

Written evidence submitted by Border Consulting Ltd (SPA0103)

My attention has been drawn to your committee's investigation of the UK satellite navigation programme following Brexit and particularly the evidence given to your committee on the 9<sup>th</sup> February. I formed a group of subject matter experts (SMEs) who were contracted by UK Space Agency to provide the technical audit of the UK Global Navigation Satellite System (GNSS) and Space Based Positioning Programmes (SBPP) from 2018 to 2021. At your meeting statements were made by Officials that simplified many important facts and issues. The resulting headlines, 'The UK's Global Navigation Satellite System vital to the nations interests is being thrown into doubt by Whitehall inertia' caught my attention.

I note that you are in receipt of a letter from Mr A Proctor concerning various aspects of the UK PNT programme and particularly the work to engineer a UK alternative to Galileo. At times during the programme I worked alongside Mr Proctor as the technical auditor. I believe I have unique qualifications to perform this task.

I retired from Dstl as a Senior Fellow (1\*) in 2015 following a career of 40 years in navigation systems. I have appended a brief CV below to give you a flavour of my work and the role of the teams I have managed.

Definition of the MOD's research, development and procurement programmes for navigation systems from 1990 to 2010, including world leading GNSS anti-jamming systems that won 2 Queens Awards to Industry.

The generation of technical specifications for the update of navigation systems in MOD platforms, including Hercules, Nimrod MR4, Tornado GR4, Harrier GR9, Typhoon, Wildcat and several other programmes.

Technical support for UK MOD at NATO and 5 Eyes Navigation Warfare meetings.

Support to DfT and NATS at ICAO, Eurocae, RTCA, to MoD and former DTI for export controls at Wassenaars Arrangement meetings, and to several other Government departments.

Support to DfT and UK Space Agency in the technical negotiations with the EC for the Galileo and EGNOS programmes from their inception in the early 1990s through to Brexit.

Following my retirement I and a colleague established Border Consulting Ltd to provide independent technical services for PNT. I led a team of technical auditors for the UK GNSS and early SBPP programmes from 2018 until the contract ended in March 2021.

I was honoured with the award of an OBE for my work.

As your committee is well aware, following Brexit the UK was excluded from the Galileo and EGNOS European Satellite programmes. Although the focus has been Galileo the loss of the EU EGNOS is a significant problem. EGNOS broadcasts integrity data that enables GNSS, mainly GPS and Galileo to be used for 'safety of life' operations, e.g. airfield approach and landing. However the refusal of the EC to allow UK access to the certification data has resulted in the withdrawal of all procedures using EGNOS in UK airspace. The cost to the EU to provide the data is minimal but it is a strong indication of their attitude to UK and reopening of their programmes to our participation. It is noted that Inmarsat have an ESA Navigation Innovations and Support Programme (NAVISP) contract to investigate use of the currently unused GNSS transponders on their Geostationary satellite to provide a Satellite Based Augmentation System (SBAS) for UK in which DfT are taking a strong interest.

These issues were foreseen by the then National Security Adviser (NSA) who instructed BEIS to instigate a feasibility study into UK producing its own system. In late 2017, I was contacted by UKSA with a request to generate a technical statement for a "Future Concepts Study (FCS)" into a UK GNSS, the so called Plan B. As UKSA did not then have funding for the programme I provided free of charge, the statements of work that enabled the programme to commence.

My brief in generating the work statement for the FCS was:

#### Capability

*Deliver a new, UK-controlled space capability that will strengthen national resilience and provide secure and assured position, navigation and timing services anywhere in the world to support a wide range of UK strategic objectives (e.g. humanitarian aid missions, trade deals).*

#### Global Standing

*Demonstrate the UK's role as a major global actor with global reach and influence, boost our standing as a credible international partner for allies, and affirm the UK's status as a Tier 1 military power.*

#### Prosperity

*Boost UK prosperity by providing new high-tech economic opportunities in the UK space sector, and stimulating innovation in sectors such as security, CNI and defence which rely on space-based position, navigation and timing services.*

The UK GNSS was from its commencement a Joint UKSA/MOD programme, MOD assigning a Group Captain and a Squadron Leader to support the work. The FCS was stood up from the end of 2017. A contract with an industrial consortium was placed in January 2018 for ~ £4.5m, with an initial output required in three months, by the end of March 2018, and a final report in September 2018. Both dates were achieved with impressive work by UK industry. The requirements for the study instructed industry to have a fresh examination of all possible architectures for a GNSS, that included conventional Medium Earth Orbit as GPS at a 20200Km orbit height and variations of Low Earth Orbit systems, that is similar to communication satellites One Web, Iridium at 500K - 1000Km. I was contracted as the technical design authority for the work.

During the FCS UK officials paid a visit to the US DoD to explain the programme. We were warmly received. A report of this visit and the reaction of the US should be available from BEIS/UKSA that would be of interest to your committee.

The FCS concluded that it was possible to satisfy NSA's requirements for freedom of action and independence with a satellite constellation and performance similar to GPS. Compatibility with GPS was seen as important so reducing to a minimum changes to user equipment and with military requirements. UKSA should be asked for the report of FCS conclusions.

To continue the work an Engineering Design and Development Phase (EDDP) was contracted in December 2018 with £92m from the Brexit readiness fund. EDDP tested the feasibility of delivering a UK system. Long lead items and components were identified and costed

It was a fundamental aspect of the work to use proven technology available from UK industry. More innovative options were deferred to a future replenishment phase. Results were required to inform the 2019 Spending Review and a Full Business Case by 2020/1. The EDDP made significant progress, by its close in September 2020 industry had developed a solution with system specifications and material for an Outline Business Case (OBC) for a Medium Earth Orbit system providing global PNT services to civilian, defence and CNI users. EDDP resolved many difficult technical issues including, the ground segment architecture, a working orbit determination and time synchronisation programme accurate to metres and nanoseconds, satellite design and deployment plan. All parts of the system were costed and independently verified.

The next phase was to many a step backwards. The Space Based Positioning, Navigation and Timing Programme (SBPP) was claimed<sup>1</sup> as, 'a major new UK Government programme launched by the UK Space Agency to explore innovative ways of delivering vital satellite navigation and timing services to the UK from space, exploiting technologies offered by companies at the 'cutting-edge' of innovation such as OneWeb<sup>2</sup>'. These words were echoed by the CEO of UKSA, 'Now is the time to drive this work further to look into wider, more innovative ways of delivering this important national capability - to help protect our critical infrastructure and put the UK at the forefront of the development of new space technologies.'

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<sup>1</sup> Secretary of State and UKSA CEO announcements.

<sup>2</sup> UK Space Agency press release

Effectively SBPP reopened the FCS studies into different satellite architectures and MEO v LEO orbits. To many it was not coincidental that UK had made an investment of £400m into OneWeb in July 2020 with the reported<sup>3</sup> intention of repurposing the satellites for a GNSS led to the following headline.

**The UK is spending \$500m (£400m) on a stake in failed satellite firm OneWeb as part of a plan to replace use of the EU's Galileo sat-nav system.**

It was reported that the UK's Satellite Applications Catapult had prepared a white paper to illustrate one potential way of using the OneWeb constellation to deliver precise timing for use in the country's power, telecoms and finance industries. This paper has not been published but should be reviewed by your committee, as it could provide an insight into why OneWeb is being acclaimed as a solution. But, UK is a minority shareholder in OneWeb, so does not have control over the system's operation or commercial decisions.

There were numerous technical reasons that LEO satellites are not optimum for GNSS, many GNSS engineers would dismiss their use entirely. A major issue is the precise prediction of satellite orbits due to the variation in the drag caused by interaction of the solar wind with the upper layer of the atmosphere. Time between uploads to satellite would be considerably more frequent than at MEO with a far more complex ground monitoring system. The situation is further exacerbated by the need to observe and calculate the data for 20 times as many satellites. Debris in LEO is becoming an increasing hazardous issue.

GNSS mobile receiver designers dislike LEO signals as they are under constant pressure to reduce power consumption. LEO satellites move in and out of visibility every few minutes rather than hours for MEOs. Signal acquisition requires higher power than tracking, the Doppler frequency range variation from LEO is several times that of MEO with the result that increased requirements are put on the all-important battery consumption. Mobile phone and tablets are now the largest user group for GNSS applications. The transmitted PNT signal in terms of powers and transmission frequencies from LEO require international agreement that was predicted to be 'challenging'. There are currently no allocations in the international frequency table for GNSS from LEO.

UKSA did not renew the technical audit contract at its end date of 31<sup>st</sup> March 2021 although it alluded an announcement would be made through SERAPIS. The work from March 2021 until the end of the SBPP in March 2022 was unaudited. Our suspicion is that we were asking too many awkward questions.

The costs, results and output of the SBPP have not been published following the contract end in March 2022. As far as can be determined from BEIS and UKSA announcements no further work is planned. The UK GNSS programme has been effectively killed off. So what credibility can be placed on the Secretary of State's and the UK CEO's statements at SBPP's commencement.

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<sup>3</sup> BBC news report [UK government takes £400m stake in satellite firm OneWeb - BBC News](#)

It is therefore reasonable to ask, considering the amount of public funds spent on the programme from 2018 that must be well in excess of £100m, what will be done with this work and where will it be used. Was this good use of public funds?

Therefore, I was somewhat surprised by the evidence presented to your committee by BEIS officials that Plan B remained a 'backup' for Plan A, UK securing full access to the Galileo and EGNOS programmes. Statements by the officials that Plan A was a realistic option demonstrate how out of touch they were and still are with European Commission (EC) and other member states intentions. Furthermore, European Council regulations covering access to the encrypted Public Regulated Signal (PRS), the programme's security aspects and allowing non EU, that is UK, industry to bid for contracts for the development and operation of the system, would require significant changes with years of work.

I am aware of these regulations as I was a lead in the UK's team of engineers and security specialists who worked with the EC and ESA to establish the design and implement the Galileo system, particularly the navigation signals and the security aspects of the system. An aspect of this work were the negotiations with the US over the compatibility of the Galileo PRS with the encrypted GPS M-code signal. The US applied huge political pressure on UK, France and Germany to ensure Galileo's signals did not overlay the frequencies used by GPS M-code. Another factor is that EU nations particularly, French, German and Italian, space industries would not want competition from UK and their Government would likely block any move to readmit the UK. It was surprising no mention was made of the UK PNT office the Cabinet Office has instructed BEIS to establish.

However the Blackett Report, the Cabinet Office work, the UK Space Strategy and Defence Space Strategy all point to the same direction. The SoS's reply 31<sup>st</sup> March 2022, to your enquiry glossed over many issues and illustrates the prevaricating within BEIS. If the SBPP work is as good as it is claimed why is it not published or open to independent technical review?

The government has made clear its ambitions for the UK to become a globally competitive space power and is taking action through the newly established National Space Council, the National Space Strategy and the Integrated Review of Security, Defence, Development and Foreign Policy, to create the conditions for a strong, secure and innovative space sector. Here is further evidence of BEIS obstruction. The Prime Minister therefore needs to stand behind British industry, be seen to be protecting the future of the economy and defence, create some certainty and throw his full weight behind a UK GNSS, approving the project without delay.

It is worth a short review of the origins of GPS. GPS was invented after the US DoD had spent billions developing Inertial Navigation Systems and failing to produce an affordable device capable of maintaining sufficient accuracy over a time of greater than a few minutes in combat systems. GPS was termed the 'force multiplier', as it enabled accurate first strike thereby reducing the number of weapons needed or the time taken, to achieve a military objective. Initially GPS was a military only system. Ronald Regan directed the C/A-code be made public following Korean Airlines Flight 007 being shot down in September 1984, after straying into Russian airspace; the incident is believed to have been due to a failure in the aircraft's navigation system. Within a few years civil use became significantly larger than the military's with the result that GPS has been changed to accommodate both civil and military requirements. There have often been questions in the US over making a charge for GPS use.

However the US Treasury believe they obtain greater income from the wider economic benefits the system provides, avoiding the potentially costly process a charging mechanism would incur.

Until leaving the EU, UK had been a leader in the Galileo project, despite UK Space Agency being small compared to the likes of CNES France, DLR Germany and ASI Italy. UK industry had made the first Galileo satellite, GIOVE-A, the navigation payloads for all the operational satellites and a large proportion of the ground control segment. We had made major contributions to the design of the signal in space and the system's security. It must be remembered that SSTL's GIOVE-A saved the frequency filings for Galileo. The satellite was launched in December 2005, just two years after ESA signed the contract. An unprecedented achievement of space engineering by Surrey Satellites Technology Ltd. Contracted at the same time a satellite manufactured by Airbus Germany, GIOVE-B, was late, it was not available for launch until April 2008 and cost three times more than GIOVE-A.

There appears to be some confusion in the evidence of the timescale and costs for Galileo. Europe's decision to develop Galileo was aimed at avoiding dependence on America, Russia, China, etc. for such an important contribution to the economy, since it was believed that dependence would put at risk Europe's ability to remain competitive in many world markets. Galileo's history goes back to the 13 January 1999 when the European Parliament adopted a Resolution, 'Towards a trans-European Positioning and Navigation Network: including a European Strategy for Global Navigation Satellite Systems (GNSS)'. The Council adopted a Resolution on Galileo on 5 April 2001 followed by a Council Regulation 876/2002, 21 May 2002 setting up the Galileo Joint Undertaking, also to run the EGNOS integrity overlay programme. But Galileo's origins go back to an ESA study in the 1980's for a NAVSAT system that mirrored the US GPS.

The cost of Galileo and EGNOS are difficult to trace but an estimate from various European documents is a current bill of €8.5 billion. The think-tank Open Europe estimated the total costs from start to 20 years after completion at €22.2 billion. Even this figure does not include many of the costs incurred by member states to participate in the political and technical control of the project. Following Brexit it is widely reported the EU are running short of funding, so if there is a thin possibility of UK being readmitted to the programmes it is anticipated to be at a very high price.

However, it is not widely reported but currently there are major technical problems with Galileo that will be expensive to resolve. Intended to achieve full operational capability by 2014. My estimation is that it will not be completed before 2025, and that is reliant on a revised launch schedule to avoid the use of Russian launch vehicles. Ten of the final batch of 12 satellites have yet to be launched due to serious problems with the manufacture and operation of the satellite clocks. There have been serious week long outages of the system. The speculation is that there are problems of maintaining the ground control software that was developed by UK's CGI, now they are no longer contracted for support.

But why do we need UK GNSS at all? I'd like to say its simple but in fact its very complex, which is perhaps one of the reasons that Whitehall seems to be running scared. Access to GNSS signals is vital for modern economies and the UK's reliance on it continues to grow as new applications are developed. The UK Government's own Blakett Review in 2018 identified a reliance on GNSS across critical national infrastructure including time-location

based systems, communications and military requirements for location, surveillance and weapons delivery.

The overall effect of the loss of GNSS timing signals on the UK infrastructure, such as ATM machines, power and utilities distribution, cargo handling, timing for various communication systems, transport and rail systems was estimated in 2015 at £1b per day with 11% of the UK's GDP directly supported by satellite navigation systems. Just one example is the change in every day procurements by the general public during COVID with doorstep deliveries by 'White-van man' enabled by the use of satnav in vehicles, mobiles phones etc. It is rumoured that a recent yet unpublished Government review has increased the cost to UK economy to £1.5b/day. Your committee should ask BEIS if such a document exists and if so request a copy.

Any loss, or even restriction, of GNSS services to the UK would be disastrous for the economy but also for national security. It is often stated there are four global and two regional satnav systems. But this is delusionary. The UK military has a critical dependency on the GPS secure encrypted signals, the Y-code and future M-code; access is via a NATO agreement. However there are several restrictions and conditions on their use. The lack of control over the encryption codes and receiver components leaves a gap in the defence of the country. Open signals from Galileo are available as the only global alternative, as to trust the Russian GLONASS or the Chinese Bei-Dou would be foolhardy. India and Japan only operate regional systems with limited coverage and performance.

At a time when the UK is stepping up to assert its place on the global stage being totally reliant on even a friendly foreign government for a vital and ubiquitous component of our economy and defence is a limiting factor to our national influence. There is no doubt that a UK GNSS would eliminate any political risk and enhance military capability. MOD are well aware of this issue as illustrated in their recent Defence Space Strategy meeting where on several occasion PNT was cited as critical to military operations.

At a top level the Government has been supportive of the UK GNSS project. The 2018 feasibility study was announced by then Prime Minister Theresa May while PM Boris Johnson has reiterated his support for the project time after time, announcing it in the Queens Speech in December 2019 and reportedly giving it his full backing in Cabinet as recently as 28<sup>th</sup> February. So why are the various departments involved, (BEIS, MOD, DfT, Treasury and Cabinet Office) seemingly either at loggerheads or running scared and trying to back away from investing in a crucial piece of Britain's infrastructure?

Can it be the cost? The work for UKSA/BEIS established, with independent verification, a cost of £5bn to build and launch 24 satellites by 2025 and operate the system for five years. Compared to a potential loss of £1bn per day it seems a tiny price to pay. Putting it in context with the infrastructure spend on HS2 for example, now estimated at well over £100bn and Crossrail at over £18bn, it looks like incredibly good value for money, as it is the small change out of these projects.

It's not the technology either. The UK was at the forefront of Galileo and has 50 companies including Inmarsat, CGI, SSTL and Airbus with leading edge technology ready to start work.

Does the sudden reluctance to take the next step therefore come down to either a lack of confidence within the Cabinet Office or in BEIS, in their capability to deliver a complex project? Or is the issue one of traditional civil service inertia, being unwilling to step away

from the status quo. After all it could be a bargaining chip in forthcoming trade talks with the US.

SBPP can now be seen as a delaying tactic, introducing chaos with proposals and counter proposals for a variety of systems that had previously been discarded as not meeting user requirements for global robust operations.

We are at a critical time for the future of the UK, as an economy and as a major player on the global stage. We cannot afford to retreat into a bunker mentality reliant on other nations to supply us with vital technology which could be denied to us at any time. UK GNSS is a stepping-stone enabling a robust future, it ensures our hands and our actions for both business and the military are not tied to a foreign power. UK GNSS is at a vital step, Whitehall has effectively killed the project with the SBPP contract ending 31<sup>st</sup> March.

Commenting on the takeover of semiconductor manufacturer Newport Wafer Fab the chair of the Foreign Affairs Committee, Tom Tugendhat MP said, "The long-term security of our nation relies not just on our Armed Forces but on the resilience of our economy and that means ensuring our future stability is never sacrificed for the sake of short-term advancement.

The consequences are just beginning to be felt for Britain's security, military, political, commercial and economic interests. We are in this 'unenviable' position as we are excluded from the control of these systems, the only way out is to take control of our own destiny by creating the UK GNSS. However to give UK the freedom of action it has been looking for during the whole Brexit project it is vital for the nation that it goes ahead. As can be detected in the evidence given to your committee the prime objections are coming from BEIS.

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