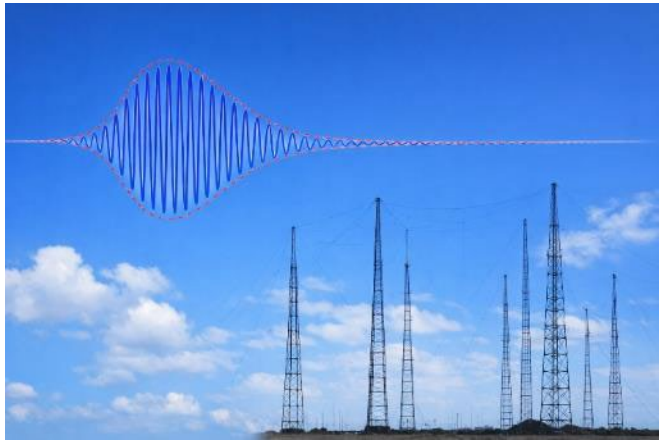
Department for
Science, Innovation
& Technology



Prioritizing PNT: The UK's Efforts to Establish a National Core Resilient and Robust PNT Architecture

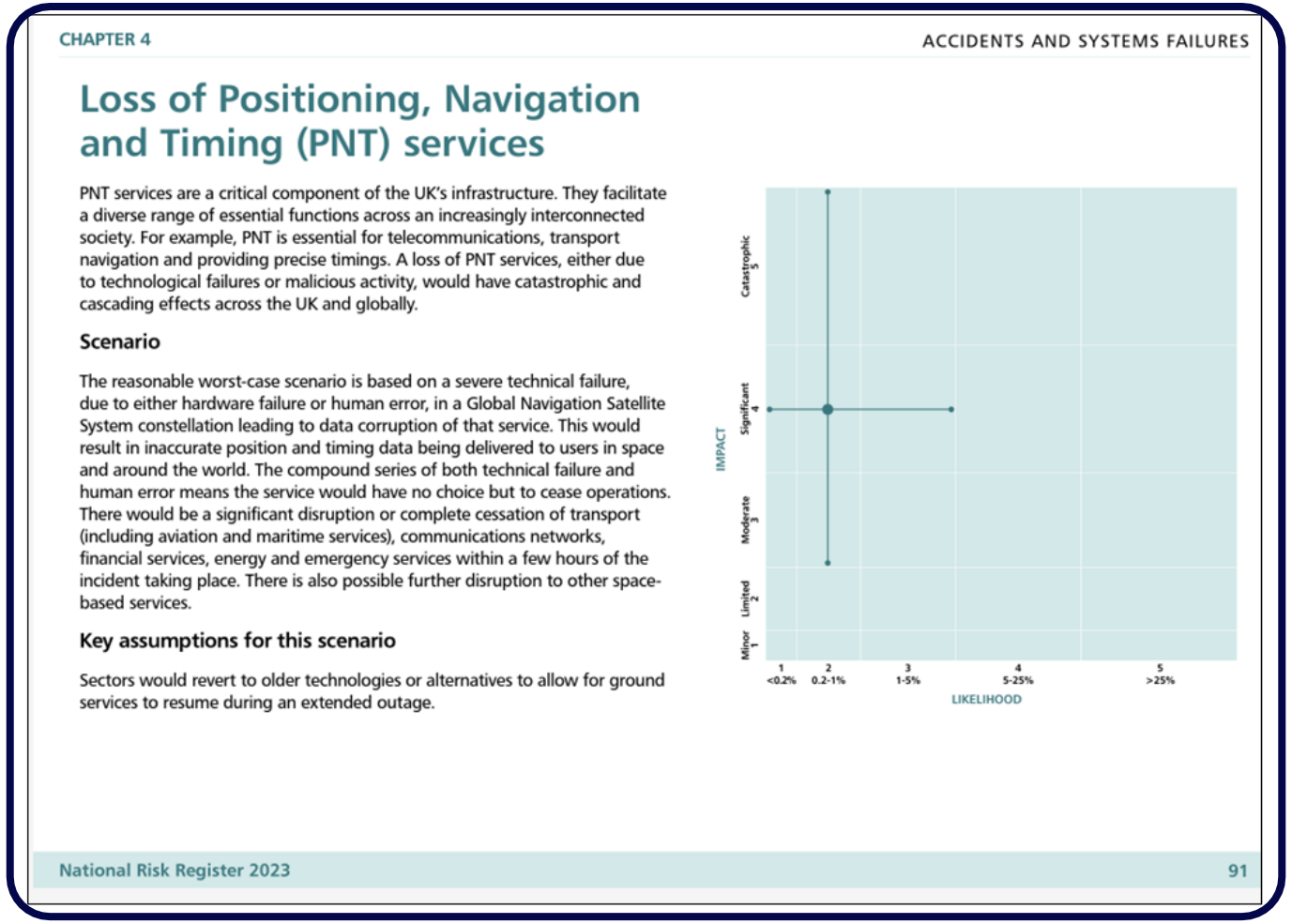
8 April 2026

DR MARK BRAMMER, WG CDR RAF, POSITIONING PROGRAMME LEAD
UK National PNT Office

A NATIONAL PNT RISK

Department for Science, Innovation & Technology

- 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.

National Risk Register 2023 91

https://www.gov.uk/government/publications/national-risk-register-2025

Risk of Loss of PNT – More Than One Cause

Department for Science, Innovation & Technology

UK National Risks to Positioning, Navigation & Timing

Severe Space Weather
Solar flares and geomagnetic storms disrupt GNSS signals
Wide-area degradation

Hostile Acts
Jamming, spoofing and cyber attacks
Intentional disruption of GNSS

Failure of PNT Systems
Satellite or ground failures
Systemic dependency risks

National Impact

Telecommunications networks
Financial systems & trading
Energy grid synchronisation
Aviation & maritime navigation
Autonomous systems & logistics

UK Journey in Sovereign PNT – Space Based

Department for Science, Innovation & Technology

UK Space-Based PNT Programmes & Strategic Evolution

Galileo (Pre-2020) → UK GNSS (2020) → SBPP (2021-23)

Galileo Participation & Brexit

EU GNSS participation
PRS access lost post-Brexit
Dependency exposed

Outcome:
Catalyst for UK PNT independence strategy

UK GNSS Programme

Proposed sovereign GNSS
Cancelled (cost/scope)
Reassessment triggered

Outcome:
Shift away from single-system GNSS

UK Space-Based PNT Programme

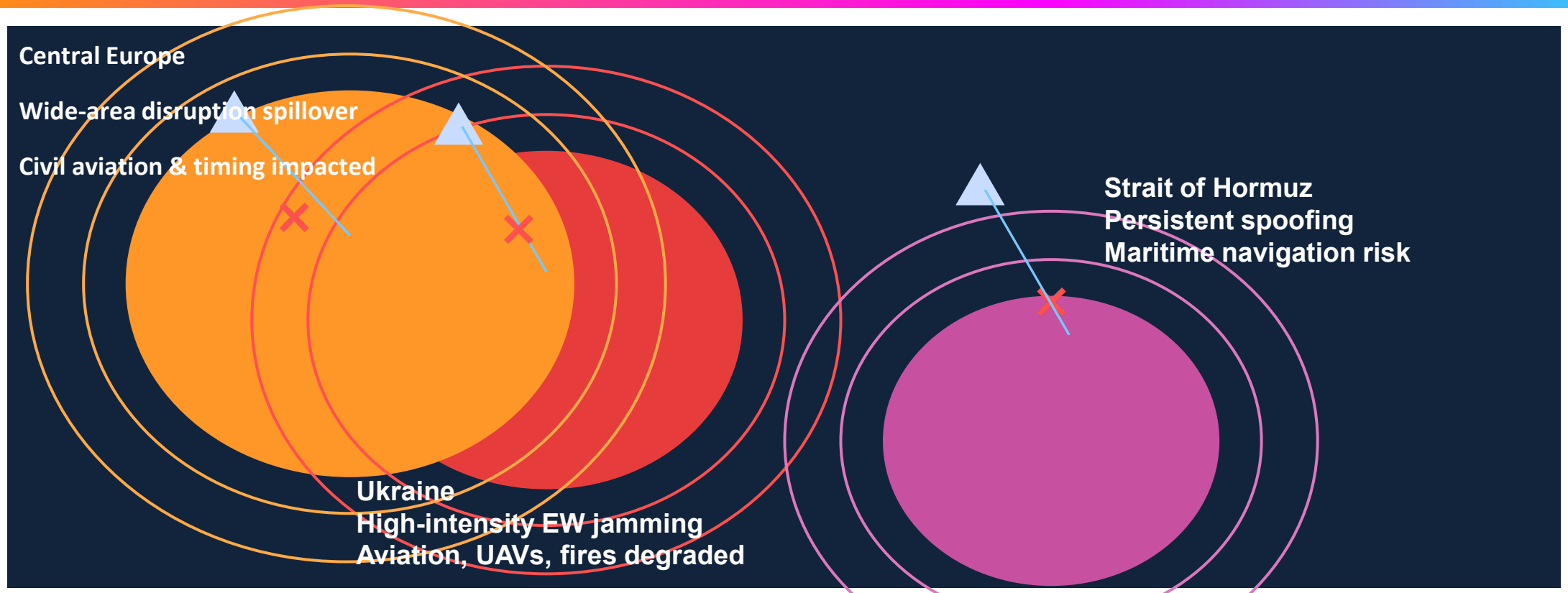
System-of-systems approach
Hybrid space + terrestrial
Resilience focus

Outcome:
Defined resilient national PNT architecture

From reliance on Galileo → Sovereign ambition → Resilient, multi-layer PNT architecture

The Evidence of Reality – GNSS Denied

Department for Science, Innovation & Technology



GNSS denial degrades navigation accuracy, corrupts timing, and elevates safety risk across aviation, maritime, and defence operations

Severe Space Weather – Impacts Support the Case for Terrestrial PNT

Department for Science, Innovation & Technology

Met Office

Severe Space Weather
Informal Briefing Note

ISSUE NUMBER: 2024/01	ISSUE DATE & TIME: 10/05/24 11:00
HEADLINE: Several Earth directed Coronal Mass Ejections are expected to lead to a G4 Geomagnetic Storm on the morning of 11th May.	
VALID FROM: 10/05/24 18:00 TO: 11/05/24 23:59 Unless superseded by further issue	
NEXT ISSUE: 10/05/24 16:00	
ISSUED BY: Simon Machin	Met Office Space Weather Operation Centre (MOSWOC) moswoc@metoffice.gov.uk / 0330 135 4254

Summary of Space Weather Activity

A very large active sunspot region (AR3664) in the southwest of the solar disc has become very complex over recent days and has been responsible for numerous Strong (R3) flares and multiple Earth-directed Coronal Mass Ejections (CMEs). The CMEs, whilst relatively modest individually, are expected to arrive in rapid succession and possibly combine into a larger arrival later today (current MOSWOC estimate of first arrival time is 20:00 this evening). There remains some uncertainty in the peak magnitude of geomagnetic activity given complex interaction between the numerous CMEs.

It is likely that storm commencement will be at a G2-G3 level, however this is expected to rise over time with a G4 peak estimated as most likely during the morning of 11th May. MOSWOC are forecasting a small 10% probability of this building to a peak of a G5 storm. Geomagnetic storming conditions are expected to steadily decline after midday on 11th May.

Possible impacts are likely to:

- High Frequency communications
- Satellite communications
- GNSS
- Satellite orbits (Low Earth Orbit)

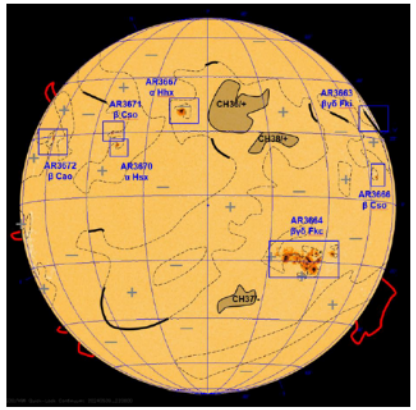
Two further CMEs are also on route to Earth and expected to arrive later in the weekend. These are expected to be less Earth effective and more likely to result in G2-G3 storming conditions.

The key sunspot area is expected to remain on the Earth facing solar disc until 14th May and MOSWOC will continue to actively monitor the region for further signs of significant activity that could be Earth effective.

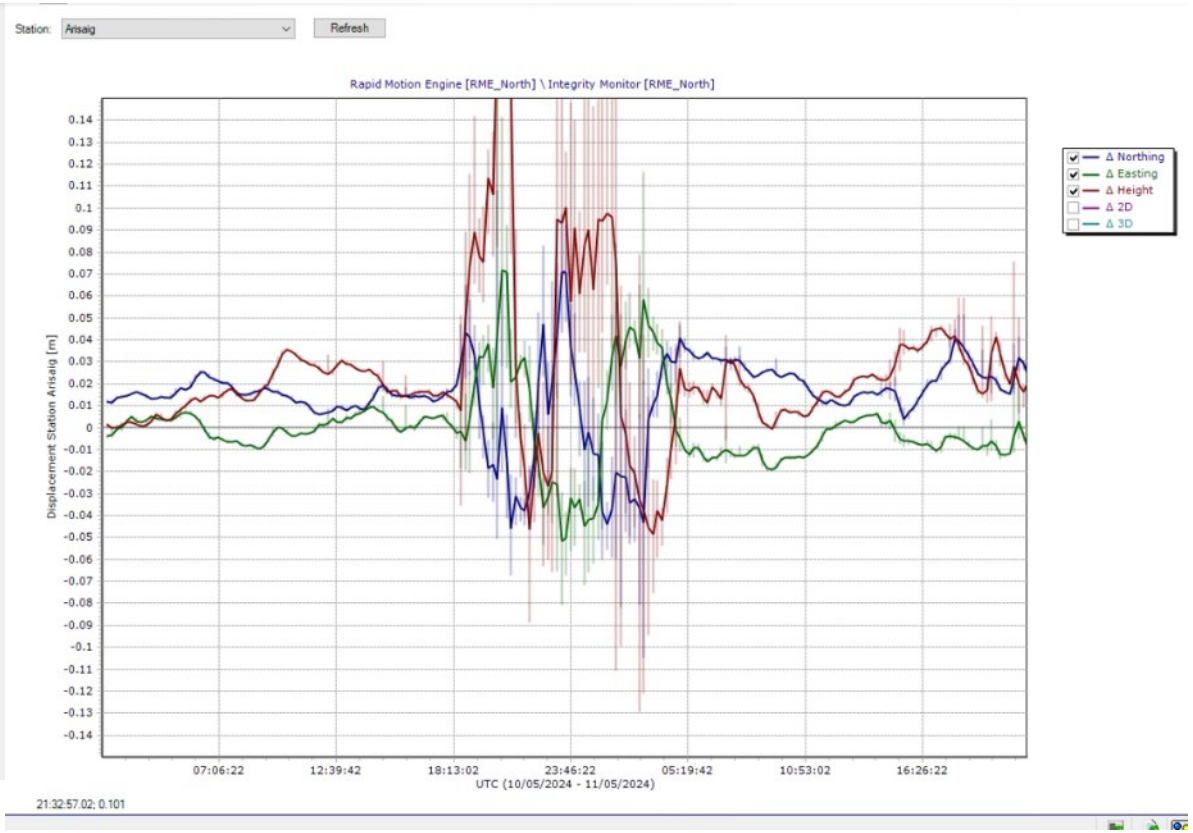
Met Office

Severe Space Weather
Informal Briefing Note

Current Solar Synoptic Map – 09/05/24 22:00



(C) Crown Copyright 2024. All Rights Reserved.

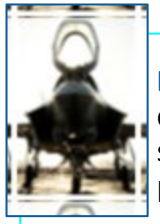


Department for Science, Innovation & Technology

UK PNT – Cross-Government Use Cases

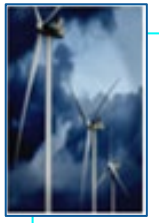
Chemicals – transportation, interoperability of IT systems.

Civil Nuclear – tracking staff, movement of nuclear fuel, IT systems.



Defence – navigation, communications, precision weapons, surveillance, sensors / radars, and personnel location.

Emergency Services – radio and fixed communications, monitoring, search, vehicles, and incident management.



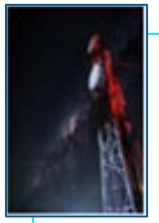
Energy – manage the flow of electricity, time stamp sales, control systems, and oil and gas exploration.

Finance – card payments, mobile banking, high frequency digital trading, geo-fencing for security.

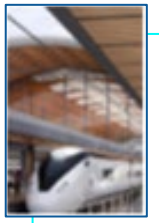
Food – precision farming, automated/autonomous operations, fishing, geofencing, and logistics

Health – ambulances, IT network time protocols, geo-blocking.

Space – satellite launch, recovery, operations & control, time, communications, orbit. Geo-location for observation.



Telecommunications – synchronisation for mobile network and core network, location function for 999 service.



Transport – air traffic control, rail signalling, maritime search and rescue, cargo handling, modern logistics, driver systems.

Water – operational telemetry, time stamping, automated activities, remote monitoring, servers, navigation and tracking.

Department for Science, Innovation & Technology

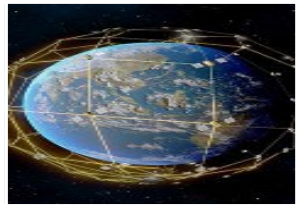
Prime Conclusion: Timing is of Critical Importance for most PNT use cases, losing PNT has a significant impact, there are relatively inexpensive terrestrial back-up technologies, and an economic opportunity

For CNI, accurate Timing is the main critical use case, rather than Position or Navigation. Losing Timing would have a significant impact for CNI. Losing Position and Navigation is less significant.

A GNSS augmentation system can enable access to high integrity services such as aviation and autonomous systems. SBAS/EGNOS (DFMC) do increase resilience by providing integrity indicators and by augmenting two constellations (GALILEO and GPS)

There is no alternative PNT system that could be deployed if the UK lost access to PNT provided by GNSS or an emergency back-up system.

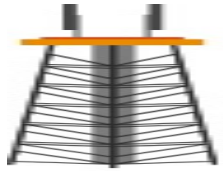
Deploying a satellite system, particularly a Low Earth Orbit system, could potentially increase resilience. However, satellites would be expensive and not fully resilient. All LEO options included a GNSS reliance.



PNT resilience could be significantly improved relatively cheaply through secure and resilient terrestrial national timing infrastructure.

Increasing use of PNT and providing more accurate PNT, is an economic opportunity to improve productivity and drive economic growth.

For CNI that need Position and Navigation, terrestrial eLORAN systems can provide a relatively low-cost resilient backup to GNSS.



For long term PNT resilience it is crucial that we develop our sovereign capabilities, including manufacturing and high-level skills, in key technologies like atomic clocks, fusion receivers and assured components.

Department for Science, Innovation & Technology

Fundamental Guidelines for UK PNT

1. All risk for the lost of PNT to be brigaded under a **single government department** – now held by the Department for Science, Innovation and Technology (DSIT)
2. A single **National PNT Office** will be created to develop and coordinate all PNT technologies and systems, to be **based in DSIT**
3. A **systems of systems approach** is essential to address the multi-domain risks to PNT
4. GNSS services will remain central to UK PNT capabilities – but use of these systems must be assured and a **terrestrial alternative is required**
5. Any new PNT capability must **eliminate GNSS dependence** to the maximum extent
6. Sovereign UTC – **traceable time to be used as the backbone of UK PNT** Services – space or terrestrial
7. Capabilities must be delivered to **international standards** with a clear pathway to certification for safety of life services
8. Assume **GNSS will not exist for a minimum of 30 days**

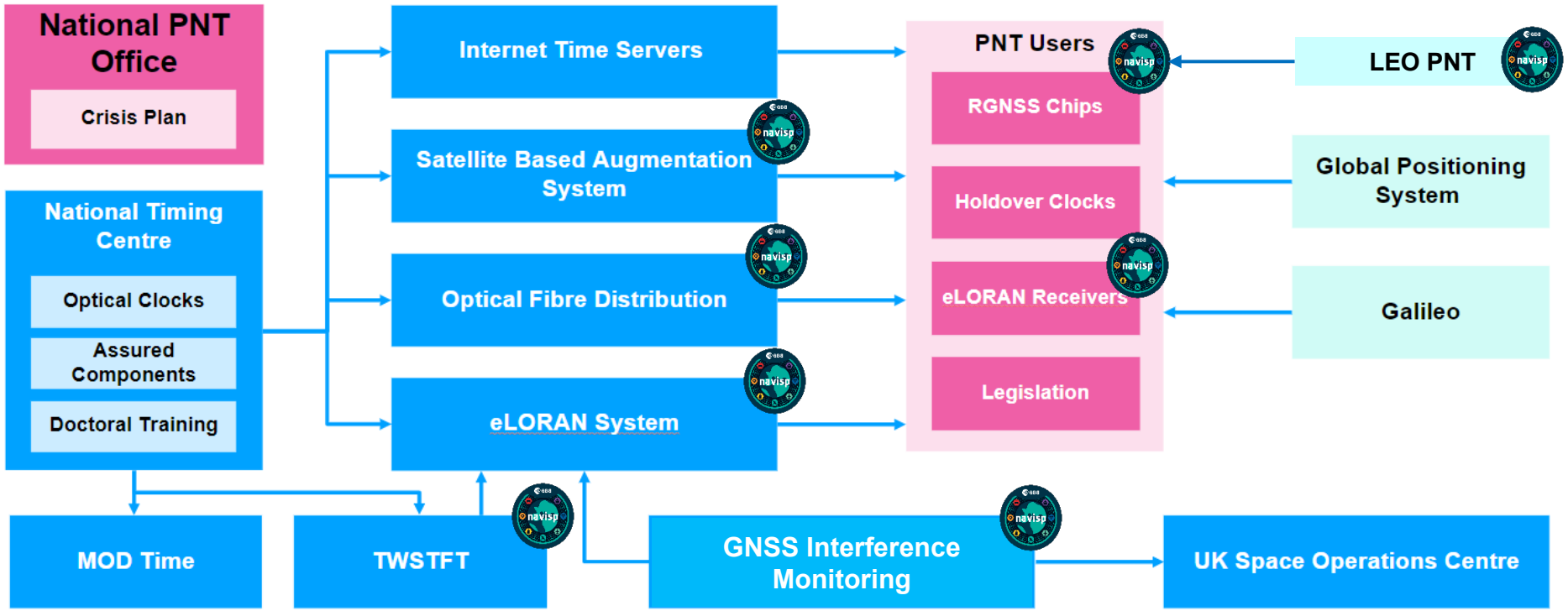
Department for Science, Innovation & Technology

Example Eliminated Options

- Any additional GNSS-service
- LEO PNT due to dependence on GNSS for ephemeris, timing and pathway to certification
- Quantum PNT capabilities
- L-band signals from space
- 5G/6G PNT***
- Heliostats
- Signals of Opportunity***
- Line of sight terrestrial signals
- ITAR restricted technologies or components

NATIONAL SYSTEM OF SYSTEMS and TECHNOLOGIES

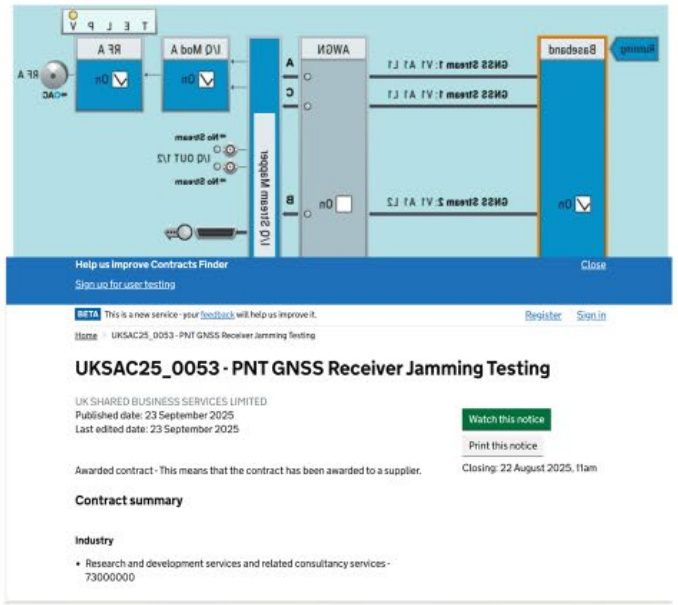
Department for Science, Innovation & Technology



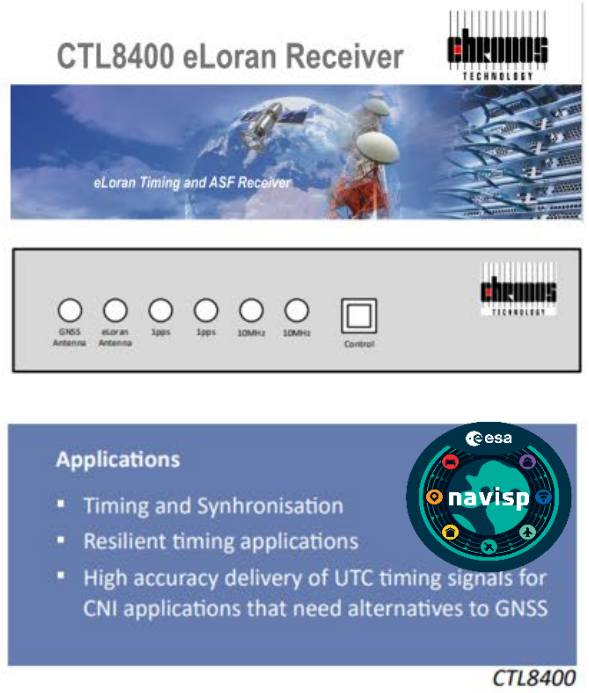
European Space Agency Navigation Innovation Support Programme (NAVISP) for New Technology Development

UK Technical GNSS and eLORAN Initiatives

Department for Science, Innovation & Technology



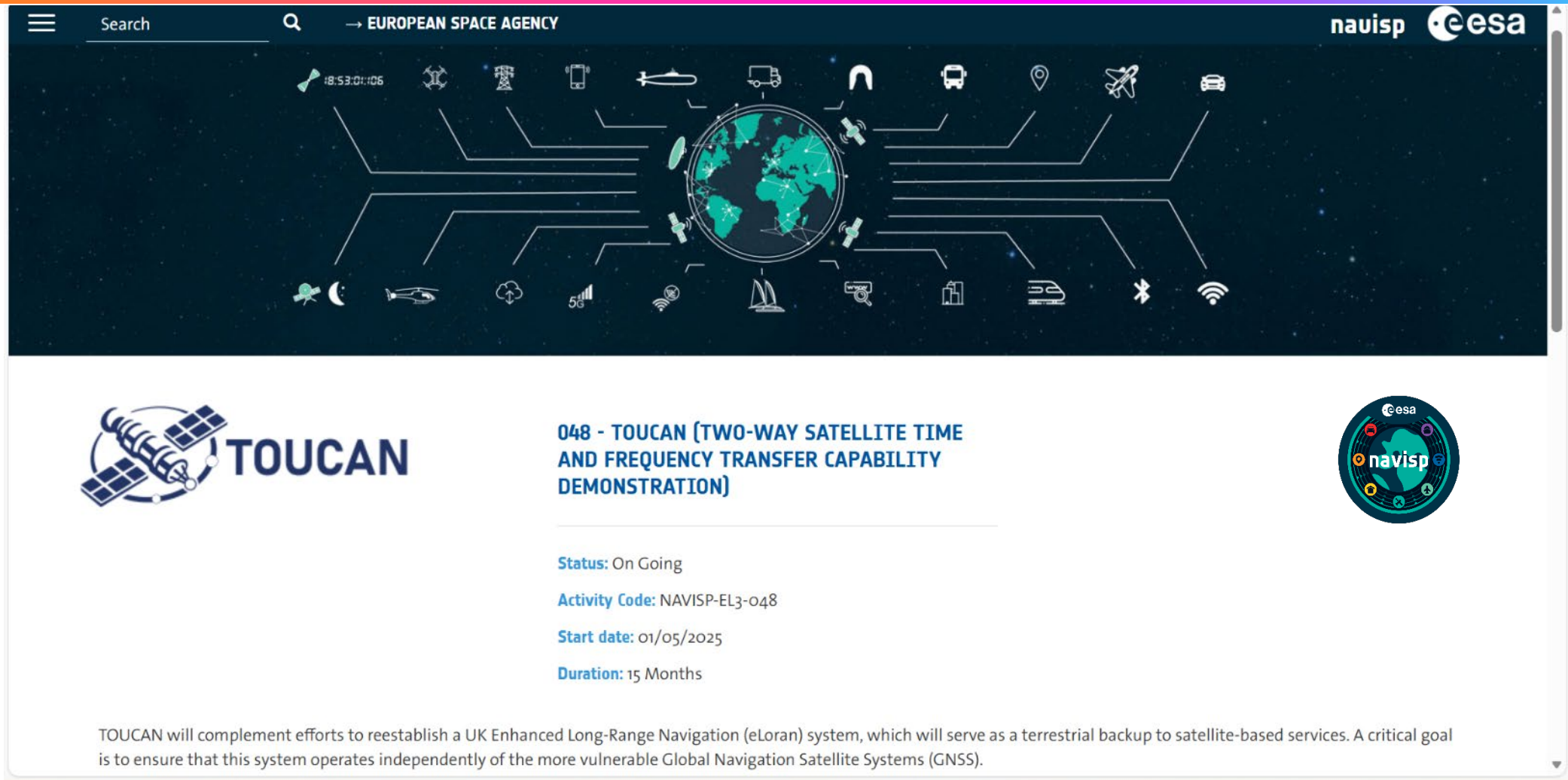
Multi-GNSS Receiver Testing for Loss of GPS and Direct to Galileo Testing – PA Consulting



Miniaturisation of eLoran antenna and receiver + high-performance eLoran timing receiver commissioned to be produced by Chronos Technology

TOUCAN – NAVISP TWSTFT for eLORAN

Department for Science, Innovation & Technology



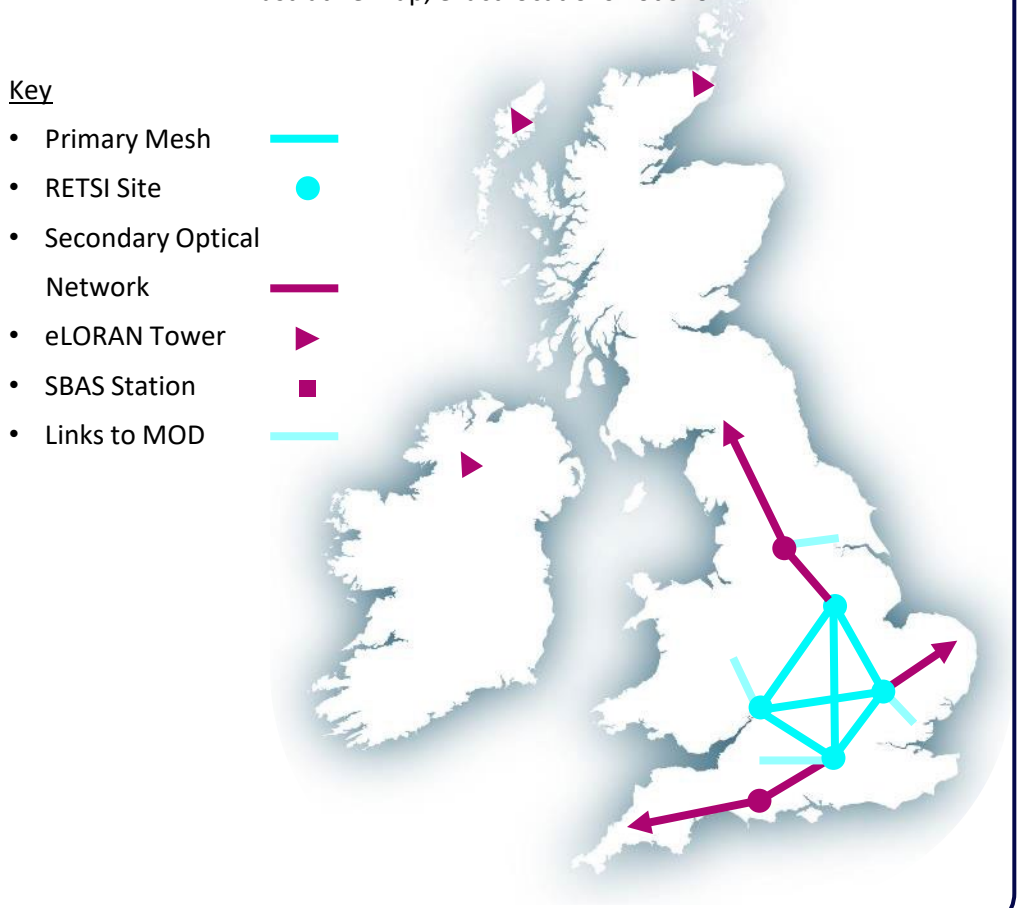
TIMING DISTRIBUTION

Department for Science, Innovation & Technology

- The Policy Framework commits to developing separate business case proposals for an **Enhanced Long-Range Navigation (eLORAN)** system and a **Space Based Augmentation System (SBAS)** and working with MOD on **Defence Resilient Time (DRT)**.
- A Secondary Fibre Optic Cables Network would provide the Timing Signal from the RETSI sites to the eLORAN towers, Goonhilly Station for SBAS, and locations for DRT.
- The Secondary Fibre Optic Cables Network would consist of 11 Service Nodes, including: 4 at RETSI sites, 3 at eLORAN towers, 2 intermediate nodes, 1 MOD private node and 1 at an SBAS station.

Map of the Primary Mesh and Secondary Fibre Optic Cables Network

Illustrative map, exact locations not shown.

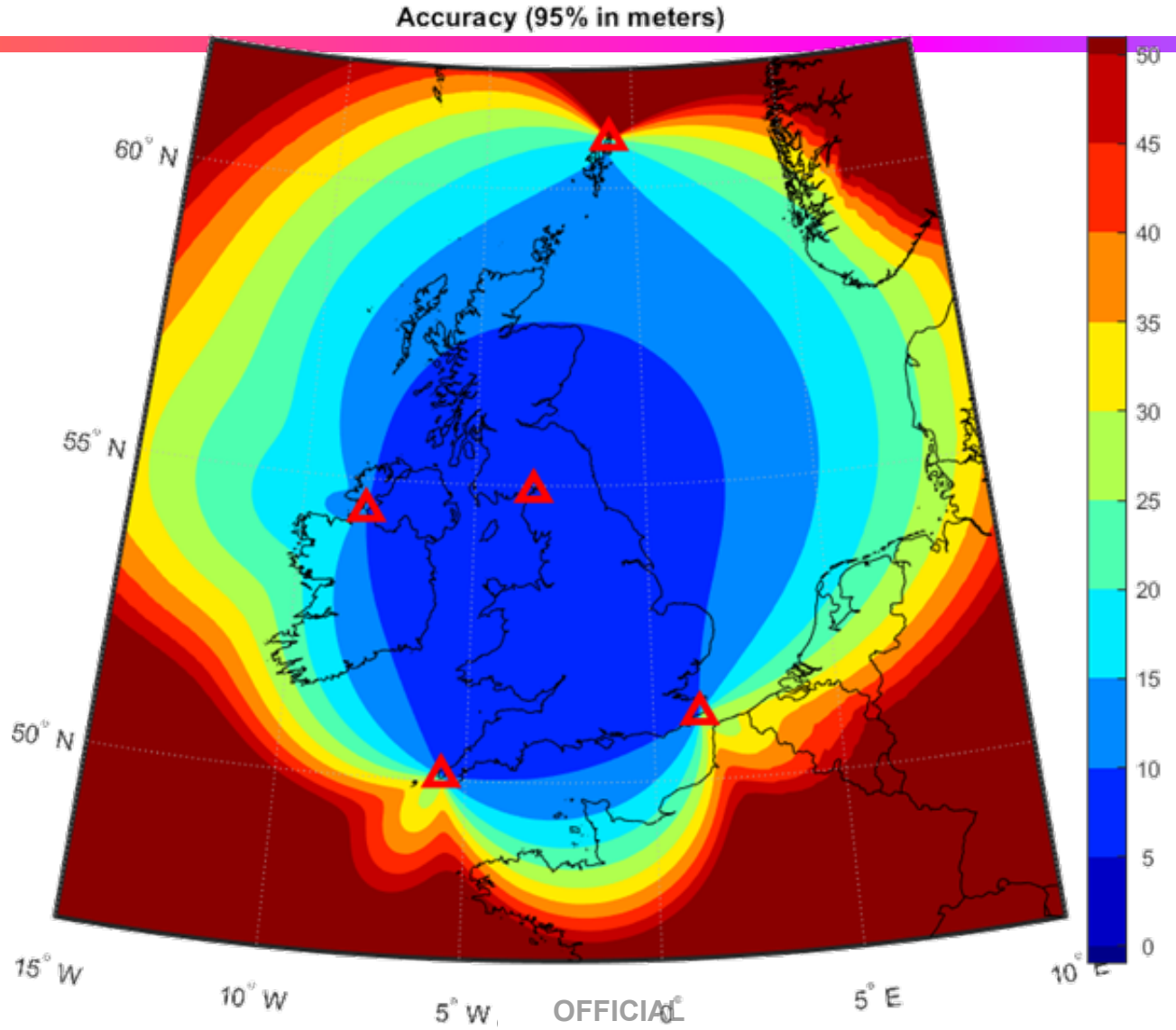


UK National eLORAN for Full PNT Services

Department for Science, Innovation & Technology

UK CHAIN ODYSSEY

Initial Positioning Coverage

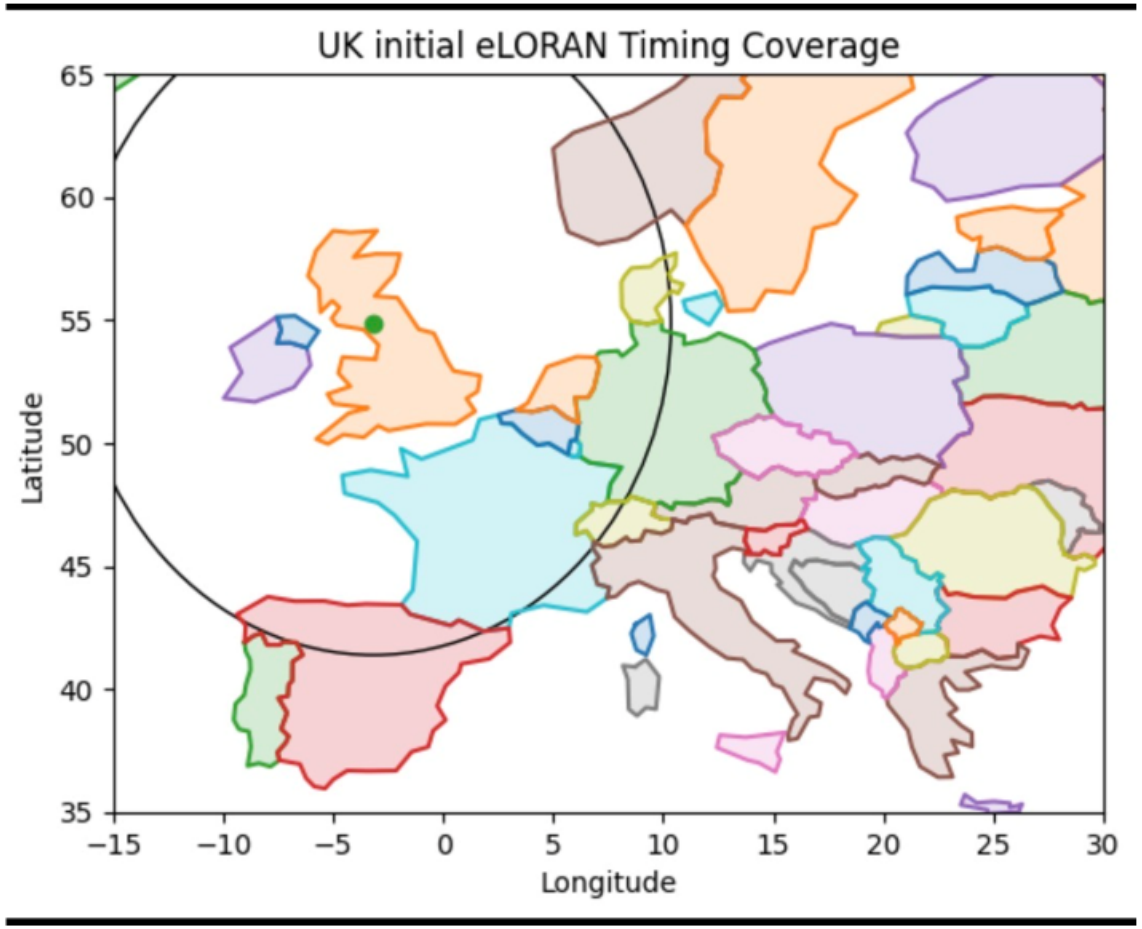


UK National eLORAN for Timing Services

Department for Science, Innovation & Technology

UK eLORAN Chain Coverage – Timing

- IOC Jan 2027
- 20 nanosecond target
- Available underwater and up to 85 metres underground
- UTC (NPL) primary timescale
- UTC (OP) as secondary
- MOD Timescale of last resort

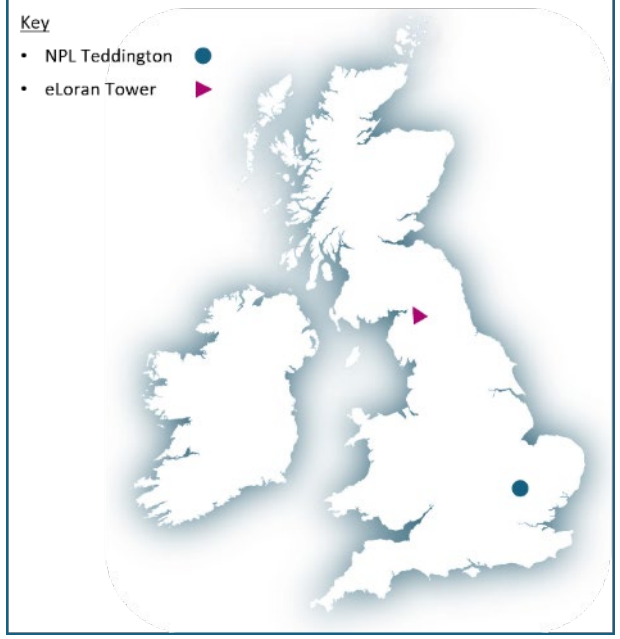


UK NATIONAL eLORAN DEVELOPMENTAL STAGES

Department for Science, Innovation & Technology

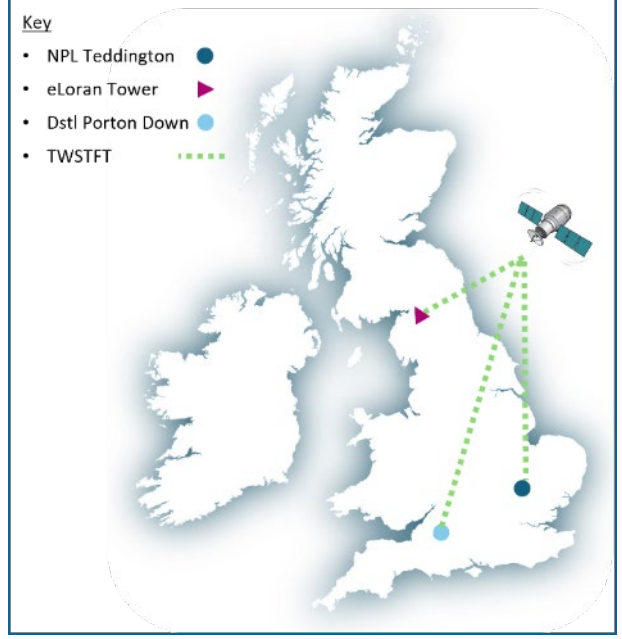
Map of current NTC and eLoran infrastructure

Illustrative map, exact locations not shown.



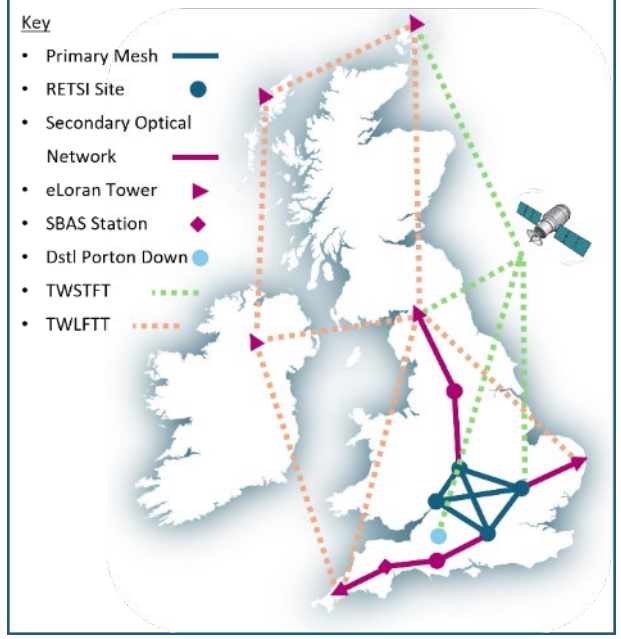
Map of eLoran and TWSTFT initial operating capability

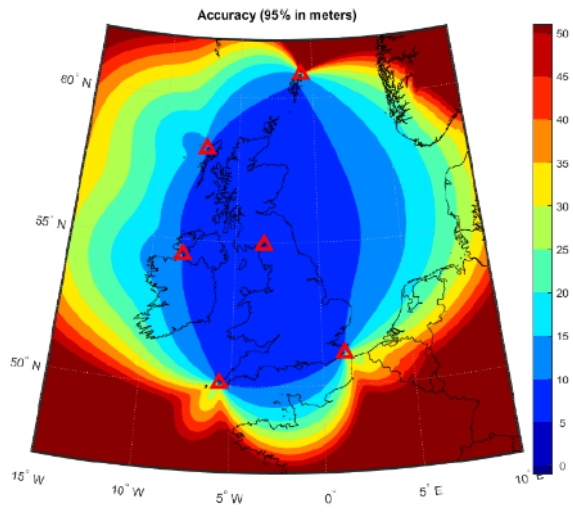
Illustrative map, exact locations not shown.



Map of eLoran full operating capability and links to NTC

Illustrative map, exact locations not shown.



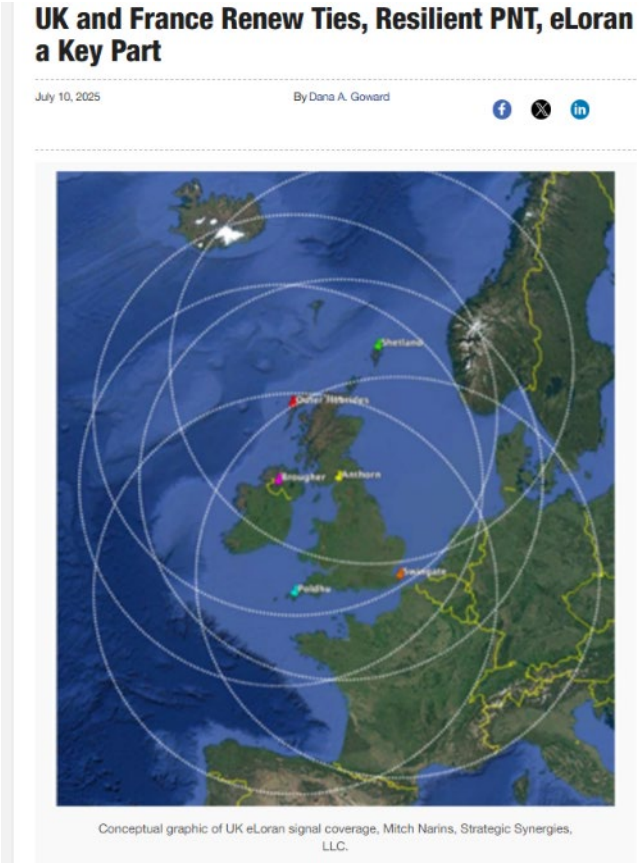


GRAD

esa

BEGINNING OF EUROPEAN ELORAN ALLIANCE

Department for Science, Innovation & Technology



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

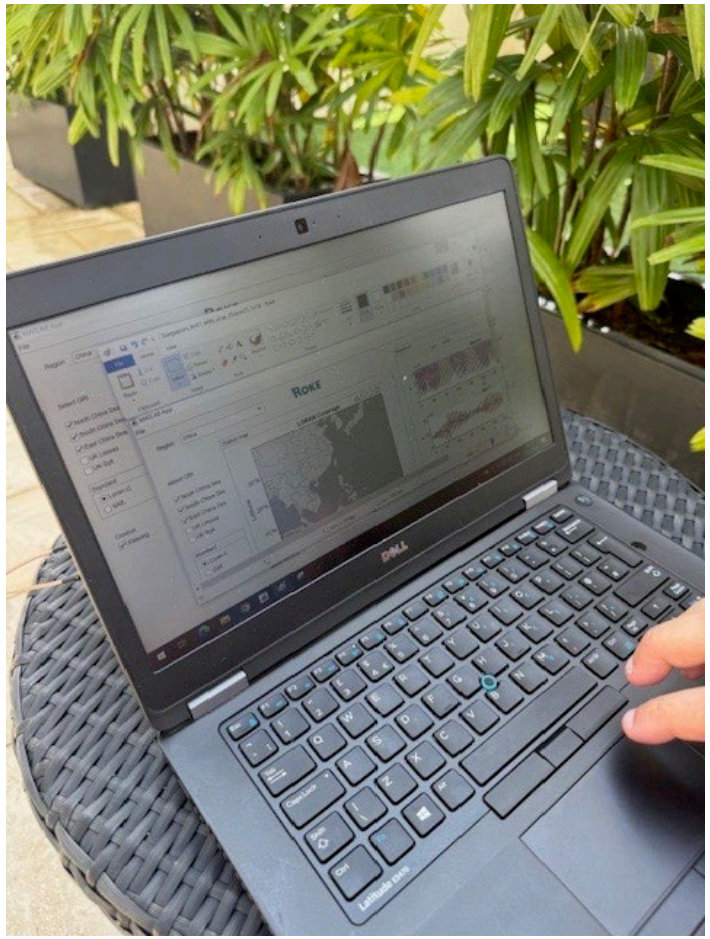
July 10, 2025 By Dana A. Goward

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

CONSIDERATIONS FOR ELORAN PARTNERING

Department for Science, Innovation & Technology

- National systems would remain sovereign assets
- Participants would work to maximise compatibility and interoperability
- Align to EUROFIX standards should be starting point
- Maximise eLoran uptake in CNI and commercial areas
- Full international network should be able to self-synchronise of either of France or UK's UTC standards (UTC-OP/UTC-NPL)
- Ensure a precision-aligned UTC timing synchronisation
- Work to further develop wider European uptake
- Share technology/research advances – ESA as a prime partnering opportunity
- Partner with global eLoran operators to enhance the signal standard definition and GRI assignment priorities – IALA and ITU pathway.

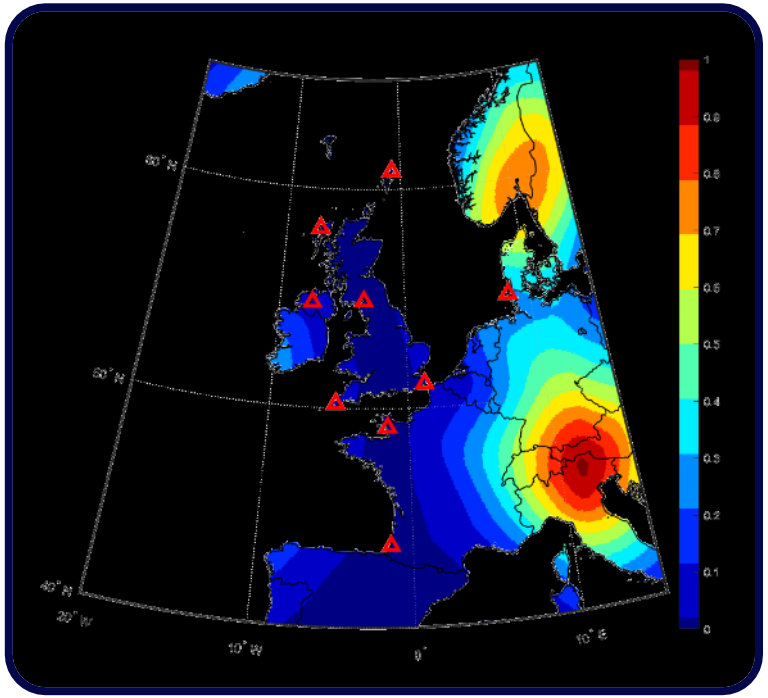


esa

International eLORAN Engagement for PNT Resilience

Department for Science, Innovation & Technology

- European Space Agency as host sponsor for next stage of international eLoran developments – France/ROK/UK Chairs
- Multiple Nations and International Bodies with interest in eLoran:
  - NATO
  - European Commission
  - Australia / New Zealand / Canada
  - 11 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



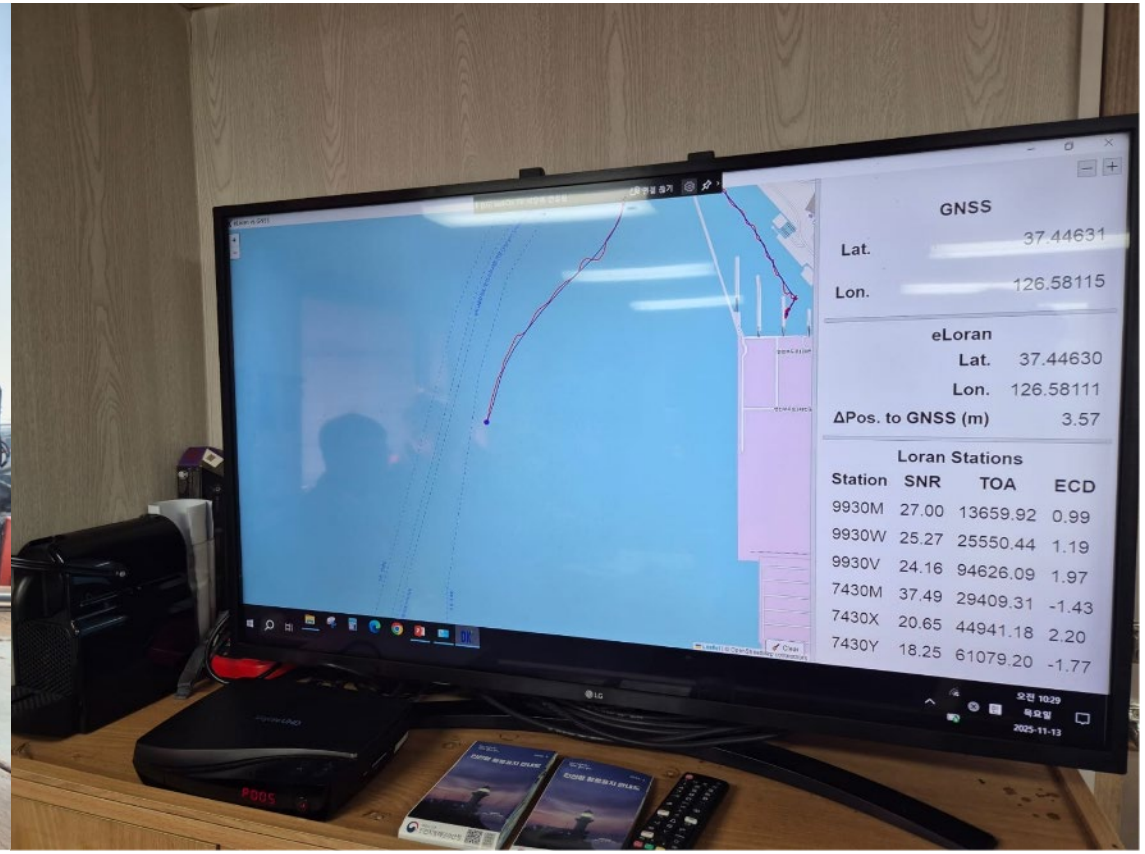
International eLORAN Conference - Mar 2026

Department for Science, Innovation & Technology

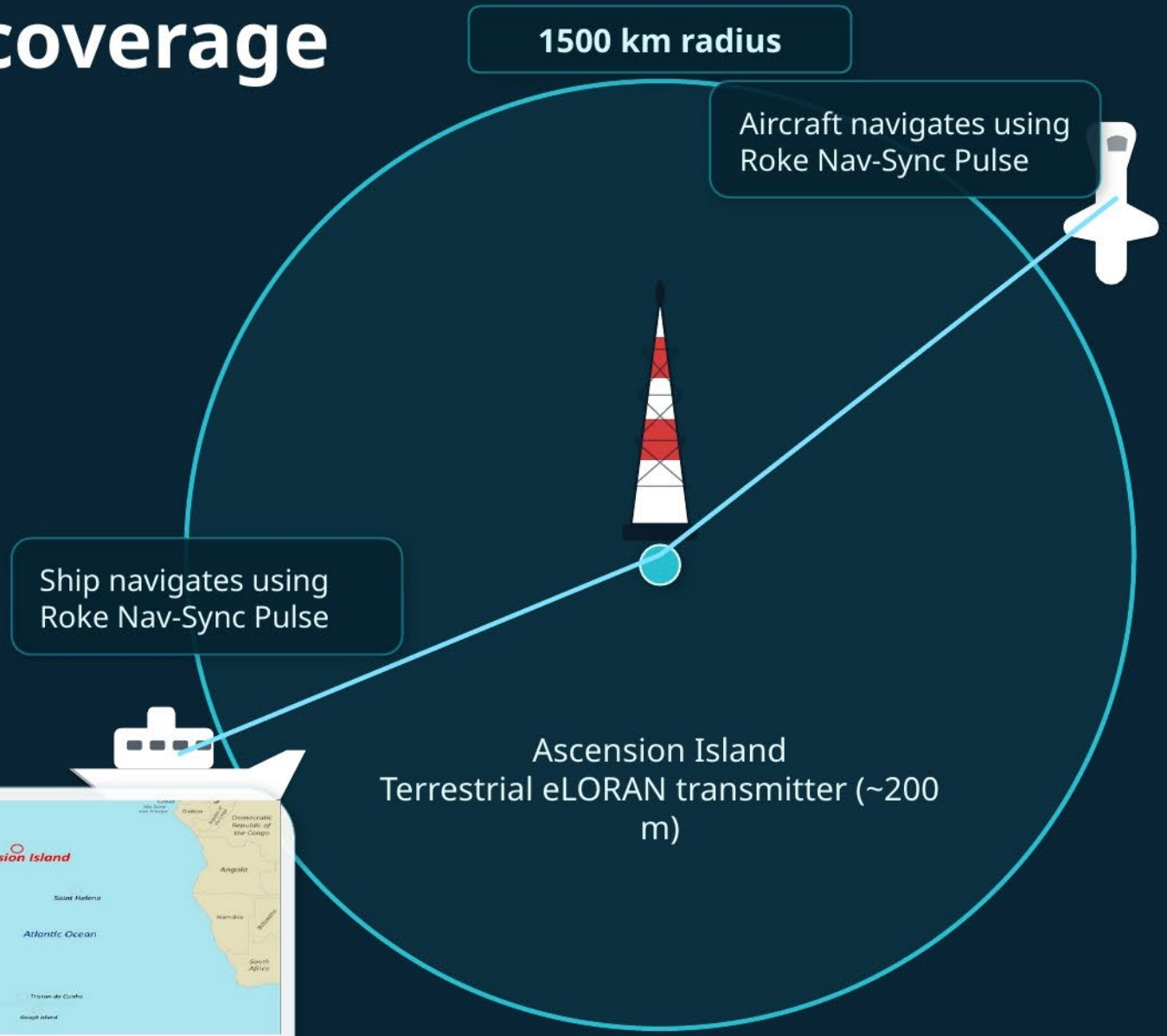
14 Nations, 4 Continents, EU, IALA, ESA and IMO

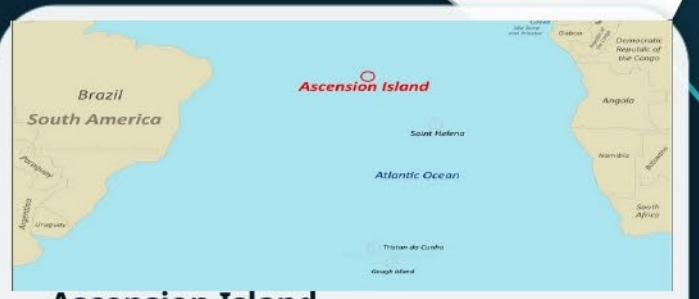
ELORAN – HOW GOOD IS IT?

Department for Science, Innovation & Technology



Single terrestrial eLORAN transmitter — Ascension Island coverage





Ascension Island (Central Atlantic)

Concept schematic (not to scale).

Roke Manor Research Nav-Sync Pulse receiver + antenna

Used on vessels and aircraft to geolocate from eLORAN pulses.

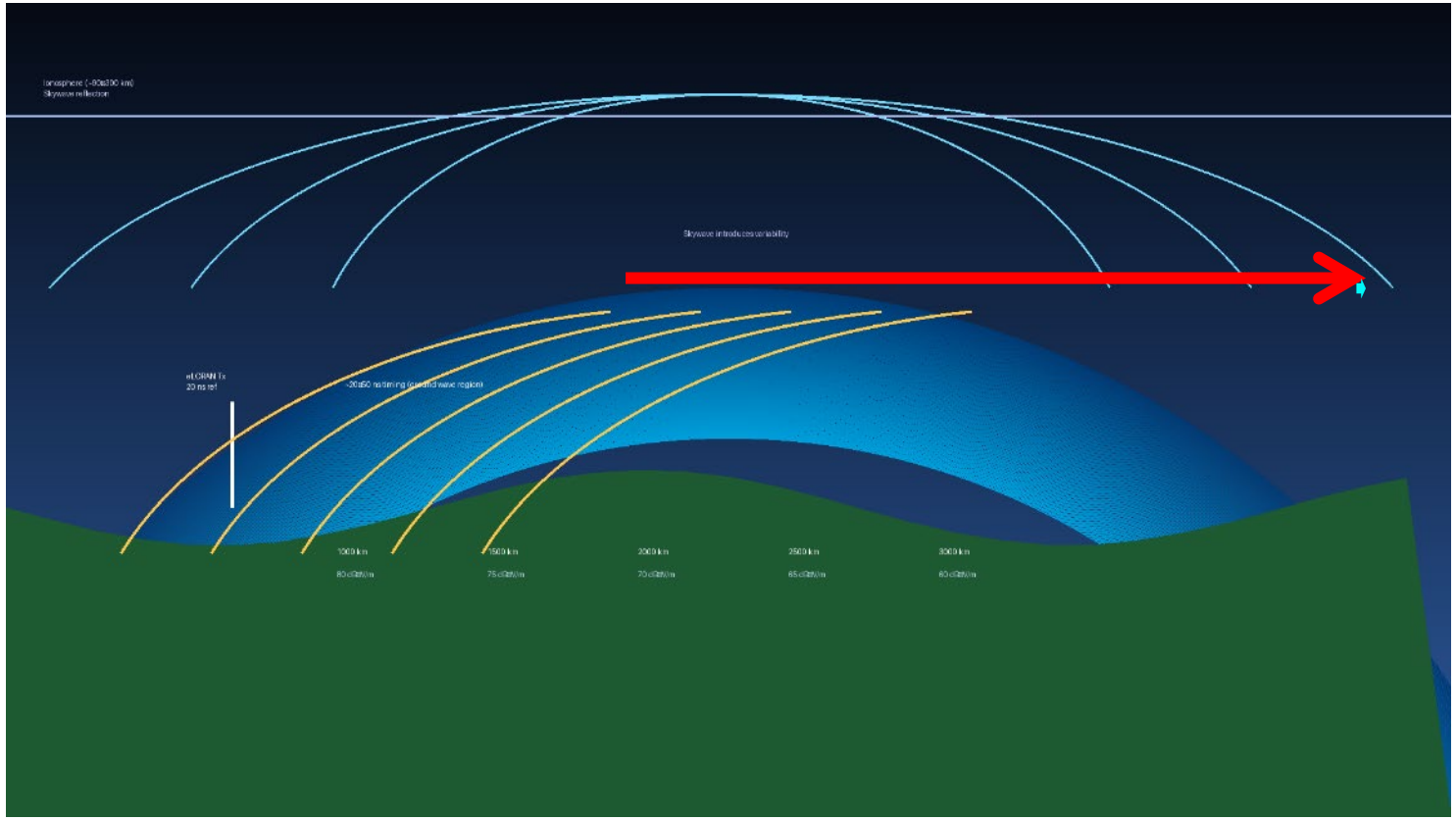
University of Cambridge Mathematics Commission: Correcting models and extending eLORAN ranges

Department for Science, Innovation & Technology

UK NPNTO commissioned University of Cambridge Mathematics Department to re-examine traditional eLORAN propagation and resolution models

Outcomes identified:

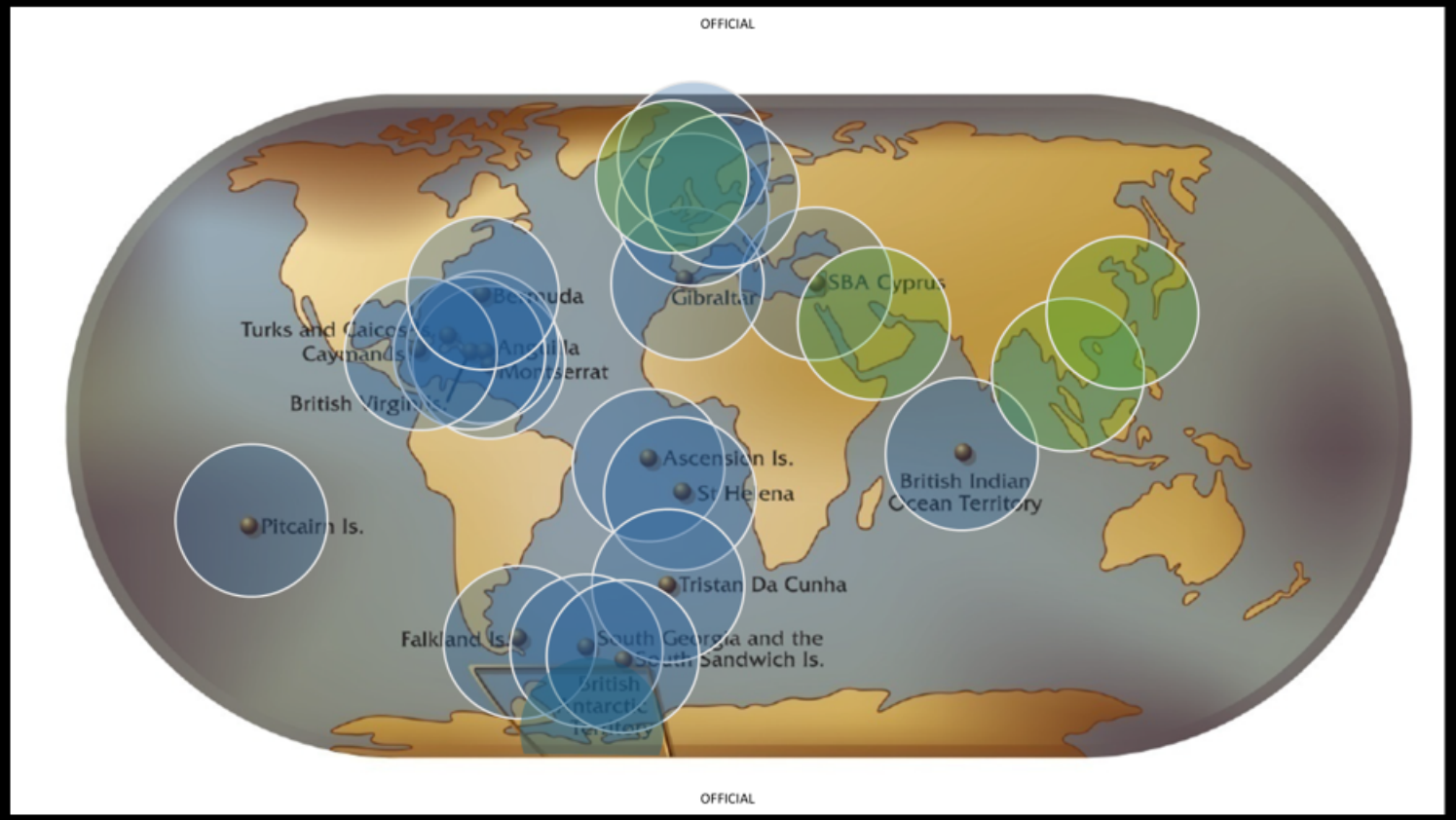
- Discrepancies in mathematical and engineering models
- Pathway to a common model for Groundwave and Skywave
- Potential to extend groundwave beyond 1500km
- Potential to use Skywave as primary PNT solution
- Next step – apply to engineering



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: **15 Nations, 4 Continents and international agencies partnering to develop eLORAN and standards for safety of life and timing applications**

URGENT COMPASS

(Tactical eLoran)

MOD TIME

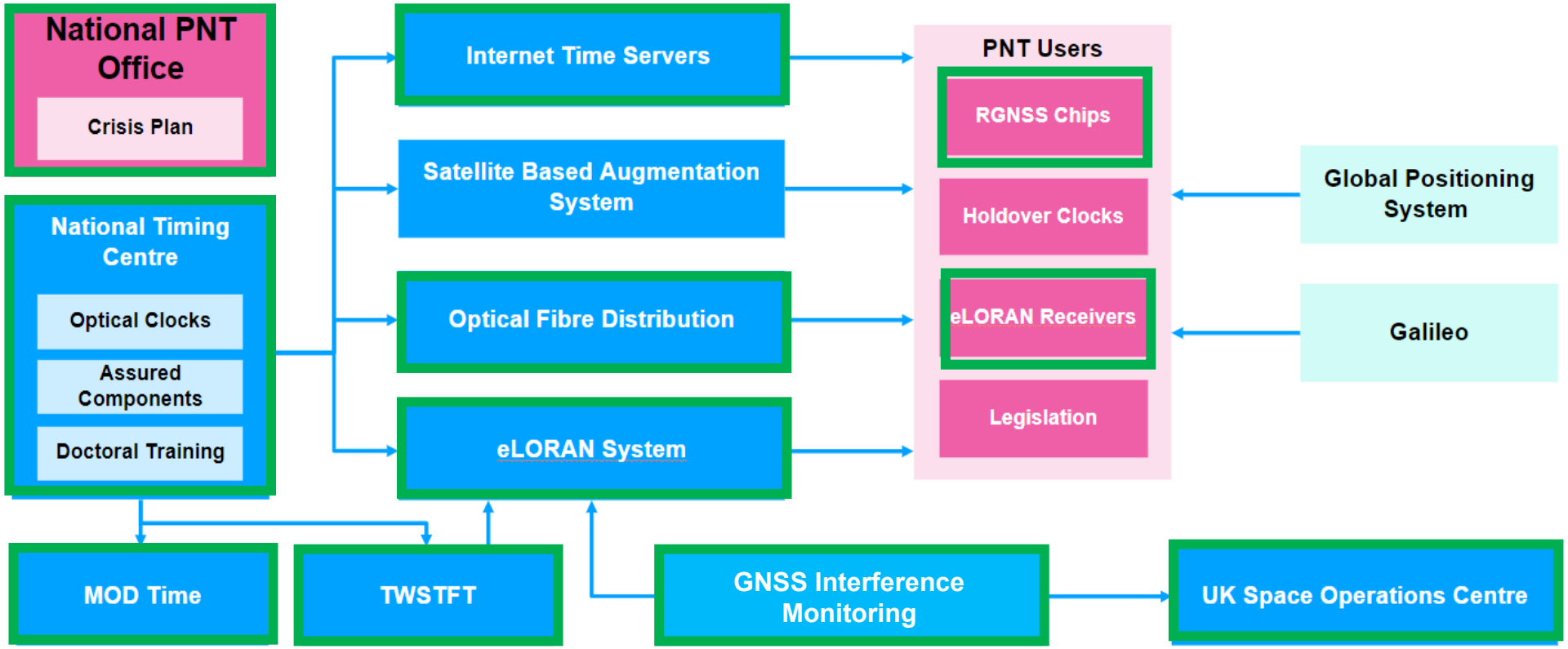
Ministry of Defence

Department for Science, Innovation & Technology

- Defence has a breadth of use cases and performance requirements similar to that of a modern CNI 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

Delivery Progress:

Department for Science, Innovation & Technology

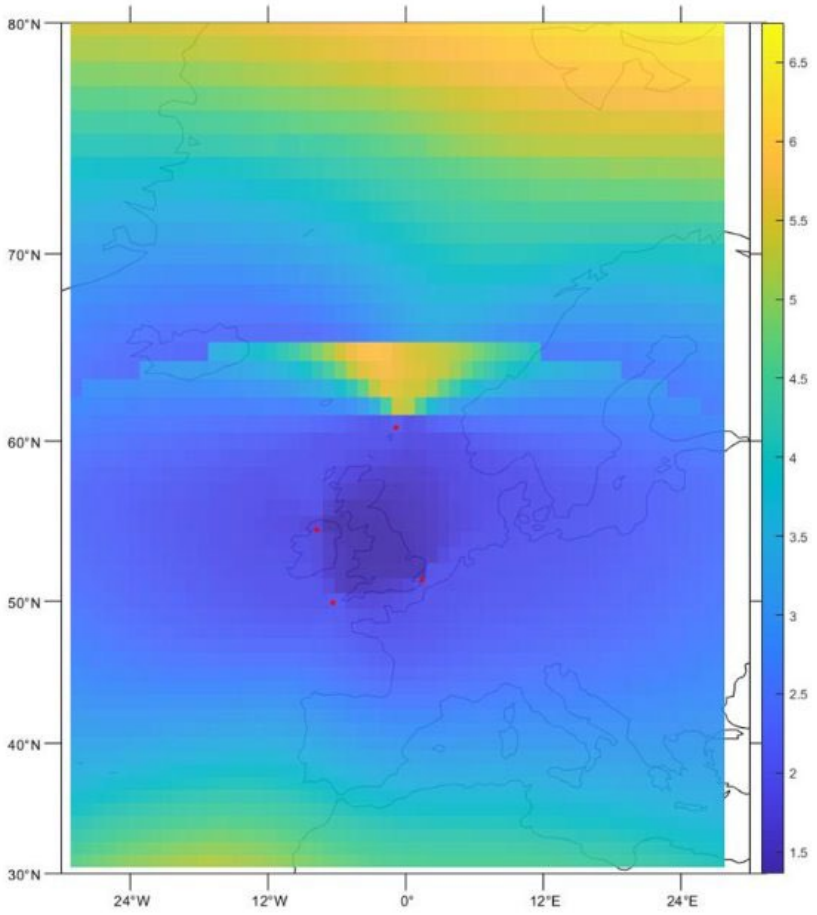


100% of funding approved by UK Treasury for National PNT initiatives – £450m+ for 2025-2030 delivery

Example Additional PNT Developmental Projects

Department for Science, Innovation & Technology

- Hybrid Space and Terrestrial PNT System Research and Trial Funded
  - Utilise eLORAN and sparse LEO or highly-elliptical (QZSS/KPS-esque)
  - Initial testing of concept in July 2026
- Space-Based Time Transfer Service (Space BaTTS) Research Funded
  - Global coverage using either GEO or GNSS-independent LEO
  - UTC (NPL) as primary system timescale
- Quantum programmes for PNT and computing Ongoing UK Funding
- Independent testing of GNSS Receivers used in CNI Funded-Underway
- PNT Wargame – Defence Science and Technology-led assessment of loss of PNT on UK Critical Infrastructure Funded and Execution April 2026
- Digital Twin of UK PNT System of Systems Funded and in Phase 2



Department for Science, Innovation & Technology

QUESTIONS

NPNTO@dsit.gov.uk

Mark.Brammer@dsit.gov.uk
Matt.Butchers@dsit.gov.uk
Elena.Payne2@dsit.gov.uk