

UK Sat+

Sovereign, Bullet-proof Critical Infrastructure for a Stronger United Kingdom

Background

Two recent ground-breaking reports have revealed the high cost and severe impact that a disruption of satellite-based Positioning, Navigation, and Timing (PNT) services would inflict on the UKⁱ, plus the surprising degree to which many facets of day-to-day life in Britain depend upon PNT from space.ⁱⁱ The “Blackett” review of GNSS Dependencies also detailed many of the vulnerabilities of these exceptionally-weak signals, specifying the threats that endanger them.

At the same time, Britain’s exit from the European Union has provided an opportunity for the UK to develop its own global navigation satellite system (for brevity we’ll call it “UK Sat+”) as a way of ensuring the UK has sovereign PNT and need not rely upon Europe’s Galileo or America’s GPS satnav systems.

Discussion

As a new start, UK Sat+ can build on all the advances made by other Global Navigation Satellite Systems (GNSS). Almost fifty years of lessons learned in development, deployment, and operation of such systems will allow the incorporation into UK Sat+ of advanced features, such as stronger signals and integration with complementary terrestrial systems, that may not be available in other constellations for decades.

The two reports mentioned above list significant shortfalls to current GNSS (including Galileo) that should be addressed in a new-start UK Sat+. These include the lack of authentication, susceptibility to deceptive signals (spoofing), and exceptionally-weak signals that are easily disrupted through denial-of-service attacks (jamming) or other interference.

Studies in the UK, the USⁱⁱⁱ and elsewhere have concluded that a strong, terrestrial signal with phenomenology quite different from that of GNSS but able to complement it must be a part of a holistic approach to ensuring the viability of satellite-based PNT. The combination of two such very different PNT sources, one from Earth and the other from space, is nearly impossible to disrupt.

The technology selected by the US studies, and recommended by the US National PNT Advisory Board, is eLoran.^{iv} Its high-power, low-frequency signal is exceptionally difficult to disrupt, penetrates indoors, underground and under water, and is sufficiently precise to meet all but the most highly-specialised navigation and timing requirements.^v

The United Kingdom has long been a leader in eLoran technology. In 2015 the world’s first eLoran network was established off the east coast of Britain and certified for use by shipping^{vi}. It re-used legacy “Loran-C” stations in Denmark, France, Norway, and Germany. Unfortunately, those countries chose to discontinue their cooperation at the end of that year, preferring instead to put all their eggs in the Galileo basket. The UK eLoran transmitter at Anthorn is still in operation. It is being used for PNT research. This and some other uses could continue when it is incorporated into an eLoran navigation and precise timing network.

Several international efforts focused on eLoran technology are underway. South Korea has recently let a contract for an eLoran test bed, a first step in upgrading their legacy Loran-C system. There are indications that Russia and China, which retained their Loran-C stations (known as Chayka in Russia) may also be looking to upgrade to eLoran.

In the United States an eLoran technical research effort has been underway since 2012, and a National Security Council sub-group is examining the way forward for resilient PNT. In 2018 the US funded a \$10M technology demonstration for GPS backup technology. And quite recently the US Congress passed the National Timing Security and Resilience Act which mandates establishment of a wireless, high power, difficult to disrupt terrestrial timing system that is compatible with other similar national systems as a backup for GPS timing.^{vii}

Even the European Commission has finally admitted the vulnerability of GNSS, announcing that GNSS signals alone are insufficient for safety-of-life and critical applications and hosting a workshop in Brussels to consider back-up systems.

The Way Forward

UK Sat+ will greatly benefit the UK's technology sector, building on its strengths in both terrestrial and satellite PNT. It would be much more than an "us too" copy of other satnav systems, replicating their serious shortcomings.

UK Sat+ will focus on protecting the nation and its citizens from the PNT hazards that are endangering critical infrastructure and the national economy. By making users impervious to almost all disruptions, the project will be the world's first comprehensive approach to sovereign PNT resilience.

We suggest a two phased approach for UK Sat+ with work to proceed on both in parallel:

1. **UK Sat+ Global Navigation Satellite System.** Development should begin immediately for a constellation of 24 or more satellites. A prompt start is essential as the project will likely take ten years and delays can be expected. Synergies with GPS, and perhaps Galileo, should be designed in, while at the same time ensuring UK Sat+ is able to operate independently.
2. **A UK eLoran network, independent of other European nations.** As a technological leader in this field, the UK could complete this in as little as 12 months. Using existing radio-station infrastructure could make the price tag less than £50M. Many users would be able to start incorporating the new signals into their navigation and precise timing enterprises during that period. eLoran receiver technology is mature, and methods of merging eLoran with GNSS signals without modifying existing receivers are widely-known and readily available. The UK could become the leader in integrated receivers that use GNSS and eLoran for bullet-proof PNT.

Deployable, tactical eLoran is also market-ready and should be evaluated for use by British forces.

The UK already has the expertise and capability to develop the world's first integrated, nearly unstoppable, satellite-terrestrial PNT system. Benefits to leveraging the UK's eLoran expertise and leadership in early in the process include:

- Filling a capability gap exposed by the Blakett review of GNSS dependencies
- Protection of UK infrastructure in 2019 with eLoran for <1% of the overall cost of the GNSS portion of the system, which will take ten years or so to implement
- Maintenance and creation of STEM jobs and skills
- Export opportunities for UK companies

Developing and deploying a satnav system is a long process, often fraught with delays and budget increases. This approach offers inexpensive and early success. The eLoran portion of this effort is mature technology deployed on Earth in the UK. Its costs are well known and designed-in from the start, and it will be a small increment of the overall project. Most importantly, it will begin protecting British interests very quickly and will ensure the UK Sat+ programme steps off on the right foot.

About the Authors:

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Mr. Dana A. Goward – retired from the federal Senior Executive Service as the maritime navigation authority for the United States. In that capacity he represented the nation at a variety of international bodies, was a founding member of the US Maritime Domain Awareness program, and served on several White House Task Forces. He is the President of the Resilient Navigation and Timing Foundation, a member of the US National Space-based PNT Advisory Board, and a Senior Advisor to US Strategic Command's Purposeful Interference Response Team.

About the Resilient Navigation and Timing Foundation

The RNT Foundation is a scientific and education charity chartered in Virginia. It supports policies and systems to protect, toughen and augment GNSS signals as component of critical infrastructure security. Its efforts are mostly focused in the United States, though it has members and supporters across the globe. See www.RNTFND.org

ⁱ <https://www.gov.uk/government/publications/the-economic-impact-on-the-uk-of-a-disruption-to-gnss>

ⁱⁱ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/676675/satellite-derived-time-and-position-blackett-review.pdf

ⁱⁱⁱ Institute for Defense Analysis “Independent Assessment Team (IAT) Summary of Initial Findings on eLoran” 2009, also “DOD-DHS-DOT Tiger Team Report to PNT Excom” 2014 (available on request from US State Dept), other reports available.

^{iv} <https://www.gps.gov/governance/advisory/meetings/2014-12/parkinson.pdf#page=2>

^v <https://rntfnd.org/wp-content/uploads/2015-ION-ITM-Offermans-eLoran-IOC-in-UK-final-4Feb.pdf>

^{vi} <http://iainav.org/News/nws0558-uk-elorán-operational.pdf>

^{vii} <https://rntfnd.org/2018/11/28/national-timing-security-and-resilience-act-sent-to-president/>

Positioning, Navigation, & Timing (PNT)

Multi-Level Resiliency Model

