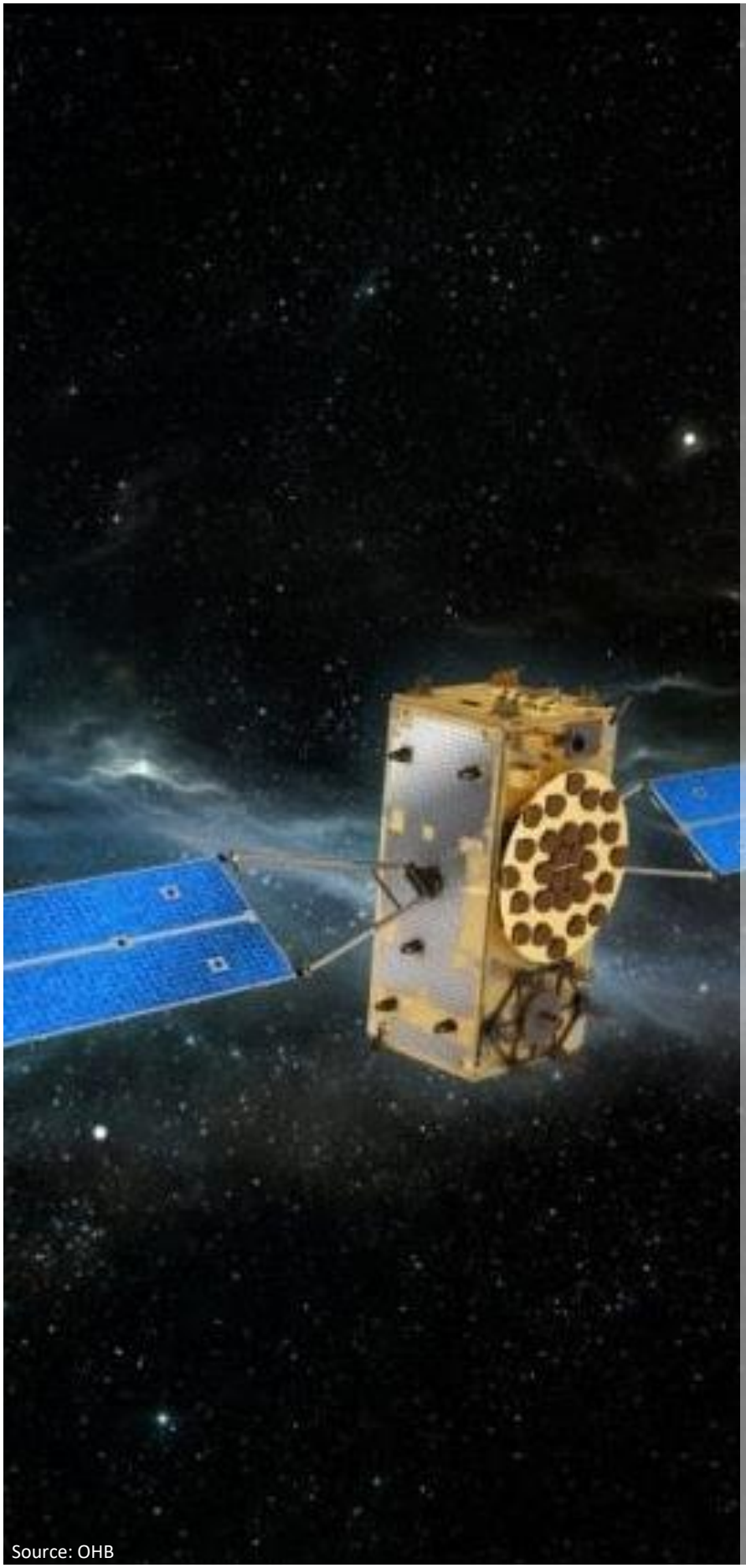

Source: OHB

Routes to Market Report

14 - Satellite Technologies for Galileo PRS

Innovate UK

LE London Economics

CATAPULT Satellite Applications

Contents

1. Introduction and Scope

The Public Regulated Service (PRS) is a specific service provided by Europe's GNSS, Galileo.

Access to the PRS is granted by a Competent Authority in a Member State of the European Union, Norway or Switzerland. The scope of this market briefing therefore covers these countries. However, recent communication from the US Department of Defence suggests the US military would be interested in accessing PRS.[1] Discussion of the political landscape and likelihood that such requests from the US will be granted are beyond the scope of this briefing, and the US market is therefore not in scope.

This Market Briefing assumes that the United Kingdom remains part of European GNSS following its exit from the European Union (BREXIT). Should this not be the case, then it is expected that **no UK entity** will be able to serve the PRS market.

This Market Briefing covers 2016-2020 (near term) and extends to 2030 (longer term).

2. Market Overview and Opportunities

The Public Regulated Service (PRS) is Galileo's dedicated service for users approved by a Competent Authority in a Member State of the European Union or in Norway or Switzerland. It is currently in development, and represents an emerging market opportunity.

The PRS is primarily intended for users in the public sector such as emergency services, coastguard, police, defence, critical national infrastructures and others, for applications where high levels of service continuity are required.

The PRS is an encrypted dual-frequency service in the E1 and E6 band that provides:

1. **Resilience to spoofing**: the encryption algorithm on the PRS ensures that a successful decryption authenticates the signal, which is therefore not as vulnerable to spoofing and meaconing as other GNSS signals[2];
2. **Resilience to jamming**: the wideband frequency of the PRS introduces some resilience to jamming (certainly more so than Open Services), but most jammers will still overpower the signal from satellites in space;
3. Availability in times of crisis;
4. Interoperability with other GNSS services.

Market opportunities in PRS should be considered separately for the design, manufacture, and operations of the PRS-specific elements of Galileo on the one hand and the applications of PRS further downstream on the other.

2.1. Manufacturing and operations

UK companies have successfully delivered a large section of Galileo's space and ground segment, and the requirements associated with the PRS have had a significant impact on the overall costs of the system due to the increased security requirements associated with a service catering to specific,

[1] http://insidegnss.com/node/5295

[2] Based on UK Space Agency (2013), *Compent PRS Authority* available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/298025/competent-prs-authority-impact-assessment.pdf

mainly public, user groups. With Galileo's second generation currently in development, UK companies may continue to win contracts related to the security of the ground system, and development of satellites and payload. In addition, the UK is home to one of two Galileo Security Monitoring Centres in Swanwick in Hampshire.

2.2. Space applications

Opportunities in space applications depend greatly on the choices made in each of the Member States (the Competent Authority in each Member State will decide on which users can access the PRS, and accordingly influences the potential market). At one extreme, only civilian law enforcement and emergency services will use PRS, while another plausible alternative is that those users as well as military applications and critical infrastructures in all EU countries plus Norway and Switzerland will use PRS.

The opportunity in space applications relates to the equipment used to decode the PRS signal and provide users with position, navigation and timing information. Only entities registered in a European country that has a competent authority can obtain the information that is required to produce the relevant devices. This means that US companies with UK (or other European) sites can obtain the relevant permissions if their employees satisfy the security requirements. It should be noted that even if a US headquartered company enters into PRS, only its European-based staff are able to work on the technology.

3. Customer and End-User

The end-user for PRS-enabled equipment is a government-approved entity in areas such as law enforcement, emergency services, military or critical infrastructures across the EU, Norway and Switzerland. The candidate users for the PRS currently rely on Open Signals (e.g. GPS SPS) and in addition, military applications in NATO member states can use the military GPS Precision Positioning Service (PPS) if authorised by the US Department of Defence.

4. Value Proposition to the Customer and End-User

The PRS is a new satellite-based PNT service that adds a significant layer of resilience to the GNSS offering. The primary appeal of the PRS is its relative strength in terms of resisting spoofing and jamming attacks and its ability to continue in times of crisis (although it should be noted that the power of currently available jammers is greater than that of the signal in space, so could overpower the signal). Therefore, the benefits of the PRS all take the form of avoided foregone benefits in the event other GNSS (mainly GPS) should fail.

As the applications that are candidates for use of PRS all play key roles in the functioning and security of the state, PRS is an important element in assuring European independence from systems over which Europe has no control.

In addition, PRS is expected to deliver a service of higher accuracy than the current alternatives owing to its dual-frequency setup, and may disrupt the positioning market more generally, inducing the use of GNSS in sectors for which open signals are not sufficient.

5. Market Competitiveness

Alternatives to PRS include the services that are already used by the candidate applications (OS, GPS SPS, GPS PPS), but it is worth noting that not all European countries are members of NATO, and therefore cannot access the GPS Precision Positioning Service (PPS). For those countries, it is very likely

that military applications will adopt PRS-based solutions as soon as they become available. A 2004 survey of EU Member States, for example, found that 18 of 25 Member States were interested in using PRS for military and all other purposes,[3] and the recent UK National Security Strategy and Strategic Defence and Security Review 2015 confirms this intention for the UK military, stating: "we will enhance the resilience of military users and key domestic resilience responders using new technologies incorporating the European Galileo system".[4]

Beyond the realm of radio navigation systems, military applications derive location based on sophisticated MEMS-based gyroscopes, accelerometers, and electronic compasses, which in combination can keep inertial track on the movement of a vehicle, and thus remove the requirement for external sources of positioning. Future developments of quantum technology could significantly improve the offering of such sources and consequently reduce the demand for GNSS, including PRS.

For critical national infrastructures (CNIs) specifically relying on the timing aspect of the GNSS signals, alternative sources of resilient timing information include network-based offerings from National Physical Laboratory and other UK companies, as well as the eLoran transmitter at Anthorn (although its future is currently uncertain). It is recommended that timing users source information from three independent sources that are all referenceable to UTC. Galileo PRS, if chosen, would enter the solution as a substitute for other GNSS-based sources, but given its improved resilience, would be a strong contender for the "slot". A combination of three sources including two GNSS (e.g. GPS and Galileo PRS) would not be sufficient as the jammers that are currently available in the market would be able to overpower signals from space (including on the PRS frequency[5]) and leave the operator with one remaining source. A potential hurdle for CNI operators is the procedures required when handling classified material (including the PRS decryption keys).

6. Role of UK Companies

UK companies have successfully delivered many system contracts related to ground segment and payload for the Galileo satellites, and other companies have already developed PRS receivers for various demonstration purposes, in fact, Qinetiq in partnership with Septentrio (Belgian) developed the device that received the first PRS signal.[6]

Wider UK defence contractors are large companies with strongly developed markets throughout Europe, which place them in a strong position to capture the market that will be generated. In addition, many US defence companies with European presence are represented in the UK, and if those companies choose to develop PRS capabilities here, the relevant employment and revenue would benefit UK society. However, given the sensitivity of defence applications remaining EU countries may choose to contract domestic companies for PRS equipment – especially in countries with a domestic industry that is similarly mature to the UK's. According to Technavio,[7] the five leading military GNSS vendors are BAE Systems (established GNSS activity in the UK), Lockheed Martin (all GNSS activity

[3] Please see: http://spacenews.com/half-galileo-prs-users-expected-be-military/

[4] HM Government (2015) *National Security Strategy and Strategic Defence and Security Review 2015,* available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/478933/52309_Cm_9161_NSS_SD_Review_web_only.pdf

[5] http://www.chronos.co.uk/files/pdfs/itsf/2015/day3/1435_LatestUpdateonGPSJamming&SusceptibilityTrials-Curry.pdf

[6] https://www.qinetiq.com/m/content.aspx?w=media/news/releases&p=Pages/Septentrio-and-QinetiQ-partnership-delivers-first-Galileo-PRS-signal-reception.aspx&i=qinetiq-logo-lp-thumb.png

[7] http://www.businesswire.com/news/home/20161202005025/en/Airborne-Unit-Continues-Dominate-Global-Military-GPS

currently in US), Northrop Grumman (all GNSS activity currently in US), Raytheon (established GNSS activity in the UK), and Rockwell Collins (all GNSS activity currently in US). All the companies that currently serve the GNSS market from the US only have significant UK presence (in addition to a handful of EU Member States), and Lockheed Martin, for example, state on their UK website that they seek to invest in and expand on their activities in the UK. However, ultimately such decisions would hinge on the conditions of BREXIT, and an assessment of the available talent and labour costs in the UK relative to other candidate countries.

In terms of GNSS timing equipment, the market is currently concentrated on few non-UK hands, but it is worth noting that many international (European and non-European) companies have UK presence, including Microsemi, Spectracom (as Steatite Limited), Rakon, u-Blox, Trimble, and the UK held retailers and consultants Chronos Technology and Sematron.

7. Revenue Projections

Estimate the likely revenue you foresee over the next few years:

European	2016	2017	2020	2030
Space manufacturing and operations	~€500m	~€500m	~€500m	~~€500m
Position, navigation (civil law enforcement and Emergency Services)	£0	£0	£600m	£900m
Position, navigation (military)	£0	£0	£180m	£300m
Timing	£0	£0	€150m	€100m

The EU's budget for completion and operation of the first generation of Galileo was defined in the Multiannual Financial Framework (MFF) covering 2014-2020 at €1bn per year.[8] It is not possible to separate the cost of PRS from non-PRS related activities, but anecdotal evidence suggests that the security requirements caused by PRS have accounted for a significant share of the budget. The actual share of the budget is not available, but we assume that 50% may be a reasonable approximation for the order of magnitude of PRS. Assuming that the UK remains a player in Galileo (with access to PRS), we can therefore assume that *approximately* €500m are addressable to UK PRS-capable companies in the manufacturing and operations segments between 2016 and 2020. The market in 2030 depends crucially on the outcome of the Galileo evolution process, which will define the developments of Galileo. The process is currently ongoing and the estimated addressable market for PRS in 2030 is therefore even more uncertain.

The PRS will not become available before 2020. Therefore, the PRS market for applications in 2016 and 2017 is estimated to be 0 (other GNSS solutions are available, and being sold in those years).

As PRS becomes available in 2020, it is expected that the market will begin to adopt PRS solutions, but the uncertainty of the relevant user groups makes quantification highly uncertain. The GSA reports[9] that there are 3m civilian security personnel in Europe and that most of these individuals may use PRS. Assuming Professional Mobile Radios incorporating PRS will cost approximately twice as much as current devices (i.e. approximately £1,200), this would suggest a core addressable market of £3.6bn, which can be expected to shift to PRS. Assuming a phased approach and device lifetime of six years, this would imply an annual market of approximately £600m. UK company, Sepura, and Hytera which

[8] European Commission (2014) Multiannual Financial Framework 2014-2020 and EU budget 2014 – The figures. Budget line D0.1.1

[9] https://www.gsa.europa.eu/news/public-regulated-service-prs-equals-public-security

has made an offer for its acquisition, along with Motorola and Icom dominate the PMR market, with Sepura reporting market leadership in more than 30 countries, including UK and Germany.[10] The other leading PMR manufacturers are not European, but all have European and UK presence. Given this existing UK PMR (terminal) capability and market share, the addressable market for UK companies for PRS-PMR is significant.

In addition, the military market in Europe could be very large as devices come at a high price. However, the classification of such matters makes quantification extremely uncertain. Technavio reports that the global military GNSS market was worth $1.3bn in 2015, growing at 4% p.a.[11] The airborne receiver market accounts for 44%, while land and naval was 26% and 12%, respectively. The residual was made up of munitions at 18%. Attribution to individual countries and regions is very uncertain and will depend on specific procurement decisions in addition to a more general defence budget. SIPRI data[12] suggests that Europe's defence expenditure is between 15% and 18% of the global total, which could be used as an indication on the proportion of the military GNSS market that would be addressable for PRS equipment. This would estimate the annual European market between £150m and £180m.[13] It is likely that European military spending would be relatively more weighted towards technological, and therefore GNSS, equipment than the global average and the estimate can therefore be considered a lower bound.

The decision whether to import PRS equipment or develop domestic capabilities hinges on information held by Member States that is not available. The UK Government's National Security Strategy and Strategic Defence and Security Review 2015[14] states a desire to support UK industry to become a leader in Galileo-related technology (in the same paragraph as it discusses military GNSS), and it is likely that other countries will adopt the same approach. However, given the UK's current European leadership in military GNSS applications, any country that chooses to import equipment is likely to approach UK companies.

The GSA *GNSS Market Report Issue 5* (forthcoming – **embargoed**) estimates that European revenue from GNSS Timing and Synchronisation equipment for critical infrastructures at €150m in 2020 and €100m in 2030. This covers only device prices relating to open GNSS signals and does not consider any price premium levied on PRS devices. The figures presented in the table represent a high scenario in which all critical infrastructure operators in Europe would switch to PRS as of 2020. Few timing companies are UK headquartered, but many have UK presence in addition to other European countries. The addressable market for UK companies is therefore limited.

[10] Sepura (2016) *Annual Report 2016*, available at: http://www.sepura.com/media/491053/sepura_annual-report_2016_v2.pdf

[11] http://www.businesswire.com/news/home/20161202005025/en/Airborne-Unit-Continues-Dominate-Global-Military-GPS

[12] https://www.sipri.org/databases/milex

[13] Using the exchange rate on 21/2/2017

[14] HM Government (2015) *National Security Strategy and Strategic Defence and Security Review 2015,* available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/478933/52309_Cm_9161_NSS_SD_Review_web_only.pdf

8. SWOT Analysis

8.1. Position Navigation Timing (e.g. GPS, Galileo etc.)

Strengths	– Strong UK expertise in developing PRS and Security system – The PRS is a unique offering in the GNSS sphere – Resilience to spoofing
Weaknesses	– All GNSS are vulnerable to jamming (intentional and unintentional), but the PRS is more resilient than Open Signals – PRS requires handling of classified equipment, key and/or processes, which could be an obstacle to uptake for organisations unfamiliar with such processes, including many non-military applications
Opportunities	– US access to PRS would represent an increase of 60% of the market (based on defence expenditure), and the timing of US accession to such a deal could allow UK companies a head start on equipment R&D. – European Competent PRS Authorities (including UK) choose to authorise PRS in multiple applications.
Threats	– By far the greatest threat to the UK PRS market opportunity is the terms of Brexit, which could result in termination of the UK Competent PRS Authority and therefore inability of UK companies to serve the upstream and downstream markets. – Allowing US-based companies access to the PRS market could result in a weakened competitive position for UK companies. – European Competent PRS Authorities (including UK) restrict authorisation of PRS to the narrowest scope of applications. – The cost of PRS (receiver/equipment and processes) becomes too high to offer value-for-money

9. Opportunity Barriers and Enablers

The PRS market is still nascent and would benefit from anchor customers who could support the development of technologies. The decision (to be) made by the UK Competent PRS Authority with regards to the domestic use of PRS could impact the likelihood that UK companies develop the capabilities required in the market.

The UK Space Agency's Impact Assessment for its competent PRS Authority suggests that a fee may be levied on access to PRS. This is not advisable (as the IA notes) because it is important to ensure the uptake of PRS is maximised in the beginning, allowing amortisation of the R&D investment among the greatest number of devices.

UK Brexit negotiation should ensure that industry remains able to recruit qualified staff from the rest of Europe to avoid self-inflicted skills shortages.

UK Brexit negotiations could determine the appetite for UK originating equipment among other European states. The PRS market addressable to UK companies could depend on the trust placed in the UK as an ally.

10.Market Dynamics

Technavio describes the military GPS device market as "Characterized by a few multinational and regional suppliers who offer heterogeneous products and services, the global military GPS device market is highly concentrated and competitive".[15] Eight military GPS suppliers are mentioned in the report: BAE Systems, Lockheed Martin, Northrop Grumman, Raytheon and Rockwell Collins are considered the main players, with Garmin, Harris and Thales listed as "other prominent vendors". All of the main vendors listed by Technavio are present in the UK, with BAE Systems headquartered here. Qinetiq (although not considered a leading military GNSS vendor) is well placed to leverage its PRS R&D to develop new equipment.

The market for professional mobile radios (PMRs) is very concentrated, with Motorola, Icom and Hytera (including Sepura) representing the main manufacturers. None of these companies are European, but Sepura and its capabilities and market share was. All the other PMR terminal manufacturers have presence in the UK and other European countries.

The market for timing equipment is also concentrated with the top 10 companies claiming approximately 80% of the market. The UK is not particularly strong on timing equipment, with companies in other European countries represented. Similar considerations as the other markets apply as many of the companies have UK presence.

11.Market Trends

The PRS equipment market grows from a standing start and therefore can be considered a growing market. In terms of the wider GNSS-enabled equipment market, it must be considered mature for all applications (professional mobile radios, military and timing), and it is therefore likely that transition to PRS would occur gradually and be driven by natural replacement.

Individual market segments may experience more significant growth, which are driven by forces external to this briefing (e.g. procurement of fighter jets or munitions required for future conflicts). European NATO members may also respond to recent communication from the US President highlighting a lack of enforcement of the 2% funding target. If all PRS-relevant NATO members that currently do not meet the target were to increase defence spending to 2% of GDP, the total relevant defence budget would increase by 30% in Europe, likely to result in a significantly enlarged market for GNSS equipment.

The nature of PRS, namely the requirement of authorisation by a national competent authority means the market is extraordinarily highly regulated.

[15] http://www.technavio.com/report/global-defence-global-military-gps-device-market-2016-2020?utm_source=T4&utm_campaign=Media&utm_medium=BW