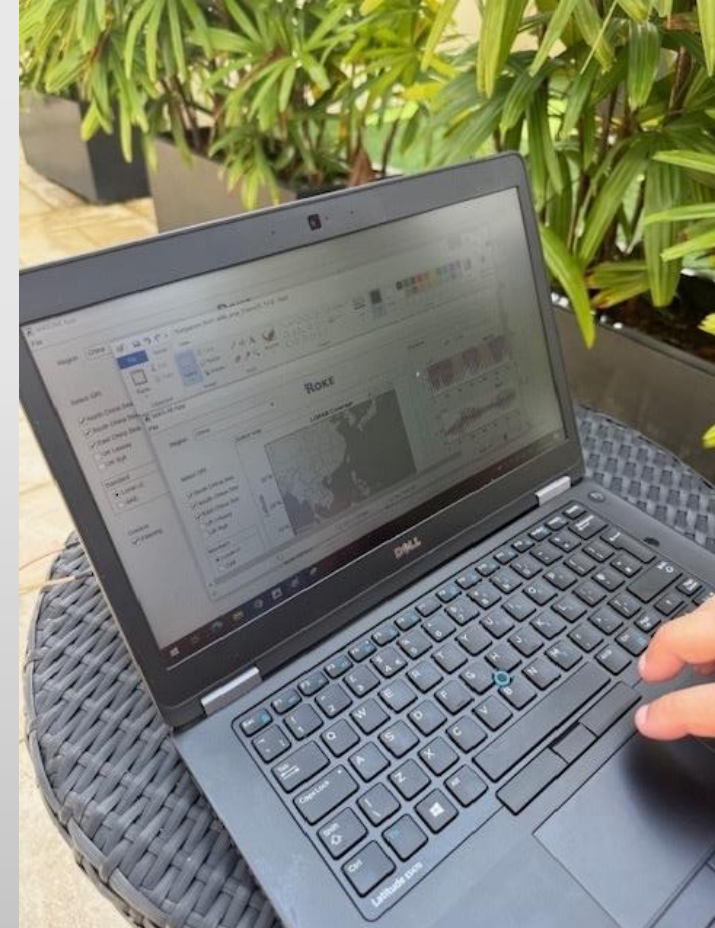
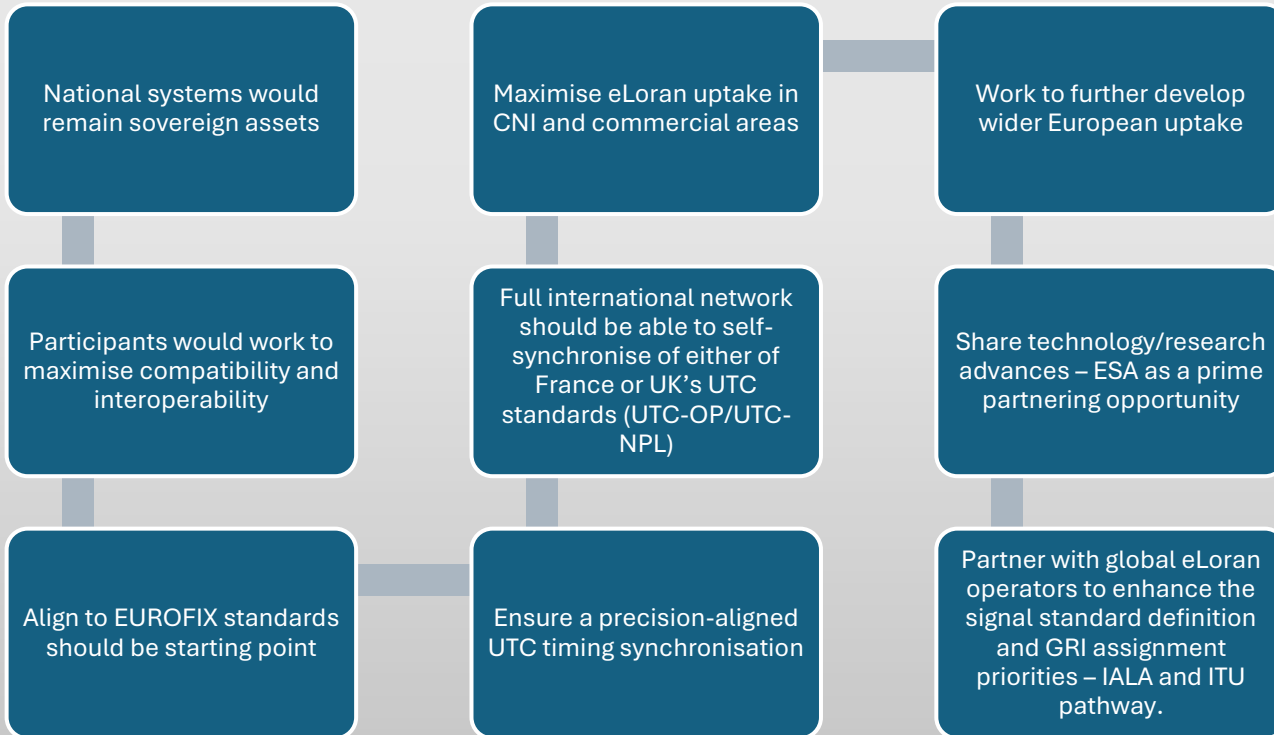


# ELORAN- UK/FRANCE-LESSAY + SOUSTONS + SYLT



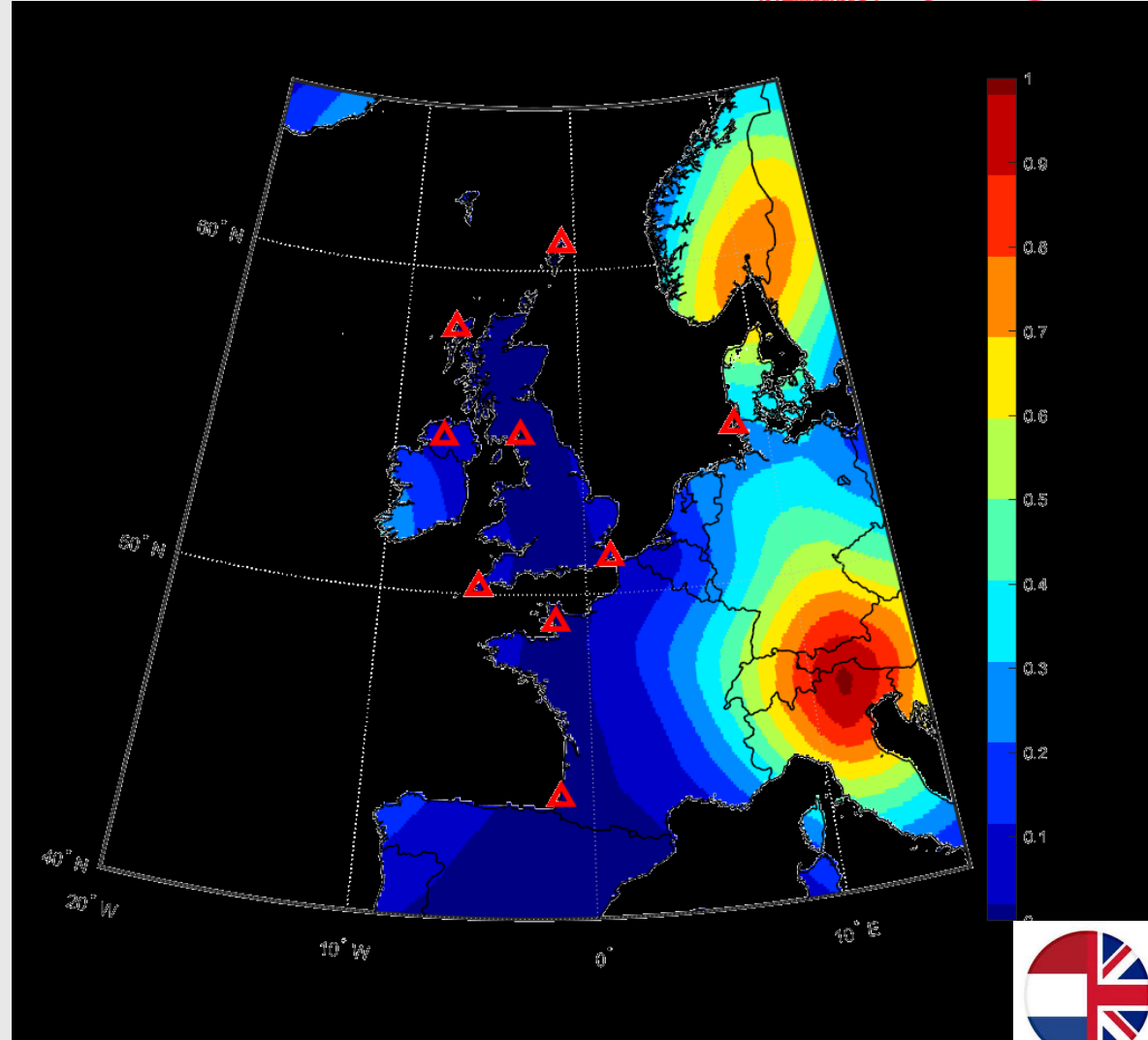


# CONSIDERATIONS FOR ELORAN PARTNERING

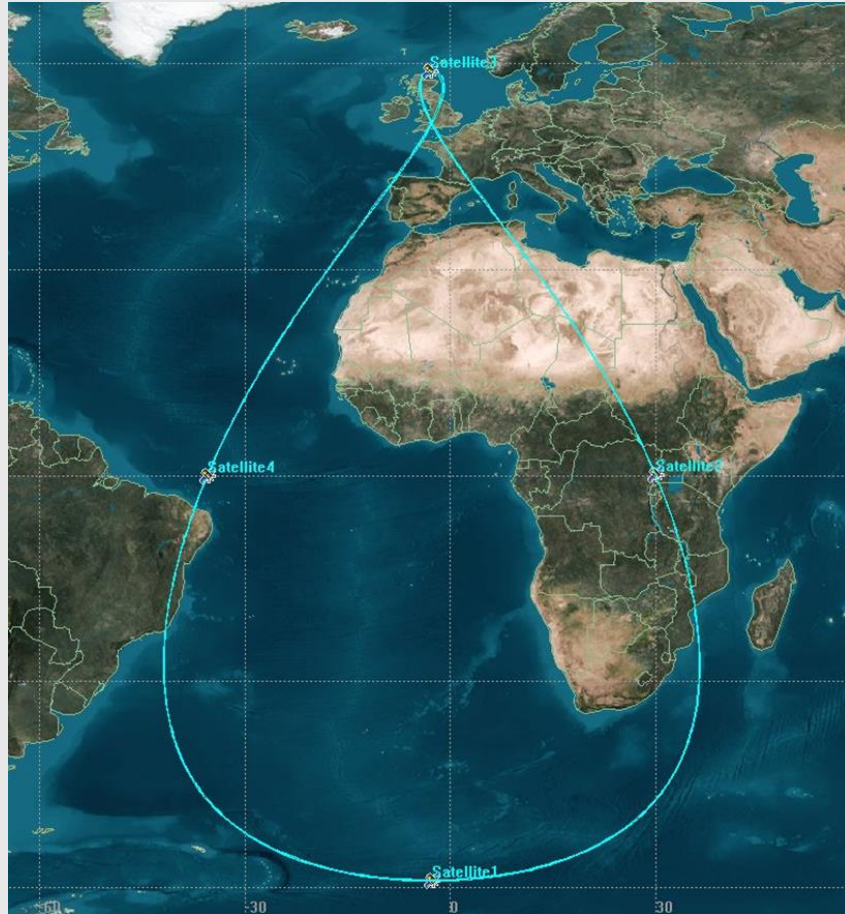


# A European Anchor for PNT Resilience

- European Space Agency offers to act as host sponsor for next stage of international eLoran developments
- Multiple European Nations with interest in eLoran
  - NATO
  - European Commission
  - Eurocontrol
  - 9 EU Member States and Counting
  - German military live-testing eLoran Oct 25
- Asian Countries engaged with eLoran
  - Saudi Arabia (fielded), UAE (installing), Singapore – UK collaboration, Japan – UK collaboration in both Defence and civil time transfer
  - Korea – Key partner to UK and host of FR/ROK/UK eLoran Summit (announced at UN ICG)
- US DOT and DOD funded-eLoran ranges in USA



# UK eLoran Example Initiatives



Hybrid eLoran / Space-based PNT System



SMALL BUT MIGHTY

## Miniature eLORAN antenna showcased with UK Carrier Strike Group

Our patented eLoran antenna delivers unmatched performance in a compact form. Now on tour with Operation HIGHMAST, it's redefining what's possible in resilient navigation.

Discover the future of resilient positioning with Roke.

**ROKE**

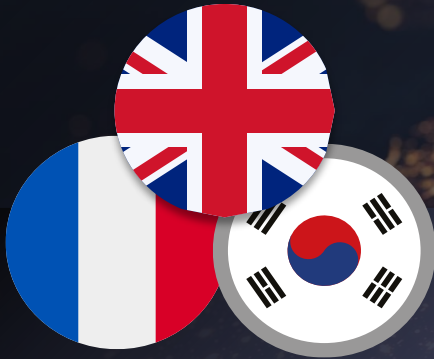
Miniaturisation of eLoran antenna and receiver



Augment



# NAVISP support efforts to rebuild eLoran



Under the leadership of the UK PNT Office, an international conference of countries interested in e-Loran will be organised next year at ESTEC



*Reception of UK Anthon eLoran station at ESTEC UTC lab showing a 30 nsec peak-to-peak variation wrt to GPS time*

**Combination of e-Loran and signals from space**

**e-Loran horizontal position accuracy can be < 10 m with differential corrections**

**Combination with signals from space overcomes limitation in vertical positioning**



# URGENT COMPASS

(Tactical eLoran)



Official Sensitive Rel FR and ROK



# Deployable eLoran Use Cases

## Objectives

5

Deployable  
Maintainable  
Replaceable/Expendable?



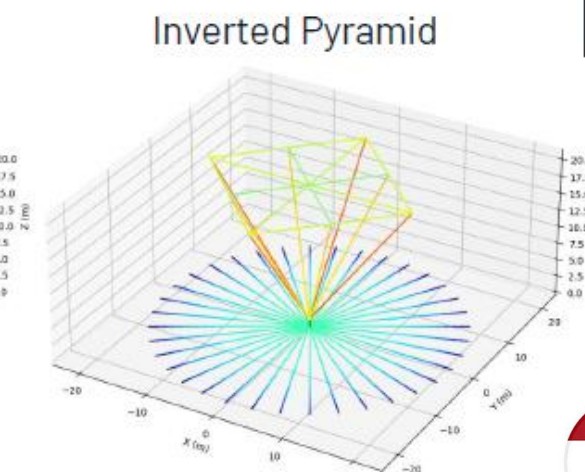
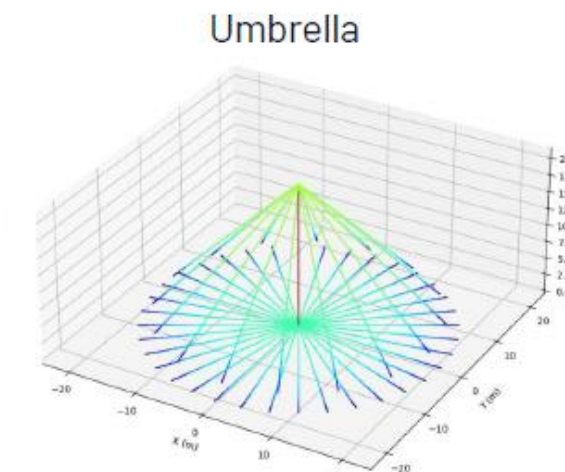
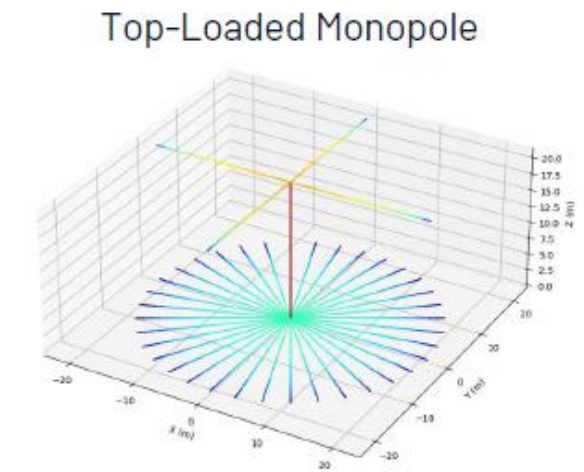
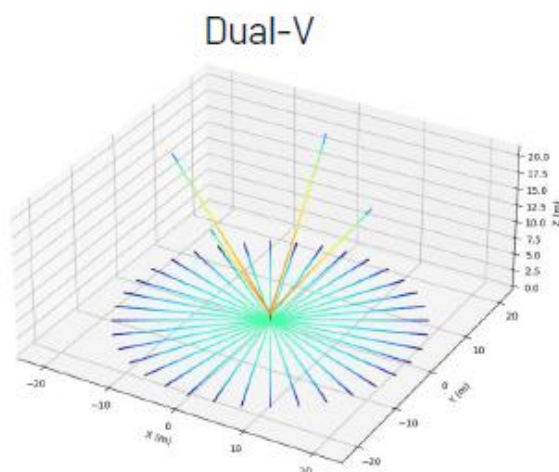
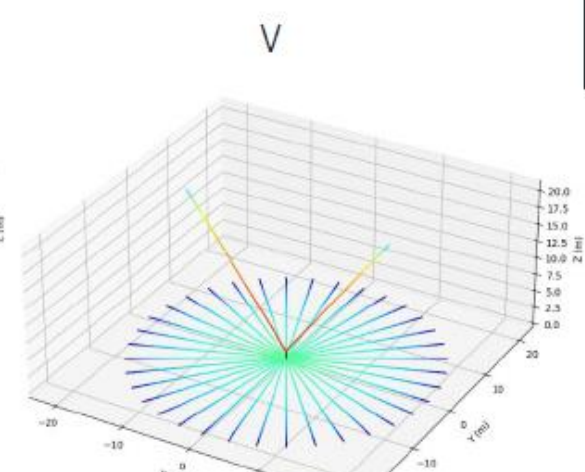
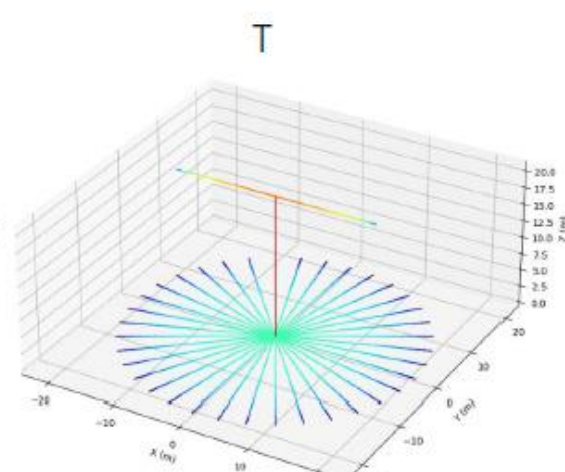
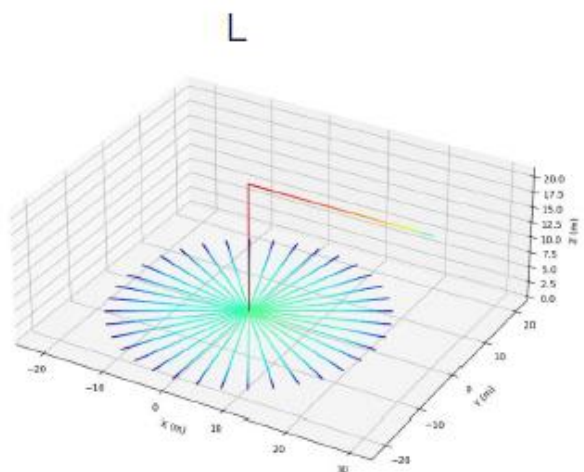
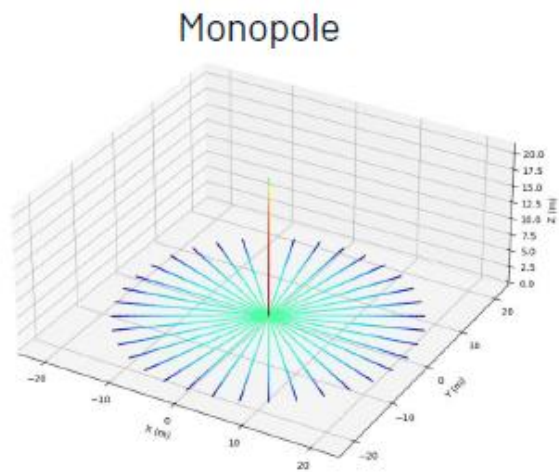
Low probability of intercept.  
Difficult to jam.  
Difficult to spoof.  
Low power.  
Use restricted to certain users.  
Low visual and thermal signature.  
UTC aligned?

### Use Cases:

- Fast airborne platforms
- Under ground
- Under water



# Candidate Antenna Types



# Candidate Antenna Efficiency

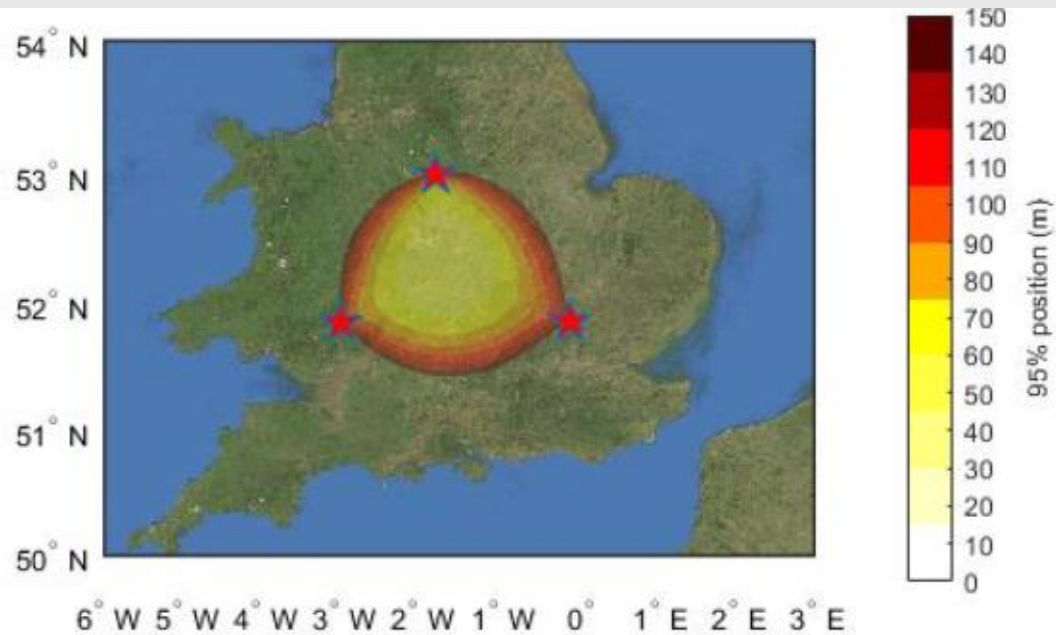
Antenna Type	Masts	Height (metres)	Peak Input Voltage (Volts)	Input Power (Watts)	Radiated Power (Watts)	Efficiency
Monopole	1	12	2958	15	0.01	0.1%
		21	2959	30	0.09	0.3%
		34	2960	57	0.57	1.0%
L-Antenna	2	12	2961	53	0.13	0.2%
		21	2964	116	1.1	0.9%
		34	2969	260	6.93	2.7%
T-Antenna	2	12	2960	49	0.12	0.2%
		21	2963	105	1.03	1.0%
		34	2968	230	6.47	2.8%
V-Antenna	2	12	2960	49	0.06	0.1%
		21	2962	98	0.52	0.5%
		34	2964	187	3.23	1.7%
Dual V-Antenna	4	12	2962	111	0.21	0.2%
		21	2964	221	1.77	0.8%
		34	2967	418	11.08	2.7%
Top-Loaded Monopole	4	12	2964	129	0.53	0.4%
		21	2969	302	4.5	1.5%
		34	2979	741	29.04	3.9%
Umbrella	1	12	2973	646	0.87	0.1%
		21	2987	1772	7.92	0.4%
		34	3016	5247	55.72	1.1%
Inverted Pyramid	4	12	2968	353	1.66	0.5%
		21	2971	738	14.61	2.0%
		34	2977	1484	96.2	6.5%



# Tactical eLoran Coverage Example

200 km between transmitters

10 watt transmitted from a 21m inverted pyramid antenna



# A Real-World Example of Tactical eLoran

- Ongoing programme with German MoD and IABG.
- ISO shelter houses transmitter and control equipment.
- Storage space for:
  - 4x 22m pneumatic masts,
  - Matching unit,
  - Feedline,
  - Antenna elements.
- Operating in Manching, Germany, since September.
- Demonstrates timing, and secure data channel performance.
- Differential reference site 35km away.
- Also receiving Anthorn (UK) and Slonim (Belarus)



Credit: UrsaNav - with thanks

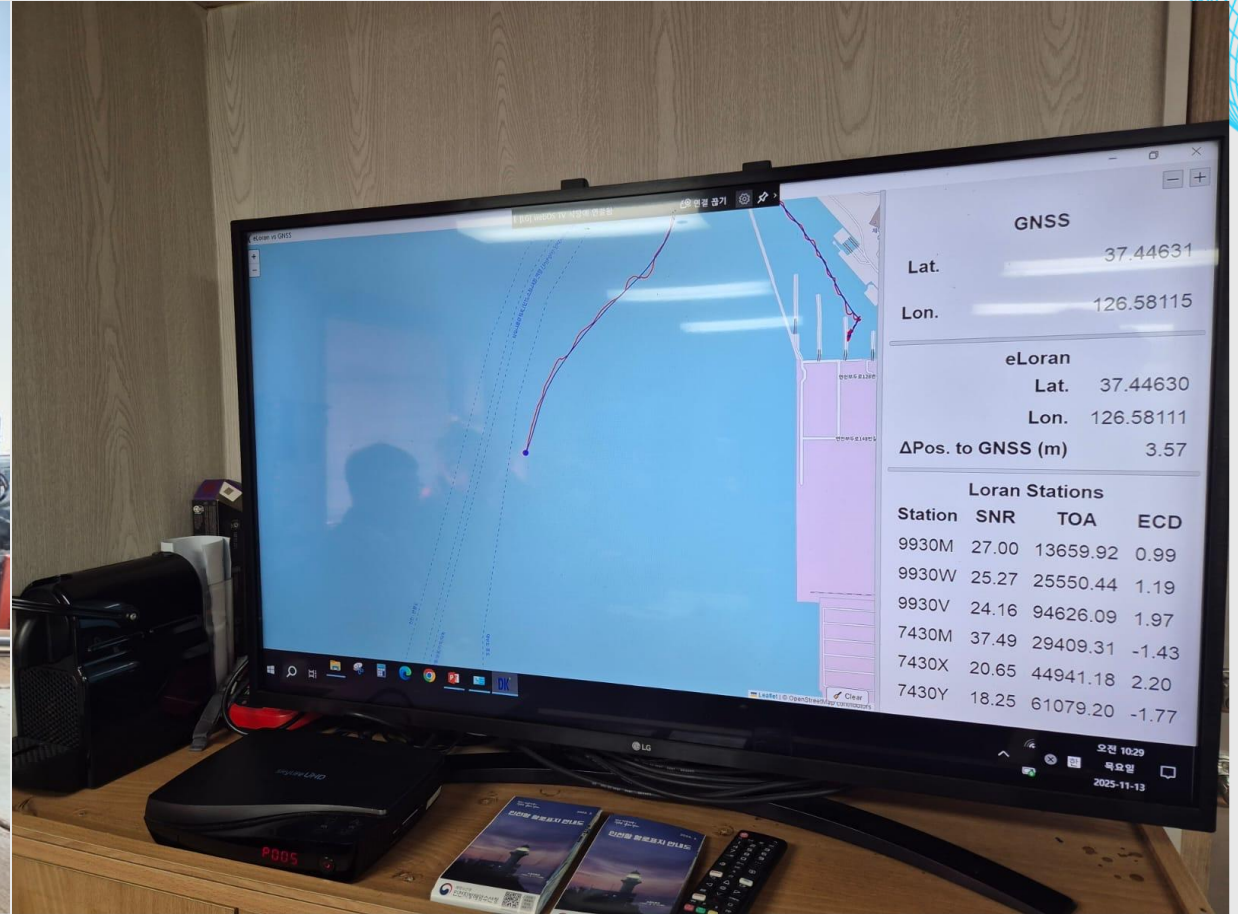


# URGENT COMPASS – Deployable eLoran

- Requirement for a non-GNSS dependent Defence Capability to provide both positioning and timing services for deployed forces
- Full assessment of current and near-term PNT capabilities by Defence resulted in eLoran being identified as the only capability that meets all Defence requirements
- Intent to acquire demonstration capability published by MOD in 2025, with commercial selection now in progress
- URGENT COMPASS would be fully interoperable with CHAIN ODYSSEY and any allied eLoran systems – standards critical
- Initial demonstration capability in UK in 2028



# eLoran – How Good Is It?

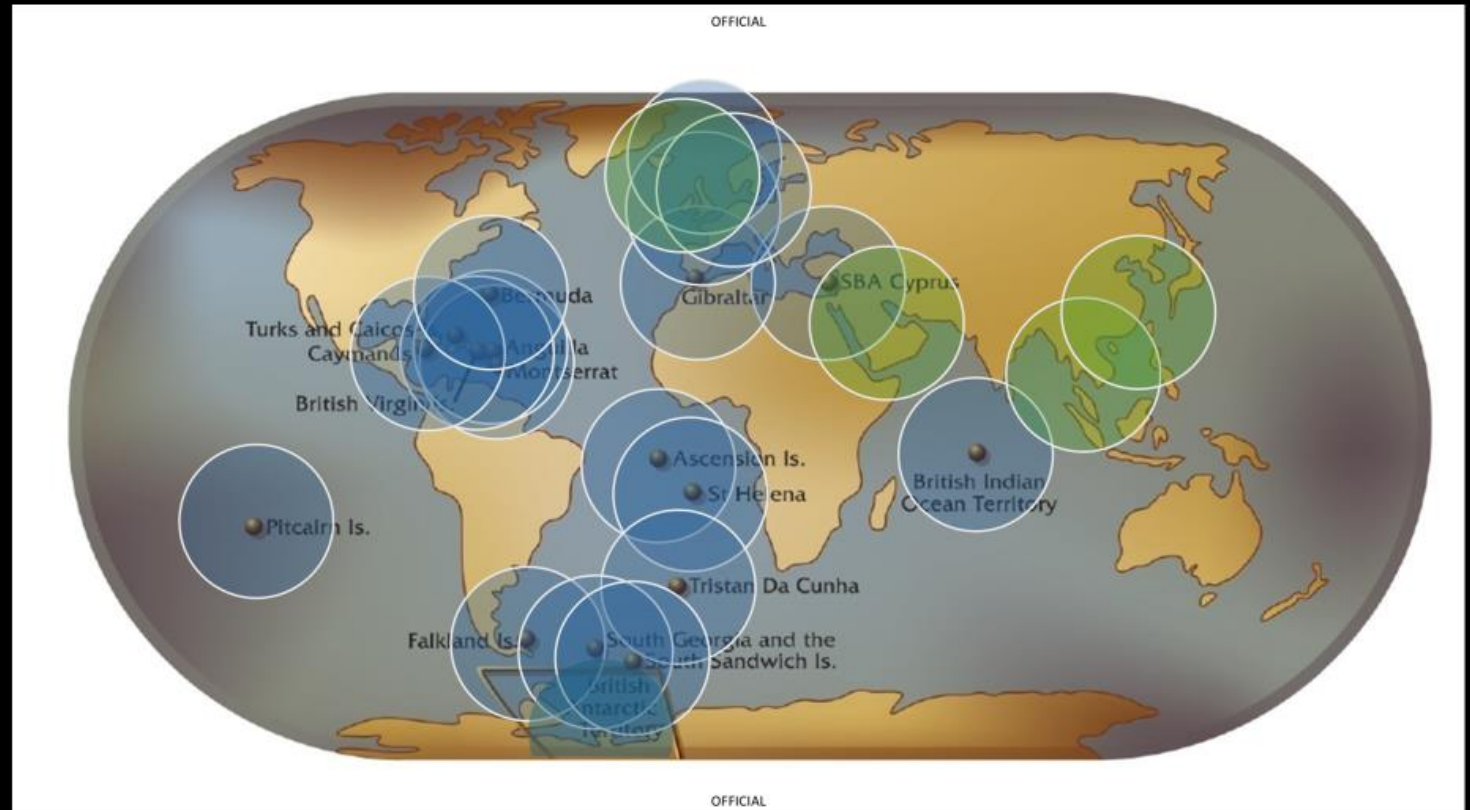


# Maximised Footprint of Global eLORAN Options



Department for  
Science, Innovation  
& Technology

- Blue circles include UK National System and **POSSIBLE** British Overseas Territories
- Almost certain initial UK systems would only be in UK and Northern Ireland, with possibly 3 x BOT (if case is made by MOD/HO/FCDO)
- Green Circles are known or planned systems
- Not shown- Australia, China, Philippines, Japan, US Test Range



**Status: 12 Nations - Europe, North America and Asia in discussion with UK on eLORAN partnering**



# PNT Interference Warning

## Ordnance Survey and Position, Navigation and Timing (PNT)

OS has been involved with PNT for over 230 years.

Today **Ordnance Survey is today critically reliant upon GNSS.**

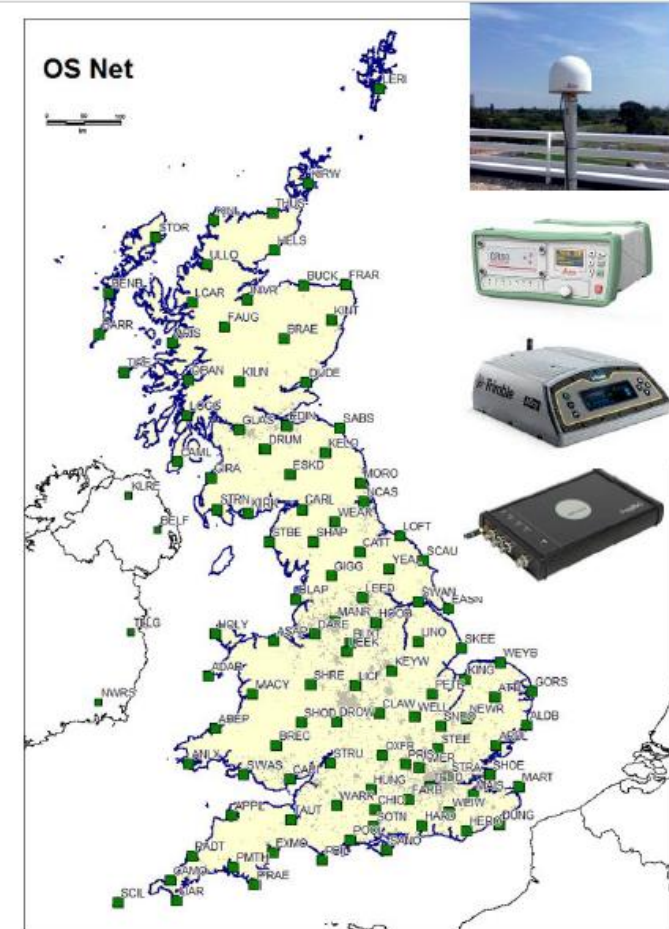
**OS Net** is a network of 115 continuously operating GNSS receivers about 60km apart, but varies considerably depending upon geography

OS Net realizes the national **Coordinate Reference System for Great Britain**, a frame of ETRS89

OS Net enables **real time cm positioning** using RTK – supporting OS surveyors, commercial partners, the **Met Office (through a collaboration agreement)** and others.

GNSS faces a wide variety of **threats and vulnerabilities.**

OS Net, our surveyors and your own devices **detect** multiple natural, non-intentional and intentional **interference events every day.**



GNSS: Global Navigation Satellite Systems, includes GPS, Galileo, GLONASS and Beidou  
ETRS – European Terrestrial Reference System  
RTK – Real Time Kinematic



# United Nations International Committee on GNSS - 2025

## UN ICG Committee Working Group S

- Co-chaired by USA and Russia
- UK proposed at ICG 2024 the necessity of a National PNT Interference Warning System
- Proposal examined during 2025
- October 2025 ICG in Busan, South Korea
  - USA proposed UN ICG Recommendation for all member nations to develop a National-Level PNT Interference Warning Capability with a goal to share data internationally
  - Russia seconded this recommendation
  - Endorse by full UN ICG membership

ICG/REC/2025

### Recommendation for Committee Decision

Prepared by: Working Group S  
 Date of Submission: 23 October 2025  
 Issue Title: GNSS Monitoring

#### Background/Brief Description of the Issue:

An increasing number of GNSS signal disruption incidents reported by users globally highlights the risk of electromagnetic interference, which would place unacceptable risks to the safety of flights, maritime and land operation including individuals daily lives supported by critical infrastructure. Multiple international organizations in these service domains already recognized this global critical issue as indicated in the following published memoranda statements below;

- International Maritime Organization (IMO) MSC.1/Circ. 1644 dated 18 October 2021
- International Civil Aviation Organization (ICAO) Assembly Resolution A41-8/C approved in 2022
- International Telecommunication Union (ITU) Resolution 676 (WRC-23) approved in 2023
- Joint Statement by The secretary General of the International Telecommunication Union, The Secretary General of the International Civil Aviation Organization, The Secretary General of the International Maritime Organization regarding Protection of the Radio Navigation Satellite Service from Harmful Interference signed on 18 March 2025

#### Discussion/Analyses:

Given the global safety and economic benefits that GNSS services provide many nations have the need to monitor GNSS/RNSS signal environment conditions for their situational awareness and decision making in the continued use of such services, particularly for safety of life applications. However, not all governments deployed GNSS interference monitoring or information gathering systems to receive signal disruption reports in particular associated with malicious or illegal jamming or spoofing activity.

The goal of GNSS interference monitoring for protecting the GNSS/RNSS signal environment is to find a balance between the safety requirements of civil transportation and critical infrastructure dependent on GNSS availability and national security interests. Coordination among various government agencies and industry for GNSS/RNSS interference monitoring is critical for real-time situational awareness to avoid placing civil GNSS users in a hazardous environment created by the GNSS/RNSS signal disruption.

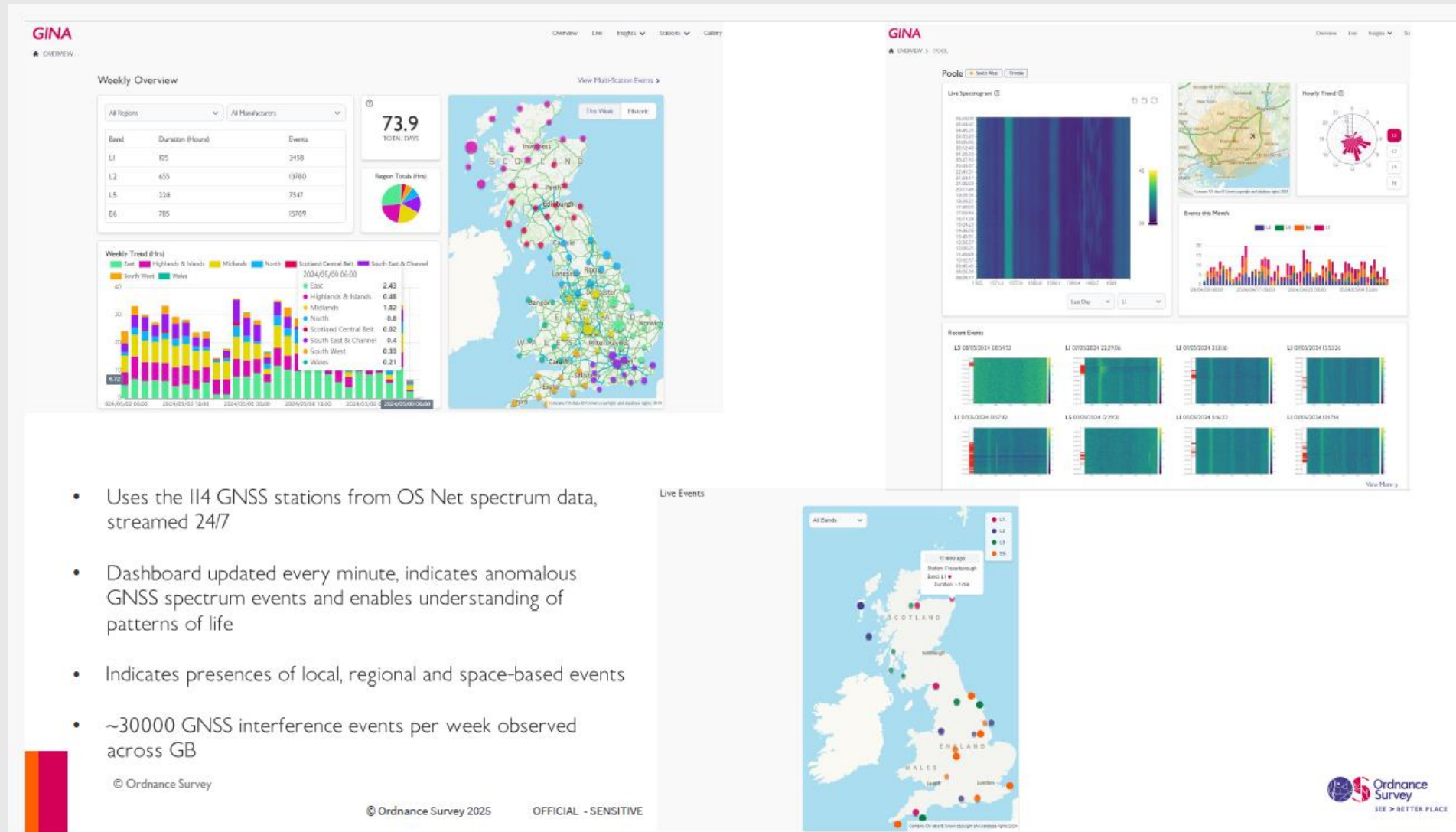
#### Recommendation of Committee Action:

*ICG encourages member states to consider use of national and/or global interference monitoring to timely inform users where interference may cause GNSS/RNSS to be unavailable (jammed) or errant (spoofed).*

Members Consensus Reached ; No Consensus Reached

Chairperson Signature: \_\_\_\_\_ Date: \_\_\_\_\_

# GNSS Interference as a Daily Occurrence



- Uses the I14 GNSS stations from OS Net spectrum data, streamed 24/7
- Dashboard updated every minute, indicates anomalous GNSS spectrum events and enables understanding of patterns of life
- Indicates presences of local, regional and space-based events
- ~30000 GNSS interference events per week observed across GB

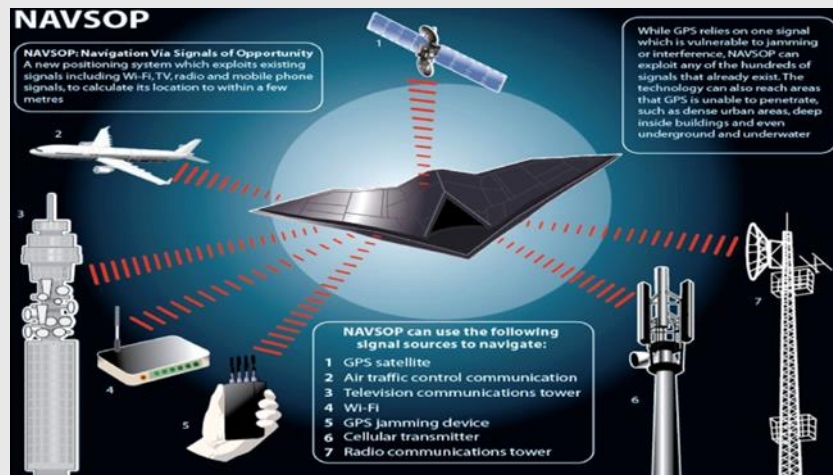
© Ordnance Survey

© Ordnance Survey 2025

OFFICIAL - SENSITIVE

Ordnance Survey  
SEE > BETTER PLACE

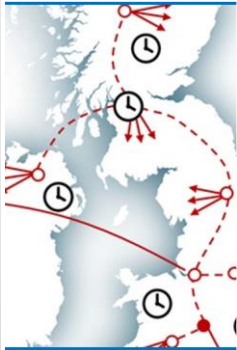
# Other Areas of UK Development in PNT





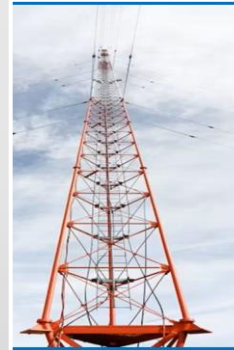
# PROGRAMME FUNDING

## PNT SR phase 2 bids – public announcement 19 Nov:



National Timing Centre programme bid for First Phase - £67m already in 2025, remaining over SR period (CDEL funding).

**LATER ANNOUNCEMENT**



eLORAN programme bid for full system over SR period (CDEL funding).

**FULLY FUNDED**



Space Based Time Transfer (SBTT) programme bid for research and development over SR period (CDEL funding).

**FULLY FUNDED**



Bid for enhanced interference monitoring capability over SR period (CDEL funding).

**FULLY FUNDED**

# Questions

