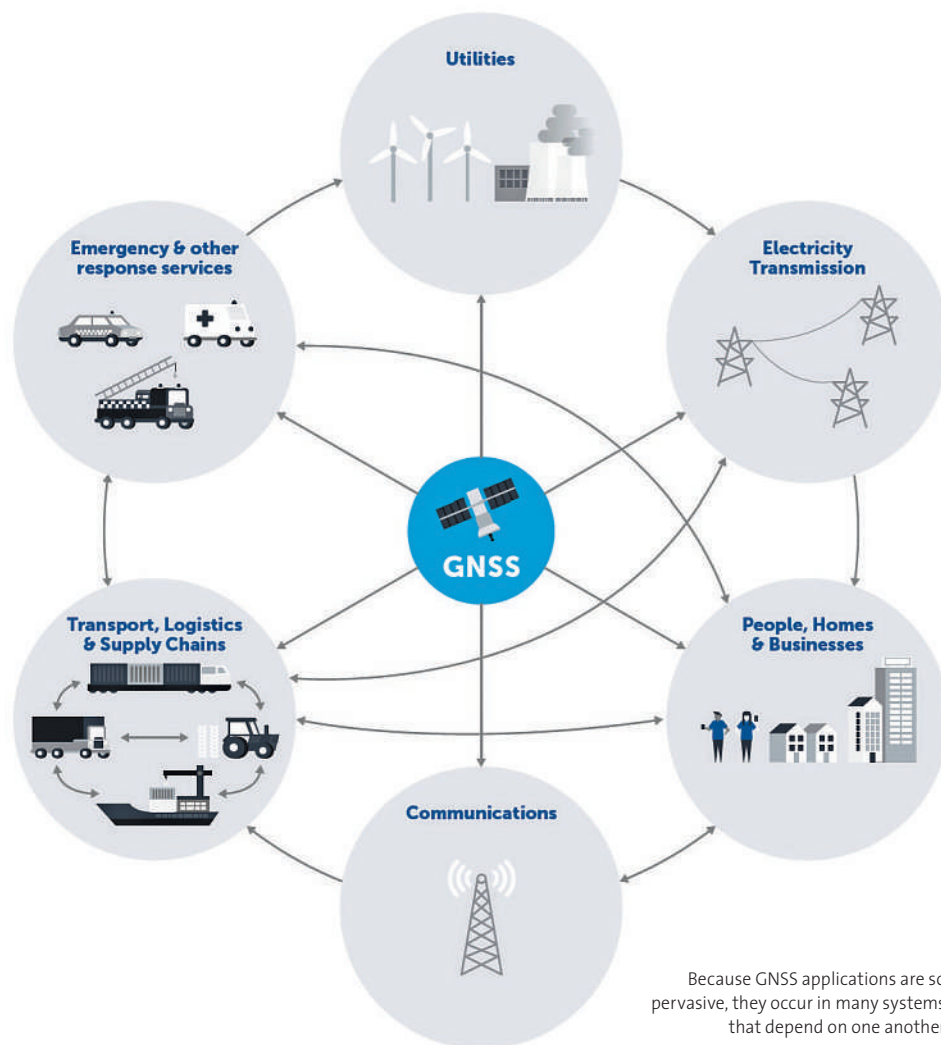


- awareness of GNSS is out of step with dependence,
- knowledge of vulnerabilities and weakness of GNSS is not widespread enough,
- resilience improvement is needed across all critical services (such as Critical National Infrastructure) including philosophy of approach. There is no magic single solution,
- we must prepare now for future technologies, skills and product needs to secure future PNT services,
- we must protect spectrum and address risks and interference issues,
- have a formal internal (government) advice system and deploy GNSS backup systems where appropriate,
- address common terminologies, procurement approaches, legislation and
- the UK is well placed globally to actually do something about it.

Addressing the issue

So, what has been done to address these findings? One of the first steps taken by the Government was to form a group to assess the feasibility of implementing the recommendations. It is unusual for the Government to respond in this way to a Blackett review, but the subject matter was taken extremely seriously by organisations such as the Cabinet Office.

The newly-formed Blackett Review Implementation Group (BRIG), with members drawn from the cross-government policy area, focussed on legislative and policy aspects arising from the review. The BRIG was chaired by a Cabinet Office Deputy Director and reported up through the UK's National Security frameworks. In addition to the BRIG, the former cross-government working group was reformed into a formal technical advisory group (a recommendation of the Blackett review itself). The membership was similar to its predecessor



Because GNSS applications are so pervasive, they occur in many systems that depend on one another

but now included representatives from industry and academia.

Many of the recommendations were assessed and indeed addressed, improving the awareness of the use of PNT by reporting requirements within the Sector Security and Resilience Plan⁵ process; understanding the current and future threat to PNT based systems, and understanding the

role of existing legislation in combatting these threats. In addition, InnovateUK, now part of UK Research and Innovation (UKRI), completed the PNT facilities study and UKRI analysed R&D options, both recommendations from the Blackett review.

Test facilities

The PNT facilities study concluded that the UK has a range of PNT test facilities with good coverage of PNT technology types and domains. These facilities are owned by a balanced mix of public bodies, academia and private entities, with the vast majority (77%) being available to third parties. It noted, however, that the coverage is limited for Timing and Synchronisation (T&S). The study identified that future needs in the testing space should cover additional types of GNSS simulation, 5G and other communication PNT hybridisation and application-level testing.

The UKRI analysis has resulted in several new submissions for funding to various Government and European Space Agency support mechanisms. Some of these submissions have moved to projects and towards commercialisation.

At the same time as the BRIG and its technical advisory group was working



A decade of reviews had highlighted Britain's dependency on GNSS and its vulnerability to both natural and man-made threats

on solutions to the issues raised in the Blakett Review, Brexit was also focussing Government minds. The widely reported Operation Yellowhammer came into force, and many of the teams engaged in the BRIG were redeployed. The result was that all specific activity on the Blakett Review recommendations was paused.

Increased awareness

Another programme also started up around the same time, that of the UK GNSS concepts assessment programme. This programme was created to investigate the UK’s options for an assured/secure GNSS in the absence of the ability to use the EU’s Galileo Public Regulated Service (PRS) capability. This programme has also increased awareness of the need, use of and the dependency on PNT, whether space-based or not.

A combination of these factors, plus better knowledge of the threat environment, led policy makers and senior civil servants to propose and implement a new structured method to analyse the UK’s PNT requirement in the post-Yellowhammer “back to normal” environment. This is another major step forward in how PNT is viewed in the UK Government. The sponsor is the Deputy National Security Advisor as the “Government PNT Authority”, now combined with a steering group and a strategy group.

The strategy group can be considered the delivery function for the steering group. This enhanced focus on the understanding of the PNT need across Government and critical services, means that for the first time, full time resources are deployed on the problem pulling support from specialists where appropriate. The structure including the sub-groups are shown below.

Capability audit

The initial tasking is similar to that of a capability audit. Identifying the use cases for PNT; assessing the technologies currently in use and available in the future; measuring



The UK is possessed of a good range of PNT test facilities, such as this multi-constellation GNSS test rig from Spirent Communications based in Paignton, Devon.

the reliability of these in the known threat environment; identifying gaps, and the credible options for filling those gaps. There is also a particular emphasis on understanding how to deliver awareness, skills and for education and training that will ensure the findings of the main body of work are understood and prioritised appropriately.

This audit will produce the following outputs:

- An assessment of the UK’s requirement for PNT services
- A draft PNT strategy
- A consolidated threat and hazard report
- Assessment of the skills and training aspects of PNT in the UK with recommendations
- Identification of current and future technologies able to address capability gaps
- Assessment of the programme and investment opportunities that are identified from the analysis

The reports are likely to be available in 2020, and the question of public release addressed

once all the available information is analysed and the sensitivity relating to the UK’s infrastructure assessed.

This is, indeed, positive news for all those involved in PNT in the UK. It is an example of proactivity within Government, although some may say it has been a long time coming. Ultimately the issue of PNT, resilience and vulnerability has now got the senior backing, focus and tasking for which many calling since the 2010 Royal Academy of Engineering report⁶ that investigated our reliance on GNSS and its associated vulnerabilities.

1 A Blakett review is process for government to engage with academia and industry to answer specific scientific and/or technical questions. The process can provide fresh, multi-disciplinary thinking in a specific area. In each review, a small panel of 10-12 experts is tasked with answering a well-defined question or set of questions of relevance to a challenging technical problem.

2 <https://www.gov.uk/government/publications/satellite-derived-time-and-position-blakett-review>

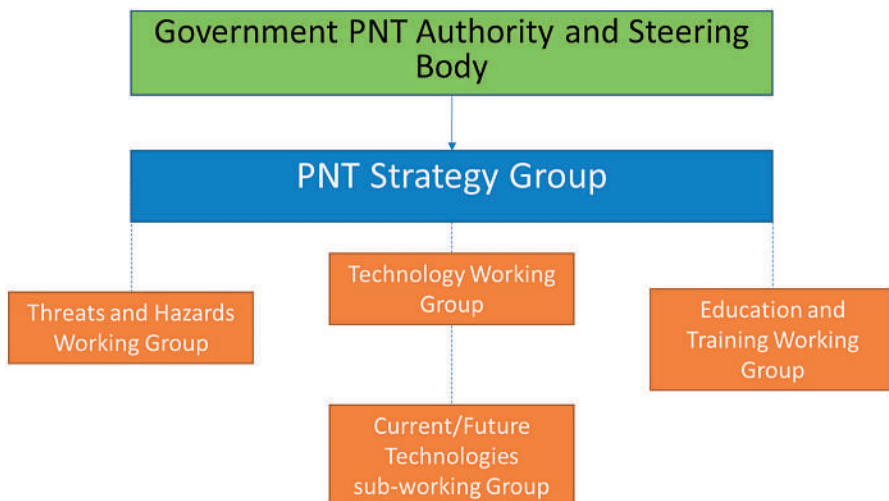
3 <https://www.gov.uk/government/publications/quantum-technologies-blakett-review>

4 <https://londoneconomics.co.uk/blog/publication/economic-impact-uk-disruption-gnss/>

5 SSRP process is a process used within Government to create plans setting out the current level of infrastructure risk. <https://www.gov.uk/government/publications/sector-security-and-resilience-plans-2018-summary>

6 <https://www.raeng.org.uk/publications/reports/global-navigation-space-systems>

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The new structure



UK GNSS: boldy going?

Born out of a Brexit stalemate, Britain's proposed alternative to the EU's Galileo satellite navigation system seems to be stuck on the launch pad. Does this signal the end, or a fresh beginning? GeoConnexion looks at the evidence

One of the penalties of Brexit became apparent early in 2018 when it emerged that the UK – as a “third country” - would have only limited access to the Public Regulated Service (PRS) of the Galileo satellite positioning system. Intended for use by government agencies, the armed forces and emergency services, this encrypted, high accuracy element of Galileo is an important component of an EU project to which Britain had contributed the best part of €1.5 billion over 25 years. The UK also hosted one of two Galileo Security Monitoring Centres at Swanwick in Hampshire, as well as two Galileo Sensor Stations located in British Overseas Territories.

A particular sticking point in the

negotiations was that British industry would be frozen out of further work on a project for which Surrey Satellite Technologies has provided the navigation payloads and atomic clocks. It was Malvern-based Qinetiq, in partnership with Belgium's Septentrio that developed the device that received the first PRS signal. Similarly, London-based CGI UK designed the core of the ground infrastructure that controls the 30-satellite Galileo constellation and manages the commercial and public sector encryption keys.

With negotiations proving fruitless, and based on preliminary work conducted in 2017, the Government began to talk-up the prospect of a home-grown GNSS. This

was followed, in August 2018 with the announcement a £92 million, 18-month feasibility study into its design and development.

Spearheaded by the UK Space Agency and supported by the Ministry of Defence (MoD), the study would deliver a detailed technical assessment and schedule of a UK global positioning system that provided both civilian and encrypted signals. A sovereign system would, it was claimed, avoid an estimated £1 billion daily loss to the UK economy in the event of a sustained disruption to satellite navigation signals. And while compatible with GPS, it would provide Britain's armed forces with an independent weapons guidance capability.

UK requests		Development/Operation		(Means of) Access		Third countries under EU rules	UK position	Issues
		Open signal	Security/PRS	Open signal	PRS			
Gov.	EU MS	Participation in governance and programme activities	Participation in non-PRS security Participation in PRS aspects if PRS MS status	Accessible and Exploitable Worldwide	All EU Member States	Agreement on participation in Space programme: <ul style="list-style-type: none"> No voting rights/no decisional power No access to all meetings Standard budget contribution Specific agreement on PRS: 'User' access to PRS signal! [Agr. on info security needed!]	Participation: <ul style="list-style-type: none"> Security & PRS meetings (incl. SAB) 'Negotiable' contribution (if "value for money") Unrestricted & guaranteed PRS access	Beyond standard third country status
	Third country	Participation, if agreements on: <ul style="list-style-type: none"> Participation Security of info (No voting rights) 	Full participation in security/ PRS matters		Guaranteed unrestricted PRS access + control of PRS signal			
Business	EU based (est.)	Non-security related tenders	Security (non PRS) related tenders PRS-related tenders if PRS MS-based	by all citizens, public authorities, businesses Open service, Commercial service, Search & rescue...	Manufacturing of Security Modules: if PRS MS-based businesses	No design & development of: <ul style="list-style-type: none"> Security-related PRS elements No role in upstream PRS activities: <ul style="list-style-type: none"> Generation of signal Control of encryption Third country industry :	Full participation in: <ul style="list-style-type: none"> Design of Security and PRS Upstream PRS activities (control and encryption of signal) 	Change of nature, from EU programme to international project
	Third country based	All GPA/EU-FTAs members based businesses eligible to non-security related tenders	Full eligibility of UK industry to tender		Full involvement of UK industry: manufacturing of security modules			
Legend		No restrictions	EU rules: possible for a third country if agreement (or, for MS, if PRS status)	EU rules do not allow for a third country				

A comparison of UK requests (left) and European Commission rules governing Galileo (right) published as part of Brexit negotiations in June 2018. Source: European Commission

Exploring alternatives

In announcing the move, former Prime Minister Theresa May, reiterated the UK's commitment to Europe's collective security post-Brexit, but added, "Given the Commission's decision to bar the UK from being fully involved in developing all aspects of Galileo it is only right that we find alternatives.

I cannot let our Armed Services depend on a system we cannot be sure of. That would not be in our national interest."

The then Business Secretary Greg Clark added his support. "Britain has the skills, expertise and commitment to create our own sovereign satellite system and I am determined that we take full advantage of the opportunities this brings, backed by our modern Industrial Strategy," Within a matter of weeks, newly-elected Prime Minister Boris Johnson was singing from the same hymn sheet. "Let's get going now on our own position, navigation and timing satellite and Earth Observation systems ... UK assets orbiting in space, with all the long-term strategic and commercial benefits for this

country." A copy of the MoD's long-awaited defence space strategy, leaked to The Times in May 2019, was said to "enthusiastically" endorse the move.

However, it was not long before the implications of this intention generated a chorus of negative comments, some appalled at the estimated £3-5 billion cost of realising a medium Earth orbit constellation of around two dozen satellite over a ten-year build phase, and others by what seemed little more than a vanity project – after all, the MoD already enjoyed licenced access to the encrypted GPS signal.

Less costly options were also on offer, with academics from Sussex University proposing a Satellite Based Augmentation System payload piggybacking on Britain's Skynet military communications satellite. This arrangement would provide a Navigation Overlay Service (NOS) similar to the European Geostationary Navigation Overlay Service (EGNOS) and, together with ground infrastructure, could be delivered in just one year at a cost of £300 million.

All objections and alternatives were

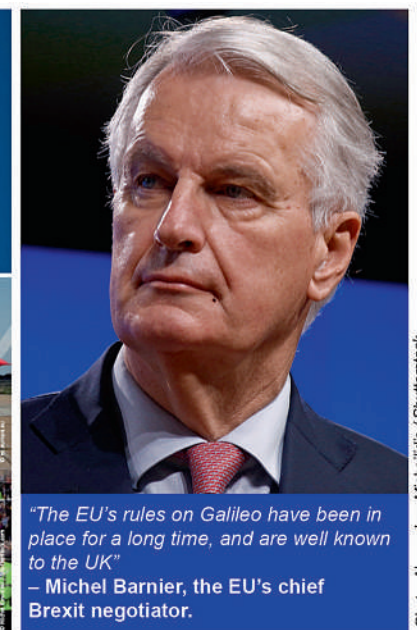
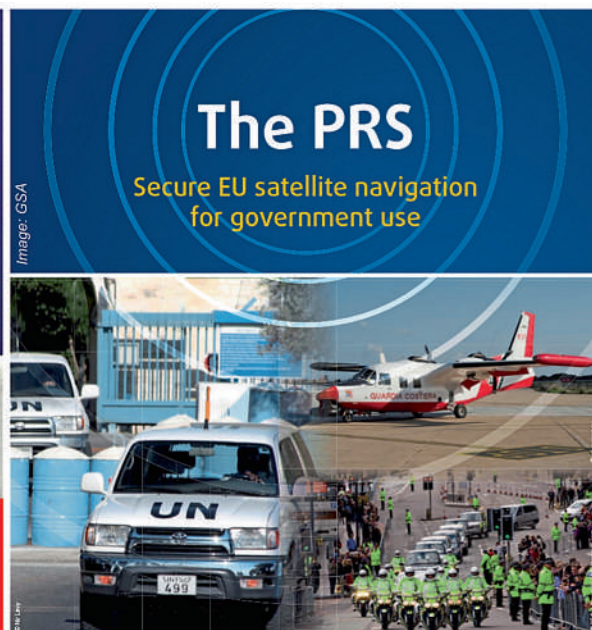
brushed aside in the fevered atmosphere surrounding Brexit, with former MI6 chief, Sir Richard Dillmot, senior defence advisor Professor Gwythian Prins, and ex-Chief of the Defence Staff, Field Marshal Lord Guthrie, all pitching-in to support the government proposal. According to Downing Street, more than 50 UK companies had expressed interest in the project by the end of 2018 and that 'a series of key contracts are now being tendered'. The then Science Minister Chris Skidmore added that the first satellites would be launched by 2025 and the system fully delivered by 2030.

Second thoughts

18 months on, and with whispers of a Cabinet Office review into the feasibility of the whole endeavour, it seems that second thoughts are taking hold. Reports of a six-month "pause" have surfaced in the mainstream media, with claims that Civil Service head Sir Mark Sedwill had branded the project "unrealistic and unaffordable" and that a cheaper, albeit less sovereign alternative was under consideration. Responding to a request by



"I cannot let our Armed Services depend on a system we cannot be sure of. That would not be in our national interest" – Theresa May, UK Prime Minister



"The EU's rules on Galileo have been in place for a long time, and are well known to the UK" – Michel Barnier, the EU's chief Brexit negotiator.

GeoConnexion, the UK Space Agency has simply confirmed that the engineering, design and development phase (EDDP) is 'ongoing'.

It was always going to be tricky finding £5 billion in Britain's post-Brexit finances to compete with tier-1 spacefaring nations. Add to this the enormous financial burden of dealing with COVID-19, and the case to scrap the project or find a more affordable alternative has become ever more attractive.

So should Britain lower its sights and rely purely on encrypted GPS for its defence and security needs? Reopen negotiations with Brussels for access to and industry participation in Galileo PRS? Settle for a regional GNSS such as India's NavIC or Japan's QZSS? Or develop a tactical GNSS platform for rapid in-theatre deployment as and where needed?

As we went to press, reports surfaced of a possible £500 million government stake in OneWeb, the London-based satellite operator that already has 74 of a planned 650 Ku and Ka Band communications satellites in Low Earth Orbit. The company, which filed for bankruptcy in March, claims it would be able to deliver a military and civilian GNSS capability – as well as broadband – when the constellation is fully operational next year.

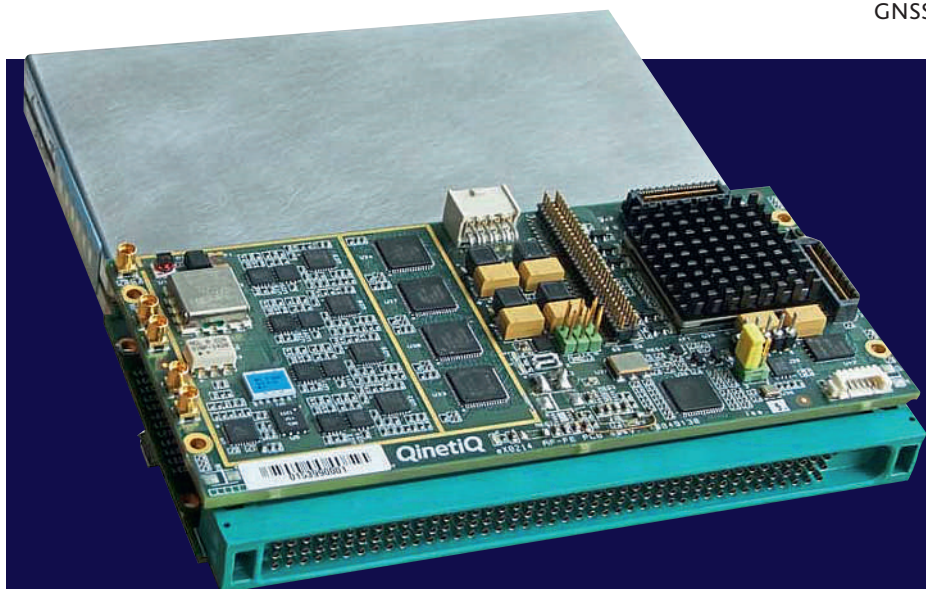
A fresh beginning?

Whatever the outcome of this hiatus, there are those, like Stuart Martin, CEO of the Satellite Applications Catapult, who told the Financial Times earlier this year that it could offer a fresh beginning. "This is an opportunity to do something that goes well beyond Galileo. If we do this it will give us an immediate export opportunity and we would be adding to the systems already there."

That suggestion endorsed a key finding of the Blackett Review, convened by the Government Chief Scientific Advisor, which published its findings in 2018. In looking at the dependency of the critical national infrastructure on satellite-derived timing and positioning, it noted that 'While the availability of additional constellations such as Galileo will reduce dependence on GPS, and bring improved performance, it will not be revolutionary and the problems posed by different sources of interference remain.'

Hopefully, some answers will be forthcoming at this year's Military PNT Conference, to be held in London in October*, and where the UK Space Agency GNSS Team is scheduled to update delegates on the options for assured Positioning, Navigation and Timing (PNT) services and exploring the technical and security challenges of a UK GNSS. Also on the opening day, Mark Lynch from UK Strategic Command will be delivering a keynote on the MoD's R-GNS programme (see section headed 'Looking for better reception')

* http://www.smi-online.co.uk/defence/uk/militarypnt#tab_overview



The UK R-GNS receiver development will benefit from the evolution of QinetiQ's jamming and spoofing-proof Q Series receivers that can receive and process Galileo PRS and Open service signals, as well as GPS, GLONASS, BeiDou, WAAS and EGNOS signals. Photo: QinetiQ

LOOKING FOR BETTER RECEPTION

Two ongoing projects that will influence the future of a resilient UK GNSS capability are currently underway. The first is a £67 million MoD contract to develop secure multi-constellation satellite receivers under the UK's Robust Global Navigation System (R-GNS) programme. Awarded to QinetiQ and Collins Aerospace in September 2019, the contract envisages advanced navigation products that are UK sovereign supplied and feature low Size Weight And Power (SWAP).

"These state-of-the-art receivers will help to ensure our armed forces can defend UK interests wherever and whenever they are threatened," explained Defence Minister Anne-Marie Trevelyan. The work, to be pursued over a 10-year timeframe, continues QinetiQ's development of its robust Q Series multi-constellation, multi-

frequency navigation receivers.

The second future-looking project was launched in October 2019 by the UK Space Agency as a Small Business Research Initiative. This invited entries for a competition that would fund R&D into the challenges, innovations and future concepts of UK GNSS receivers.

Nine projects were selected from 18 expressions of interest and funding totalling £770,000 was invested across a range of innovative techniques for secure GNSS services, distribution of timing and synchronisation information, provision of emergency alerts, and new techniques for signal processing of GNSS data.

GeoConnexion understands that outputs from this research are now under review by the UK Space Agency's GNSS team.



Image: Harvepino / Shutterstock.