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Tracking the position
Global satellite navigations in Europe
Expanding man's understanding
'*GALILEO*: 2020!'

Abstract

Mankind has a thirst to travel and while travel into outer space is a relatively new concept, we increasingly rely, on Earth, on technologies deployed in space to aid our safety, security – including in a transport context, where we look for efficient and effective means.

This paper focuses on satellite navigation systems and European undertakings to compete in, what is becoming, an ever-growing, competitive market. The specific focus is on GALILEO – the journey undertaken in terms of endeavouring to make it fully operational by the end of 2020. As part of this, comment and reflection are provided as to the challenges encountered – including Covid-19 and the relationship between the UK and EU. This includes commentary as to the implications of Brexit, in terms of access and use of, and to, European satellite navigation systems.

The research-design applied is historical, policy and legislative based. It commences by considering the origins of global navigations systems before the focus is turned to Europe and reviewing the development of GALILEO (alongside EGNOS and the European Global Navigation Satellite Systems Agency).

The research finds that a fully operational GALILEO will likely not be achieved in 2020; and, that the UK, whilst contributing massively (both financially and technologically) is unlikely to reap the full benefits of GALILEO.

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1. Introduction

The meaning, and understanding, of 'space' is a complex phenomenon.[1]

The word (definition of space) is able to be applied both as a noun and verb. From the perspective of the former (according to an agreed approach by most dictionary definitions) it is viewed as an area that is free and unoccupied. We occupy a 'space' by moving objects or persons into it; thereby, in many ways, staking a claim, or ownership, or occupancy of that space. From this perspective, 'space ownership' stands to cover many areas and aspect of law and is variably a multifaceted concept.

Mankind has a thirst to travel, to discover and even to conquer.[2] Many 'spaces' have been fought over. While, this normally involves the concept of space on a landmass, and hence land being defended, this does not have to be case, and thus, battles have also been pursued on the sea and in the air to defend a space, or, put another way, a claimed territory. From a social perspective, we look to travel – for many, many reasons: to visit new places, to have new encounters or experiences and to revisit areas and places – to reconnect to something positive, to somewhere we have previously been, to get new knowledge, to develop, or to see friends and family members. The reasons are numerous and again complex.

There is thus a synergy, or symbiotic relationship between space and movement; and, hence we enter into the realms of travelling into or through space to arrive at a destination. And, from this concept, perhaps one of the biggest 'spaces' that can be envisaged, is the space that lies outside of Earth's atmosphere – that which is above us – or viewed another way, in *outer space*.

Mankind's travel into outer space is a relatively new concept and one which has already led to competitive practices and space-races.[3] These days, there is also an inherent linkage to the concept of virtual travel or communications – where the information and data travels, rather than the actual person travelling to acquire the knowledge.

This paper looks at the concept and progress of European space endeavours;[4] (*those above us*) and as said, appreciating that this is a multi-layered and complex subject, covering many EU areas and policies – this research is confined to the area of global navigation satellite systems, exploring the (historical) development of the European satellite system(s) and the relationship with transport.

The study is therefore undertaken by applying the following research-design approach, to:

- Firstly, consider the origins of global navigation systems, including within Europe; and,
- Secondly, review the development of respective satellite systems (in Europe) commencing with EGNOS and the changing role of the (now) European Global Navigation Satellite Systems Agency.

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Before, turning to the main focus;

- Thirdly, to examine in further detail, the development of the navigations services and systems – with specific focus on 'GALILEO' – the name given to Europe's system – which was declared to become fully operational in 2020.[5]
  In this respect, brief comment is made to the implications of Covid-19.

Finally, the paper concludes with a short discussion of the UK relationship with the European satellite systems, post Brexit.

The legislative (law) approach applied, in this design, relates to identifying and analysing key EU documents (past and present).

1.1. Structural approach

In order to appreciate the design and approach of this paper (and therefore the specific research area) it is perhaps important to firstly appreciate the relationship between the key aspects being discussed; namely as viewed from the current structure/remit of the European Global Navigation Satellite Systems Agency[6] (Figure 1: Organisational structure)

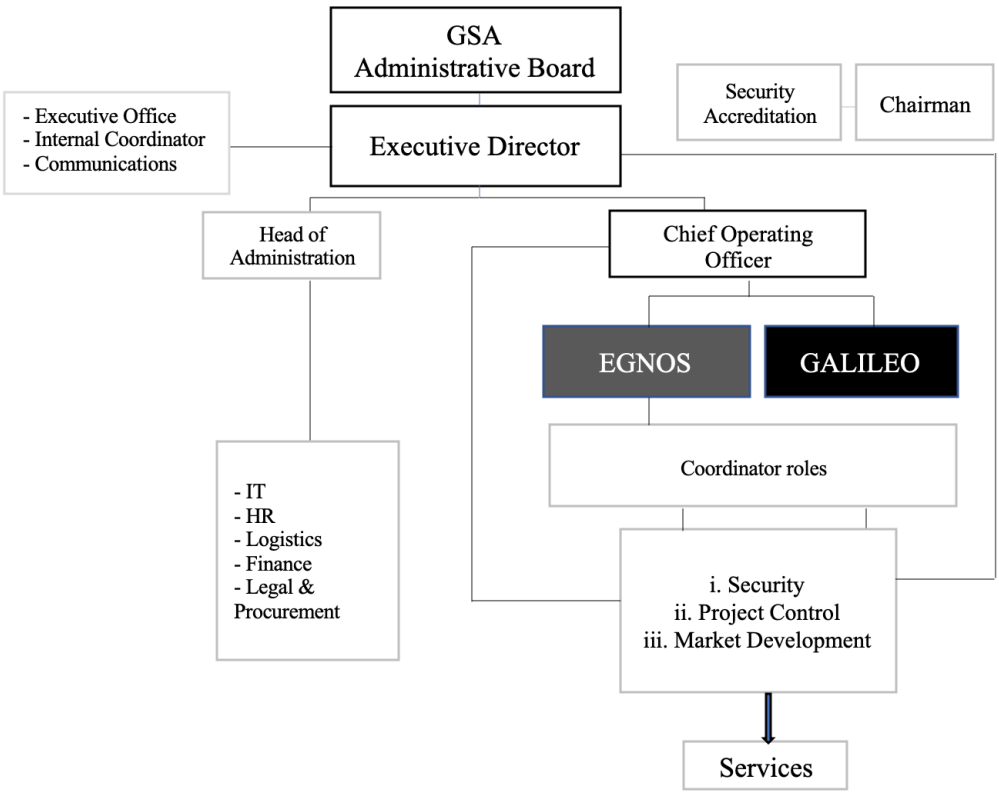

Figure 1: Organisational structure of the European Global Navigation Satellite Systems Agency (Adapted from the website[7])

This paper therefore researches how the current organisational structure has risen in support of the aims of Europe to develop global navigations satellite systems.

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2. Global Navigation Satellite System

2.1. A brief look at the global position

Global navigation satellite system(s) are a relatively new invention which has its origins traceably back to the 1950's and the original space race.[8] However, the US military began experimenting with the technology in earnest in the 1970's.

Today global navigations satellite systems are recognised to refer to a constellation of satellites providing signals from space that transmit positioning and timing data to receivers. The receivers then use this data to determine location. Much is the same way a '*Hoover*' is used to refer to a vacuum cleaner, and certainly from a European perspective, the most commonly referred to name for the global satellite navigation system is 'GPS', taken from the USA system (NAVSTAR[9]) *Global Positioning System*.

Outside of the USA, other systems exist in Russia, which has a system called Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS[10]), with the Chinese equivalent being the BeiDou Navigation Satellite System.[11]

In general, the performance of such satellite navigation systems is recognised to be assessed using four criteria[12]:

1. **Accuracy**: the difference between a receiver's measured and real position, speed or time;
2. **Integrity**: a system's capacity to provide a threshold of confidence and, in the event of an anomaly in the positioning data, an alarm;
3. **Continuity**: a system's ability to function without interruption;
4. **Availability**: the percentage of time a signal fulfils the above accuracy, integrity and continuity criteria.

2.2. European (EU) Origins

In 1993 Europe launched its initial telecommunications satellite.[13] The following year, a Council Resolution on 19 December 1994 identified the relevance and need for a European Global Navigation Satellite System (GNSS).[14] Specifically, it was stated that GNSS was needed for civil use so as to 'contribute to the attainment of important Community objectives, such as the completion of the internal market and the strengthening of economic and social cohesion.' The preamble within the Resolution identified that, the setting-up and development of a satellite navigation system was also aimed at improving the long-term and sustainable mobility of people and goods throughout Europe thus also aiding transport safety, plus assisting in the trans-European networks in the fields of transport, telecommunications and energy infrastructure. The legal basis was stated (by the European Commission) as being in accordance with Article 129 (b) of the then Treaty (the Treaty establishing the European Community.)[15] This specifically is the Trans-European Networks (TENs) chapter.[16]

Recognition was made to the contribution of a European GNSS in respect to transport and the following were cited:

- Resolution on the situation of European civil aviation[17]
- Resolution on telematics in the transport sector[18]

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Prior to this, in, June, 1994, it was acknowledged that Europe needed to act promptly so that control of the entire system did not lay overseas – specifically, from a EU perspective, by way of the civil complement to the American military Global Positioning System (GPS).[19]

The European Parliament (EP) Resolutions of 19 January 1995[20] and 18 November 1994[21] reinforced the need for Europe to play a key role in the implementation of GNSS, and attention was drawn for the need for a coherent and consolidated European strategy to be developed in this field. It was said that this would necessitate a coordinated action across programmes which should be undertaken by the European Space Agency (ESA).[22]

In 1997 a proposal was put forward for a Council Decision on the agreement between the European Community, the European Space Agency and the European Organisation for the Safety of Air Navigation[23] on a European contribution to the development of a global navigation satellite system.[24] Reinforcement was again made in terms of the significance to transport, with specific reference being made to Article 75 of the Treaty,[25] which determined:

> For the purpose of implementing Article 74, and taking into account the distinctive features of transport, the Council shall, acting in accordance with the procedure referred to in Article 189c and after consulting the Economic and Social Committee, lay down:
> (a) common rules applicable to international transport to or from the territory of a Member State or passing across the territory of one or more Member States;
> (b) the conditions under which non-resident carriers may operate transport services within a Member State;
> (c) measures to improve transport safety;
> (d) any other appropriate provisions.

It was stressed once again that the Trans-European Transport Network (TEN-T) recognised the importance, and indeed it necessitated, the implementation of a navigation system which implements satellite technology.[26]

As a consequence of this call, the Council gave a Decision which adopted the proposal, in 1998.[27] Within it, Article 84 was also cited which refers to: transport by rail, road and inland waterway, whilst also stating that this may be laid down and applicable to transport by sea and air transport.[28] This remains still in force.

The Proposal was quite detailed and gave a review of the direction that was to be pursued in terms of a European GNSS. Within this reference was made to the proposal entitled the European Geostationary Navigation Overlay Service (EGNOS) which was accepted by the Inmarsat[29] Council on 21 November 1994 and also on 15 November 1995.

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3. EGNOS

3.1. A brief historical overview: contextualisation

In 1994 the European Council approved the launch of the EGNOS programme.[30] EGNOS marked Europe's first activity in the field of GNSS and is a forerunner to Europe's newer 'Galileo' system.

EGNOS is therefore the first phase (GNSS 1) of the European Union's policy on a global navigation satellite system with the second phase (GNSS 2) being the Galileo programme.

EGNOS was established as a joint project of European Space Agency (ESA), the European Commission and Eurocontrol.[31] On 1 April 2009, after the successful completion of its development, EGNOS was transferred to the European Commission. Hence, the Commission took over ownership of the EGNOS infrastructure from ESA on behalf of the European Union. In this way, EGNOS is said to be technically owned by European citizens. EGNOS Open Service has been available since 1 October 2009 and the positioning data is freely available in Europe through satellite signals to anyone equipped with an EGNOS-enabled GPS receiver.

EGNOS has a clear mandate to aid satellite navigations within Europe and particularly in the area of aviation. The aim of the EGNOS programme was thus to improve the quality of signals from existing global navigation satellite systems.[32]

The UK has had a founding role in the operational management (as assigned by the European Commission) for the service provision and maintenance of EGNOS – this is through the European Satellite Services Provider[33] (ESSP) which is a company founded, in 2001, by seven European air navigation service providers:

- AENA (Spain)
- DFS (Germany)
- DSNA (France)
- ENAV (Italy)
- NATS (United Kingdom)
- NAV (Portugal)
- Skyguide (Switzerland)

EGNOS is a regional (European) satellite-based augmentation system (SBAS). It works via a number of reference stations deployed across Europe, taking GNSS measurements which are transferred to a central computing centre, where differential corrections and integrity messages are calculated.[34] The calculations are then broadcast across the area using geostationary satellites that serve as an expansion of the original data.

The objective of EGNOS, in terms of applying improved performance and accuracy of GNSS's, is hence to enhance safety of transport services across the fields of aviation, maritime and other land-based modes across most of Europe. In the aviation sector GNSS alone (without EGNOS) does not satisfy the strict operational requirements set by the International Civil Aviation Organisation (ICAO) for use in critical flight stages, such as the final approach into airports. Since 2011, EGNOS has been certified for civil aviation use,

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thus satisfying ICAO standards. From a shipping perspective, European EGNOS contributes to successful navigation for all passenger ships and cargo ships larger than 500 gross tonnage, which are regulated.

Since 1 January 2014, the utilisation of EGNOS has been fully delegated to the European GNSS Agency by the European Commission.[35]

3.2. European GNSS Agency (GSA[36])

Initially the GSA[37] was established as a Community Agency,[38] on 12 July, 2004, by Regulation (EC)1321/2004, as a structure for the management of satellite (radio-navigations) programmes in Europe.[39] This Regulation was later amended by Regulation (EC) No 1942/2006. [40] Neither remain in force, the latter having been repealed in 2010.[41] The 2010 Regulation was hence amended by Regulation (EU) 512/2014[42] whereby the GSA was restructured into an Agency of the European Union – called the European GNSS Agency (although still sometimes referred to as the European GSA).

Article 4 refers to the legal status of the European GNSS Agency, stating;[43]

> 1. *The Agency shall be a body of the Union. It shall have legal personality.*
> 2. *In each of the Member States, the Agency shall enjoy the most extensive legal capacity accorded to legal persons under the law…..*

The benefit of GNSS's is continually stressed through the Agency in terms of enhancing not only the safety but the security of persons and goods – that is, within the realms of the movement of both. And, noticeable, overtime, more emphasise has clearly been accorded to the aspect of security, which has become embedded into the operation role of EGNOS and the Galileo systems.

The website for the European GNSS Agency states the following tagline and hence objective for the Agency - namely *linking space to user needs*.[44] In this respect it is said that, '*space is the new technological revolution and it is changing the way we live, work and play.*'[45]

The GNSS Agency states its mission is to:
'*support European Union objectives and achieve the highest return on European GNSS investment, in terms of benefits to users and economic growth and competitiveness*.'[46]

Space equals big money. In 2007, it was identified that the Space market worldwide had a value/worth of €90bn, growing then at 7 per cent per annum.[47] Today's forecast, from the perspective of the GNSS alone, identifies that Europe will have a greater share of the €175 billion global GNSS market due to this innovation.[48] This will see the creation of many new products and services across a wide area of EU policies and initiatives. Globally the GNSS downstream market continues to grow rapidly. The forecast for 2019 predicted that the global installed base of GNSS devices would reach almost €6.5 billion by the end of that year.[49]

Whilst maritime, air and land have always been stressed in terms of identifying the benefit to the various modes – (shipping, manned aviation and train); of late, the importance of GNSS to the evolving and growing area of unmanned aerial vehicles (UAV's: drones) is also being recognised and emphasised. In fact, drones have become a significant GNSS market segment. It is emphasised in particular that as an unmanned transport mode GNSS positioning information helps to enable both safety in operations alongside harmonious drone market

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growth. The drone section now actually exceeds mature segments (such as maritime, aviation and agriculture) in terms of shipments. In the last 3 years the shipments of drones have actually tripled; and, it is anticipated that the growth will continue into the next decade for all drone categories.[50] It is therefore forecast that this will lead to the generation of more than 2 billion EUR revenue from 2029, both from device sales and services.

The increasing use of drones necessitate accurate positional information. It is now being recognised that almost 50% of drone users expect a horizontal accuracy of below 10 cm and 38% a vertical accuracy of below 10cm – this is where EGNOS comes into play in terms of drone functionality.[51]

Alongside the increasing use of GNSS by drones, the European GSA Market Report (2019) identified the recognition of the second developing and important area for GNSS, that of Emergency Response use (including for first responders and search and rescue (SAR) utilisation). It is perhaps obvious, that there is a direct linkage to the use of transport for such operations. The use of GNSS for SAR is particular significant in land, sea and air recoveries, with maritime using beacons, such as Emergency Position Indicating Radio Beacons (EPIRBs) and Personal Locator Beacons (PLBs); and aircraft using - Emergency Locator Transmitters (ELTs) as well as PLBs.

The vision statement of the European GNSS Agency stresses the positive impact of satellite navigation systems within society and to individuals; and, whilst it is stated that this is significant across various areas, the utilisation within the various transport modes is however heavily, once again, emphasised. This therefore reinforces the concept of space, travel/movement and communications being symbiotic and thus shows the interdependency and synergy of these areas.

In this respect, it is stressed further, that the next logical step 'will be the integration of accurate positioning devices into every mobile telephone or similar handheld device, making possible a deep transformation of the way society deals with the dimensions of time and space.'[52]

There are four principle aims assigned to the mission of the European GNSS Agency. These are:[53]

- *Designing and enabling services that fully respond to user needs, while continuously improving the European GNSS services and Infrastructure;*
- *Managing the provision of quality services that ensure user satisfaction in the most cost-efficient manner;*
- *Engaging market stakeholders to develop innovative and effective applications, value-added services and user technology that promote the achievement of full European GNSS adoption;*
- *Ensuring that European GNSS services and operations are thoroughly secure, safe and accessible.*

Galileo is an essential factor related to these aims but the journey to get Galileo operational has not been without challenges.

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4. GALILEO: Background

Albert Einstein called Galileo the "*father of modern science" – expanding man's understanding of the Universe*.[54]

Galileo di Vincenzo Bonaulti de Galilei[55] was born in Italy in 1564. While being widely regarded as a polymath….. a physicist, an engineer, a mathematician and an astronomer. He is said to be the first person to use a refracting telescope to make important astronomical discoveries. He is known to have studied speed, velocity and gravity and is therefore recognised to have made fundamental contributions to the science of inertia, the law of falling bodies, parabolic trajectories and hence the fundamental change of thinking in the study of motion. Given this, Galileo is described as a *Renaissance Genius*,[56] the "father of modern (observational) astronomy"[57] the "father of modern physics,"[58] the "father of scientific methods"[59] and, ultimately, as the "father of modern (or experimental) science.[60]"

It is perhaps fitting therefore that the name Galileo was applied to the European global satellite-based navigation system.

4.1. Origins of Galileo: Stages

In 1999 the Commission issued a Communication entitled Galileo and stressed the need to involve Europe in a New Generation of Satellite Navigation Services.[61] This Communication clearly set out the situation that Europe presently found itself in and the options that were available to it.

The Communication reinforced issues previously identified and faced by Europe[62]due to the reliance on systems from third countries; namely:

- In terms of both sovereignty and security: the fact that Europe's safety critical navigation systems lay outside Europe's control.
- Functioning ability: (the then present) systems could not fully meet civil users' requirements in terms of performance.
- That there was a need to offer some protections: there was a need to ensure that European users were not at risk from changes in the service or excessive future charges or fees, which could arise due to dominant position or virtual monopoly outside of Europe, which would mean it would be difficult to resist such charges (and/or perhaps impossible to develop alternatives quickly).

It was recognised that there were opportunities to work with the US and their GPS and/or the Russian authorities' equivalence - GLONASS. And, hence, it was stressed that Europe had already been scoping choices which had narrowed it down to two key options:

(i) the potential for joint approaches (with the US, the Russian Federation, plus others); and
(ii) clarifying what a European system would look like, plus how much the cost would be.

However, emphasis was accorded to the fact there was the capacity for EU industry to compete in the lucrative market but that Europe's potential to compete would be seriously constrained, if it did not have equal access to the technological developments in the system

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itself.[63] Therefore, the key outcome was the central recommendation that Europe needed to develop its own 'new' satellite navigation constellation, combined with appropriate terrestrial infrastructure: *Galileo*.

The possible method to finance Galileo related to a three-point financing strategy:

- substantial financing at a European level, that being through the EU Budget, notably the Transport (TEN-T), and through ESA;
- establishment of revenue streams, (no doubt requiring regulatory action; and through the,
- development of a public private partnership (PPP).

The follow-up Communication in 2000[64] clarified the four phases, as the;

(1) Definition phase: due to be completed at the end of 2000

(2) Development and validation phase (2001-2005)

- - Overall detailed definition of the segments (space, ground, user);
- - Development of the satellites and ground-based components;
- - Validation of the system "in orbit."

(3) Deployment phase (2006-2007)

a. - Production, launching of the satellites;
b. - Installation of the complete ground segment;

(4) Operating phase (2008 onwards)

- - Satellite renewal, operation of the Centres, maintenance.

4.2. The Galileo constellation

The Galileo concept: ultimately, was to be based on a constellation of 30 satellites placed in a medium earth orbit (at an altitude of approximately 24 000 km) which will continuously cover the entire surface of the earth.

The selected configuration is said to be optimal, as it is said to ensure '*the presence of a minimum of four satellites above any point of the earth at any moment. Indeed, navigation receivers can calculate their position only if they receive simultaneously the signals of a minimum of four satellites*.'[65]

4.3. The relationship of EGNOS to Galileo

The relationship and structure for EGNOS and Galileo was questioned and debated for a period of time.

In the 2000 Communication update[66] it was reiterated as to the positive impact Galileo would have in terms of enhancing the contribution to the good management and safety of all modes of transport, namely by adding to the quality of existing systems by virtue of its global coverage, precision and integrity.

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Initially a Galileo Joint Undertaking was set up in order to complete the development phase of the programme.[67] However, there were noticeable delays in setting this up due to problems within the ESA structure and the relationship with Member States. This subsequently led to a slippage in terms of anticipated completion of certain phases.

EGNOS, as the European precursor to Galileo, was established as a satellite radio navigation system that relies on the American GPS and the Russian GLONASS. A 2003 Communication considered the need and methods for the integration of the EGNOS programme in the Galileo programme.[68] Within it, clear recognition was given to the fact that EGNOS was viewed as an essential step in the development of the European global navigation satellite system, enabling Europe's industry to acquire expertise in the related technologies whereby it was said that the '*know-how accumulated in the framework of the EGNOS programme, both on the technical and institutional level, places Europe in a good position to embark on the ambitious Galileo programme*.'[69] It was also acknowledged that EGNOS provided the "*Galileo brand"* to be immediately recognised on the satellite radio navigation market.

However, despite recognition of the contribution that both EGNOS and Galileo could make to Europe, in terms of being a leader in global navigation satellite systems, further difficulties were encountered which were clearly spelt out in a Communication from the Commission to the European Parliament in 2007.[70] This led to further questions being raised in terms of the relationship between EGNOS and Galileo, the respective governance structure; and, indeed, the direction of Europe in respect to satellite systems.

4.4. Galileo at a cross-road

Whilst the first Galileo experimental satellite was launched in December 2005,[71] the Communication identified that decisions were needed as Galileo (and indeed EGNOS) lay at a cross-roads in terms of the ability to meet phased deadlines and targets – which could impact, not only on costs, but ultimately success in a developing and succeeding in an ever competitive area.

In essence, the European GNSS programmes - Galileo and EGNOS, had accumulated a delay of five years with regard to the initial calendar and deadlines for a number of reasons and at various intervals over the previous seven years, including political, governance and industrial factors.

The 2007 Communication referred to the fact that the Council of Transport Ministers (22 March 2007) requested the Commission to:

- assess and report by the June Council on overall progress of the Galileo project, including reporting on the project cost and financing thereof;
- submit, as soon as possible solutions for securing the long-term public financial obligations;[72]
- assess (assisted by the GSA and ESA) the progress including risks and affordability.

Likewise, the European Parliament, in its Resolution of 24 April 2007,[73] whilst reiterating its support for the Galileo programme, also expressed its concerns about the progress. It therefore called on the Commission to come forward with appropriate proposals, based in

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part on the same points as mentioned by the Council and, in particular, '*for a strengthening of public governance by ensuring political responsibility and leadership of the Commission*.'[74]

One factor questioned, in the Communication, was: *Does Europe need a satellite navigation system?* And, whether in view of the difficulties encountered, asked whether the programme should be pursued or even stopped.

However, all the reasons for the original conception, incentive and motivation were again, not only identified, but reinforced: Europe needed to be in space to compete in a growing industry that would inevitable see a return on the already engaged €2.5 billion in the development of the European GNSS programmes (as of that date[75]). In other words, Europe could not afford not to be, particularly given this enormous investment already i.e. to date. The question(s) therefore, given this acknowledgment, centred around how to deliver on this outlay. This necessitated revisiting the original concept; that said, it was also recognised that any '*radical change in design would lead to the cancellation of the actual industrial contracts in the development phase and therefore to a full re-bidding for the entire programme*.' This would therefore cause a further delay and an even later entry-to-market of a system with the potential of having a '*degraded performances and an undoubtedly low resistance in competition against new systems like GPS-III*.'[76]

Across 2007, several other communications and discussions occurred which considered the project and particularly other ways to financially support the programme, if it was decided it should be continued.[77]

Finally, in, November, 2007, the Transport Council reached a historical conclusions (at its 29/30 November session) in which it announced the next phase – the deployment of Galileo. It was said this would be carried out and financed by the Community. It was at this stage that the Commission declared itself in the new role, namely that of programme manager. Subsequently, due to this clarity, in particular the fact that the European Community was to assume direct responsibility for the deployment of the system together with the additional cost burden, (namely, €2,100 million for the Community budget during the 2007-2013 financial framework) it was deemed that the initial proposal for a Regulation, relating to deployment, should be amended.[78]

The amended text proposed the need to fully incorporate the EGNOS programme, alongside Galileo, as one of the two pillars of the European satellite radio navigation policy.[79] This was subsequently confirmed in Regulation (EC) No 683/2008 which gave the needed clarity, in terms of structure and financing.[80] This included repealing the Galileo Joint Undertaking system.[81]

Reference was made within the Regulation (683/2008) to the fact that the development of satellite navigation was fully in line with the Lisbon Strategy and other Community policies, citing in particular the transport policy, as set out in the Commission's White Paper, of 12 September 2001, entitled 'European transport policy for 2010: time to decide.'[82] Hence, it was identified that the programmes were a key priority of the projects that were included in the Lisbon Action Programme for Growth and Employment (proposed by the Commission and endorsed by the European Council) and were therefore considered also as one of the major pillars of the future European Space Programme.[83]

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Article 22 of Regulation (EC) required a mid-term review of the European satellite navigation programmes to be carried out in 2010. This was submitted to the European Parliament and to the Council, on 18 January 2011, and, as a consequence, this led to a Proposal for a new Regulation.[84] At the same time, the Commission proposed to assign 7000 million Euros to the financing of the European satellite navigation programmes during the next multiannual financial framework, for the 2014-2020 period.

Within the Proposal, reference was made to both the Galileo and EGNOS programmes being "flagship" projects of the Union, and an essential factor to the Europe 2020 strategy and policies for sustainable development.[85] Reference was also made to the updated space strategy[86] and the estimated projected value of both these programmes, estimated to have a cumulative worth of approximately EUR 130 billion in the period 2014-2034.[87]

Most notably the Proposal made reference to the Galileo programme phases, which revealed significant delay and slippage from the 2000 Communication.[88] Whilst the definition phase was identified as being complete, the development and validation phase was identified for completion in 2013, some 8-years later than originally stated. The deployment phase was identified as having been launched in 2008 and was said to be due for completion in 2020; whilst the exploitation phase (to be progressively launched from 2014/15) was also anticipated to be fully operational system, also in 2020.

During the procedural steps of the Proposal being heard and debated, reference was made to the need again for a better governance structure in order to build "repair the damage to market confidence", the need to accelerate the pace of GNSS deployment and market development, especially in light of

(i) cost of Galileo's delay and
(ii) the increasing competition from the US, Russia and China.

In particular, it was cited that China was expanding its military '*Beidou*' satellite navigation system into the global COMPASS system with the intent of offering competitive civil service worldwide by 2020, including within Europe. Hence, there was an identified need for both Galileo and EGNOS to become the GNSS standard in Europe as quickly as possible.[89] During the 3171st Council meeting Transport, Telecommunications and Energy in 2012[90] there was again general consensus given for the new Regulation; and, as a consequence, Regulation (EU) No 1285/2013 of the European Parliament and of the Council repealed both Council Regulation (EC) No 876/2002 and Regulation (EC) No 683/2008.[91] This Regulation remains in force today.[92]

5. GALILEO: Steps towards 2020

Regulation (EU) No 1285/2013 articulated the significant of 2020 to the Galileo programme. Article 3 referred to the fact that both the deployment phase and the exploitation phase were scheduled for completion by 31 December 2020.

From 2013 onwards there were a number of measures taken to underline the importance of using Galileo system within Europe. The Space Strategy for Europe[93] adopted in 2016, announced measures introducing the use of the Galileo positioning and navigation services in mobile phones. And in its conclusions of 5 December 2017, as part of the required mid-term review, the Council emphasised it support for the development of a strong downstream

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market for space-based applications and services.[94] As part of this it stressed that adequate measures, including regulatory ones (where appropriate) should be taken to achieve the full compatibility of devices sold in the Union with the Galileo system, encouraging the application of Galileo-ready devices in the global market.

5.1. Mid-term review

Article 34 of Regulation 1285/2013 called for a mid-term review.[95] (There were a number of documents associated with this review and the below is extracted from these.[96])

The interim evaluation assessed the progress of the Galileo and EGNOS programmes towards their objectives over the period 2014-2016. The aims stated were threefold, namely:

(i) to inform stakeholders and the public on the status of the programmes;
(ii) to contribute to improving their implementation; and
(iii) to provide evidence-base for preparing the subsequent programming period.

The review stated that the Galileo and EGNOS programmes had achieved all the milestones set for the period and that progress was positive in terms of delivering on all programme implementation objectives set for 2020.

It was identified that the Galileo programme had recovered from the initial delay, caused in the previous period, in respect to launching satellites. Reference was made that this delay was partly due to the wrong insertion in orbit of the first two Full Operational Capability (FOC) satellites.[97]

The review identified that the Galileo programme had now succeeded in the deployment of a total of 14 satellites launched in that specific review period (in addition to the 4 satellites launched in 2011). However, it was identified that the procurement of the remaining satellites (to complete the constellation of 24 satellites plus six in orbit spares), planned for 2016, had been postponed to 2017.

It was also recognised that some Member States were expressing dissatisfaction and concern about the incomplete coverage of the then EU-28 States with the EGNOS services. However, positively it was reported, that as of the end of 2016, the Galileo and EGNOS programmes were implemented within the budget limits set by the GNSS Regulation. Comment was made that this was largely due to the governance system that was now in place, and, it was also said that the performance of the GSA had been positive overall.

The strategic objectives of the Galileo and EGNOS programmes were reinforced[98] in terms of:

1. guaranteeing continuous and autonomous access to satellite navigation services for Europe interoperable with other GNSS systems, notably US GPS;
2. ensuring resilience of the European economic infrastructure;
3. maximising socio-economic benefits for European economy and society;
4. building Europe's technical capacity to develop, deploy and operate complex large-scale space infrastructures.

In general, there was fortification given to the fact that the original rationale for EU intervention in the field of satellite navigation and the related objectives were still highly

relevant to society and the EU economy. However, it was also stated that there had been, and continued to be, challenges in realising the objectives. This said, it was acknowledged that society was becoming ever increasingly dependent on satellite navigation applications and services, including in terms of human safety.

At the end of 2018, Regulation (EU) 2019/320[99] was adopted (Article 2 stating it would become applicable as from 17 March 2022). This concerned caller location in emergency communications from mobile devices. Within the Regulation, reference was made to the significance of the single European emergency call number '112' as part of the benefit of the Galileo system. It was identified that earlier legislation[100] already required receivers in 112-based eCall in-vehicle systems be compatible with the positioning services provided by the Galileo and the EGNOS systems.

5.2. Challenges: will Galileo be realised in 2020?

On 15 December 2016, Galileo started offering, initial, or Early Operational Capability (EOC).[101] At the time, Paul Verhoef, ESA's Director of the Galileo Programme and Navigation-related Activities, said, "*Today's announcement marks the transition from a test system to one that is operational.*" However, he acknowledged, "*Still, much work remains to be done*."[102]

In July, 2019 the following comments were headlined, *"Europe Billed Galileo as Its Answer to GPS. It's Been Mostly Down for Days.*"[103] The press coverage referred to 'mishap[s]' befalling the programme – since the pilot phase of 2016. However, it also commented that users were unlikely to have even noticed the outage as phones and other devices are also programmed to other systems conjunction such as GPS, Russia's Glonass system and even China's *Beidou* in conjunction with Galileo. The GSA's official comment acknowledged the service was down "affected by a technical incident related to its ground infrastructure."[104] It identified that the incident had led to a temporary interruption to Galileo (with the exception of the Galileo Search and Rescue (SAR) service).

In 2017, the BBC had raised concerns that the onboard atomic clocks that drive the satellite-navigation signals on the Galileo network have been failing at an alarming rate, identifying that across the 18 satellites now in orbit, nine clocks have stopped operating.[105]

The initial plan was for Galileo to be fully operational before the end of the first decade of the new millennium. However, as it has continued to suffer a string of delays, cost have inevitably sky-rocketed. There have been various calculations as to the overall cost to build and operate Galileo.[106] The UK Government stated that the "*estimated costs for the Galileo programme in its entirety are less transparent than might be wished for*."[107]

It therefore remains questionable as to the overall cost of Galileo; and indeed, when it will be completed. Whilst some challenges arguably could have been foreseen and factored in, other perhaps could not.

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6. Entering 2020: A year like no other!

6.1. Covid-19

Entering 2020: who could have predicted the challenges that Europe, indeed, the world, faced due to what remains a global pandemic, declared by the World Health Organization (WHO) on 11 March.[108] The new type of coronavirus (SARS-CoV-2) was first 'officially' identified in China in December 2019.[109] Since then, there has been a ripple affect across the globe. Whilst comments as to the effects of completion of Galileo are difficult to source, it is known that digital advancement, in the shape of the roll-out of 5G has been hampered and delayed.[110]

Ironically, as European States start to plan their phased recoveries from the lockdown caused by the COVID-19 pandemic, the positioning delivered through satellite navigation (satnav) is becoming more critical than ever. Since the outbreak, many apps have been developed that use satnav-based location data to monitor the global spread of the disease. Determining accurate location is essential when assessing, monitoring and mapping the spread of a disease. Satnav based apps are even been used to help people to implement social distancing in queues and other public spaces.[111] This said, with the promotion of the advantages of satnav systems, there have also come concerns that Galileo could be used to track individuals mobile phones as part of the monitoring or surveillance process. In this regard, the EU has striven to convey the message that the use of technology and related data (in particular concerning mobile applications) remains anonymised and the benefits should far outweigh any concerns.[112]

6.2. The UK

The UK joined the then European Economic Community (now known as the European Union) in 1973. Some 43 years later, after a public referendum in June, 2016, the UK decided to leave the Union. However, it was not until 31 January 2020 that the UK formally left – this is viewed as '*Brexit Day*'. Currently, until the end of 2020, the UK is in a transition or in an implementation period. This began immediately after Brexit day and is due to end on 31 December 2020, which ironically coincided with the anticipated realisation, or, fully operational completion, 'deployed' system, phase of Galileo.

This transition phase allows time for the UK to negotiate the terms of the exit with the EU (the now 27 member states that comprise of it). Talks have and continue to centre across many policy areas; however, whilst the media (pre-Covid-19, at least) have reported on these aspects and made mention to key areas, largely concerned with the free movement of goods and persons, little reference has been made to the linked element of movement related to navigations systems, to which the UK has invested time and money in, contributing vast sums across the extended years. In essence, there has remained uncertainty as to the impact to the UK upon leaving the EU in respect to Galileo, and, in general, the European GNSS.

By all accounts, the UK could be viewed as being naïve in terms of not anticipating that the EU would seek to stop the UK having full access (once it had left the EU) with it being reported that the UK government was somewhat taken aback that the EU plans to exclude Britain from the Galileo satellite programme (or parts of it) due to Brexit.[113]

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In December 2018 it was reported that the UK was poised to walk away from "negotiations over its post-Brexit involvement in the European Union's Galileo global navigation satellite system (GNSS)"[114] as the EU began excluding the UK from security aspects of the project's development in preparation for Brexit. The UK Government's press release was titled, 'UK to tell EU it will no longer seek access to secure aspects of Galileo.'[115] Within this statement, reference was made to the fact that British Armed Forces were due to have access to Galileo's encrypted system when it is now said to become fully operational in 2026. However, according to the the National Cyber Security Centre and Ministry of Defence expressed the view that, "it would not be in the UK's security interests to use the system's secure elements if it had not been fully involved in their development."[116]

Earlier in 2018 it was said that the UK was pondering partnering with another country, such as Australia, to build a new GNSS with the British government also looking to study the potential of building an independent alternative to Galileo.[117] However, Christopher Newman, a professor of space law and policy at Northumbria University, has indicated that "[t]he cost of developing a national replacement has been estimated to be in the region of £3 billion to £5 billion ($3.8 billion to $6.3 billion)" which he states "is a significant expenditure when considering that the current U.K. space budget is only £370 million ($470 million) per year with the majority of that going to fulfil U.K. commitments to ESA."[118] Though, this projection fails to take into account the enormous investment in the European Space and GNSS programmes, which potentially could be lost or not fully maximised and/or returned on – in respect to the substantial investment in this space area. According to one report the UK has contributed in the region of £1.2 billion on the Galileo project alone.[119]

Conversely, it has also been reported that engineering academics at Sussex University have drawn-up plans for a Galileo replacement that would give the UK a more effective satellite navigation system but at a fraction of the price of the EU project.[120]

The direction being expressed indicates that the UK has and continues to explore options to deploy in space and build its own Global Navigation Satellite System that can "help guide military drones, run energy networks and provide essential services for civilian smart phones."[121] Whilst also looking, at the same time to "work with the US to continue accessing its trusted GPS system."[122] A (2018) BBC report also pointed to the fact that the UK was looking to claw back some of its investment, asserting that the EU repay £1bn if it continued to push for exclusion from the Galileo satellite navigation system after Brexit. At the same time, David Davis's (of the then Brexit department) indicated, that without UK contributions and involvement, the EU may have to find an extra €1bn (£876m).[123] There is the potential that the project will suffer further delays, initially predicted, in 2018, to be up to three years without British technology.[124] As it is, the (updated) date proposed for realising a fully operational Galileo system in 2020 has invariable now been pushed back again with estimates, as above, extending past 2023 to 2026.[125]

The UK is recognised to be a world-leader in developing satellite technology with Britain having a 40% share of the global export market for small satellites. It also makes major components for one in four of the world's telecommunications satellites."[126]

The UK is advocating that it has played an "integral part in designing, developing and managing Galileo to date, particularly the delivery of payloads for satellites, the ground control segment and the development of the PRS software."[127] The UK has also aided to

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support Galileo's coverage by means of hosting two sensor stations at secure locations in the south Atlantic.[128] However, due to the 'consequence of the UK withdrawal from the EU' the back-up security monitoring centre for the programme has now been relocated to Spain from the UK.[129]

In 2020, it is still said that the UK is looking at variable access scenarios,[130] with the UK Space Agency reportedly stating that it would "not be drawn on the fate of those shifted onto other work" …reaffirming, that, the "UK will continue to play a leading role in European Space Agency programmes, from missions to Mars to Earth observation and advanced telecommunications. The work to develop a UK Global Navigation Satellite System, as an alternative to the EU Galileo system, [was said to be] progressing well."[131] However, other reports have pointed to the fact that the UK has had to put some of its plans and aspirations on hold due to costs being higher than those initially envisaged.[132]

6.2.1. The 2020 affect to UK's space endeavours: post Brexit

According to the UK Governments (latest) position, after 1 January, 2021, any contractor working on the programme should contact the relevant contracting authority to make sure that arrangements were still in place to comply with the conditions of the contract and to avoid possible penalties.[133]

The advice being conveyed to users is that UK businesses and organisations will continue to be able to use "the freely available 'open' signal to develop products and services for consumers, and will be able to continue using the open position, navigation and timing services provided by Galileo and EGNOS."[134]

However, this is not the same for the following areas, whereby after 2020 all involvement and access ceases in relation to:

- the use of Galileo (including the future Public Regulated Service (PRS)) for defence or critical national infrastructure;
- access to the encrypted Galileo PRS;
- and any future development of Galileo projects

The PRS has been enforced in statutory law in Britain.[135] Access to PRS is controlled through operational and technical means, including governmental grade encryption. Therefore, limited or no access would impact upon other areas (outside the military) that have a public safety and emergency service role including:

- fire brigades
- health services (ambulance)
- humanitarian aid
- search and rescue
- police
- coastguard
- border control
- customs
- civil protection units.

The UK seems resolved to the fact that after 1 January 2021 it will not have access to key aspects of Galileo that it has contributed to and at the same time it has delayed its own replacement system, an independent sovereign satellite navigation system that it stated would

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be a symbol of post-Brexit independence. Similar to Galileo, disagreement, internally, has arisen over the scope and costs of the multibillion-pound space project.

7. Conclusion

Initially, Galileo was supposed to be fully operational by 2008, although it was pushed back to 2020. The GSA website still states that it expects all Galileo services to be available once the satellite constellation and ground infrastructure are completed, which is says is "expected to happen by 2020."[136]

Today Galileo is even behind this schedule and hugely over budget with costs continuing to rise and no transparent date being openly declared as to when it will finally become fully operational and having full capabilities (FOC). One of the most realistic forecasts seems to point to 2026 (at the earliest).

Currently, the European GNSS only offers initial services from Galileo, meaning navigation signals come from 26 satellites. Only when the 30 Galileo satellites are in their final orbit and fully deployed will the European satellite navigation system be complete and fully operational.

In terms of costs, the EU was also unable to stay to its original plan. According to statements, in 1999, it had budgeted between 2.2 and 2.9 billion euros for the construction of the system; whereas, the EU revised budget provided for 7.2 billion euros to be spent on the construction of the system by 2020 — plus a further 3 billion euros for its operation.[137] With the extended date to completion now six years in the future these costs will once again rise.

Whilst all reports seem to continuously support the need for a European Global Satellite Navigations System to reduce reliance on the American GPS system and rival other competitors such as the Russian GLONASS system and the newer Chinese equivalent - COMPASS (and *Beidou/Beidou-2)* – this huge delay must surely compromise some of the very objectives and arguments put forward advocating the need for a standalone European system.

Galileo was always said to be a valuable asset in terms of contributing to European safety and the safety/security of its citizens. The advantages of utilising Galileo has often been cited in terms of the development of numerous applications in areas that are associated, directly or indirectly, with Community policies, such as transport (positioning and measurement of the speed of moving bodies – including aviation), motorway tolls, and related insurances; alongside law enforcement (surveillance of suspects, measures to combat crime), customs and excise operations (investigations on the ground, etc.), agriculture (grain or pesticide dose adjustments depending on the terrain, etc.) and fisheries (monitoring of boat movements).

There is little doubt that space will increasingly be the frontier that man will continuously turn to, to aid and address problems and issues on earth.[138] However, this comes at a huge financial cost.

For the next phase of the EU bloc's long-term budget, running from 2021 to 2027, the European Commission has proposed the allocation of 16 billion euros, for its space

programme, including Galileo.[139] Elżbieta Bieńkowska, the Commissioner for the Internal Market, Industry, Entrepreneurship and SMEs issuing a statement in 2019 stated the following:

> "*space technology, data and services have become indispensable in the daily lives of Europeans….. The new EU Space Programme will not only do that, but also address global challenges, such as fighting climate change, a transition to a low-carbon economy, smart mobility and digital economy. More will be invested in space activities to adapt to new needs and technologies, while reinforcing Europe's autonomous and secure access to space……. Space matters for Europe."*[140]

Space also matters for the UK – although it now stands in a somewhat precarious position, particularly in terms of utilising satellite navigation systems for security (military) and some safety (public service) applications directly linked to PRS. The UK has made a huge contribution to the development of Galileo. The withdrawal away from the EU comes at arguably both a financial cost as well as having potential implications to citizens of the UK (in terms of protection viewed across the area of jobs and invariably safety/security and advancement - *economic growth and competitiveness*).

Galileo has presented massive challenges to the EU and seen a number of revisions to governance and administration systems to get it where it is today, but it is still not complete. The UK stands to experience the same, or similar, should it pursue its own version in the future. Inevitably, there are lessons that can and should be learnt but these should not be underestimated. Increasingly we will rely on communication systems that utilise satellite technology – mankind will continue to want to travel; stifled in 2020 by a virus that actually swept across the Earth because of mankind's reliance on various transport systems. Ironically, we turned to Space and to virtual communications systems in a period of uncertainty, reinforcing, once more, that there remains merit and worth of pursuing satellite navigation systems to the benefit of mankind – *whatever the cost!*

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[1] See Sarah Jane Fox, SPACE: The race for mineral rights. '*The sky is no longer the limit.'* Lessons from Earth. *Resources Policy* (2016) Vol. 49, Pages 165-178.
Discussions within relate to the work (amongst others) of Stephen Rubenstein Colonialism, the Shuar Federation, and the Ecuadorian state. (2001) Environment and Planning D: Society & Space. 19:263-93. Philip Steinberg. The maritime mystique: Sustainable development, capital mobility and nostalgia in the world ocean. (1999) Environment and Planning D: Society & Space. 17:403-26.

[2] Sarah Jane Fox, Policing Mining: in outer-space *Greed and Domination vs. Peace and Equity A governance for humanity!* (2019) *Resources Policy* 64 101517 [https://doi.org/10.1016/j.resourpol.2019.101517]

[3] Ibid.
Sarah Jane Fox, SPACE: The race for mineral rights. '*The sky is no longer the limit.'* Lessons from Earth. *Resources Policy* (2016) Vol. 49, Pages 165-178.

[4] Since the 1990s, the EU has been developing a space policy which looks to ensure independence from other space powers, in particular through the development of programmes and applications in key industrial sectors such as communications, security, emergency services, navigation systems, information, event broadcasting, climate change, weather forecasting, etc.
As reiterated within the recent Opinion of the European Economic and Social Committee, which made a 'Proposal for a Regulation of the European Parliament and of the Council establishing the space programme of the Union and the European Union Agency for the Space Programme and repealing Regulations (EU) No 912/2010, (EU) No 1285/2013, (EU) No 377/2014 and Decision 541/2014/EU' (COM(2018) 447 — 2018/0236 (COD))
EESC 2018/02993. OJ C 62, 15.2.2019, p. 51–55
[5] "The constellation is expected to be completed by 2020, when it will include 24 satellites and 6 spare satellites." https://ec.europa.eu/growth/sectors/space/galileo_en
[6] As discussed further within 3.2. of this paper.
[7] European Global Navigation Satellite Systems Agency
https://www.gsa.europa.eu/gsa/organisation
[8] See NASA: https://www.nasa.gov/directorates/heo/scan/communications/policy/GPS_History.html and 'The Origin of Global Positioning System' within the following link:
https://www.rewiresecurity.co.uk/blog/gps-global-positioning-system-satellites.
[9] Originally NAVSTAR – GPS.
[10] The Government of the Russian Federation, approved GLONASS by its Decree No. 587 of 20 August 2001, as a Federal Task Program on the Global Navigation System (GNS)
(https://gssc.esa.int/navipedia/index.php/GLONASS_Future_and_Evolutions).
[11] This began operating in 2018.
[12] As stated by the Global European Satellite Navigation Systems Agency (GSA):
https://www.gsa.europa.eu/european-gnss/what-gnss
[13] As stated by the Global European Satellite Navigation Systems Agency (GSA)
https://www.gsa.europa.eu/about/what-we-do/services
[14] Council Resolution of 19 December 1994 on the European contribution to the development of a Global Navigation Satellite System (GNSS). Official Journal C 379, 31/12/1994 P. 0002 – 0003.
[Also see the discussions on EGNOS]
[15] Codified version of the Treaty Establishing the European Community. OJ C 224, 31.8.1992, p. 6–79.
Article 154 (ex Article 129b) – Title XV.
[16] Article 154 TEC initially became Article 154 TFEU (Treaty of Lisbon) before the renumbering of the Treaty made it into Article 170 TFEU in the consolidated version (OJ 17.12.2007 C 306/217).
[17] OJ No C 309, 5. 11. 1994, p. 2.
[18] OJ No C 309, 5. 11. 1994, p. 1.
[19] Commission issued Communication "Satellite Navigation Services: a European Approach" (COM (94)248 final). This also included a draft Council Resolution on the subject. The Communication, was part of the Action Plan "Europe's Way to the Information Society." [Also see the discussions below on EGNOS].
[20] Cornelissen report on GNSS (A4-88/95), on behalf of the Committee on Transport and Tourism.
[21] Castellina, Cornelissen report on a specific programme for RTD in the field of transport (A4-65/95), on behalf of the Committees on Research and Technology and Transport.
[22] European Space Agency was created in the mid 1970's by merging the European Launcher Development Organisation (ELDO) and the European Space Research Organisation (ESRO), both established in 1964. The European Space Agency was established by the Convention of the European Space Agency opened for signature in Paris on 30 May 1975 (hereinafter referred to as 'ESA.'
https://www.esa.int/About_Us/ESA_history/A_history_of_the_European_Space_Agency
[23] The European Organisation for the Safety of Air Navigation established by the Convention relating to Cooperation for the Safety of Air Navigation of 13 December ·1960, as amended by the Protocol of 12 February 1981 (hereinafter referred to as "EUROCONTROL").
[24] Submitted by the Commission on 23 September 1997. COM(97) 442 final - 97/0231 (CNS.)
Official Journal C 337, 07/11/1997 P. 0037
[25] Article 75 within the Treaty establishing the European Community - part three: Community Policies - Title IV: The Transport Chapter (within the codified version: Official Journal C 224, 31/08/1992 P. 0027).
Now Title VI of the TFEU which reads (identical as follows):
Transport
Article 90 (ex Article 70 TEC)
The objectives of the Treaties shall, in matters governed by this Title, be pursued within the framework of a common transport policy.

Article 91 (ex Article 71 TEC)
1. For the purpose of implementing Article 90, and taking into account the distinctive features of transport, the European Parliament and the Council shall, acting in accordance with the ordinary legislative procedure and after consulting the Economic and Social Committee and the Committee of the Regions, lay down:
(a) common rules applicable to international transport to or from the territory of a Member State or passing across the territory of one or more Member States;
(b) the conditions under which non-resident carriers may operate transport services within a Member State;
(c) measures to improve transport safety;
(d) any other appropriate provisions.

[26] The Council and the Parliament also adopted Community guidelines for the development of the Trans-European Transport Network in June 96. These guidelines justify Community action in the navigation and positioning sector. O.J. No. L228 of 9.9.1996.

[27] 98/434/EC: Council Decision of 18 June 1998 concerning the Agreement between the European Community, the European Space Agency and the European Organisation for the Safety of Air Navigation on a European contribution to the development of a global navigation satellite system (GNSS).
OJ L 194, 10.7.1998, p. 15–15.

[28] Official Journal C 224, 31/08/1992 P. 0028.
Now Article 100 (TFEU) (ex Article 80 TEC)

[29] Described as a pioneer and world leader in mobile satellite communications. It was set up by the International Maritime Organization (IMO) in 1979 to provide a satellite communications network that would aid to protect the lives of mariners anywhere at sea. They operate by meeting the stringent requirements of various other transport sectors such as Global Maritime Distress and Safety System (GMDSS) and the International Civil Aviation Organization (ICAO) for global safety communications.
https://www.inmarsat.com/about-us/who-we-are/

[30] EGNOS, as a concept, was first mentioned in a communication of the European Commission of 14 June 1994 [as above: in COM (94) 248 final]. It was adopted by the Council of the European Union in its resolution of 19 December 1994 on the European contribution to the development of a global navigation satellite system [OJ C 379, 31.12.1994, page 2] and at its meeting of 14 March 1995, where it called on the Commission to take all necessary steps to lease Inmarsat transponders for EGNOS [1834th Council meeting on transport in Brussels, 13 and 14 March 1995; point 11].

[31] The development of EGNOS was the result of a tripartite agreement between the ESA, the European Commission and Eurocontrol (the European Organisation for the Safety of Air Navigation). The agreement having been signed in June 1998.

[32] Regulation (EC) No 683/2008 of the European Parliament and of the Council of 9 July 2008 on the further implementation of the European satellite navigation programmes (EGNOS and Galileo)
OJ L 196, 24.7.2008, p. 1–11.

[33] https://www.essp-sas.eu

[34] https://www.gsa.europa.eu/egnos/what-egnos

[35] https://egnos-user-support.essp-sas.eu/new_egnos_ops/egnos-system/about-egnos

[36] Sometimes cited as EGSA – European GSA

[37] European GNSS Supervisory Authority (GSA)

[38] The Authority was recognised as an Community agency (then meaning - a body within the meaning of Article 185 of Council Regulation (EC, Euratom) No 1605/2002 of 25 June 2002 on the Financial Regulation applicable to the general budget of the European Communities).

[39] Council Regulation (EC) No 1321/2004 of 12 July 2004 on the establishment of structures for the management of the European satellite radio-navigation programmes. OJ L 246, 20.7.2004, p. 1–9

[40] Council Regulation (EC) No 1942/2006 of 12 December 2006 amending Regulation (EC) No 1321/2004 on the establishment of structures for the management of the European satellite radio-navigation programmes
OJ L 367, 22.12.2006, p. 18–20

[41] Regulation (EU) No 912/2010 of the European Parliament and of the Council of 22 September 2010 setting up the European GNSS Agency, repealing Council Regulation (EC) No 1321/2004 on the establishment of structures for the management of the European satellite radio navigation programmes and amending Regulation (EC) No 683/2008 of the European Parliament and of the Council, OJ L 276, 20.10.2010, p. 11–21.
See further discussions within Section of this paper 4.4. *Galileo – at a cross-roads.*

[42] Regulation (EU) No 512/2014 of the European Parliament and of the Council of 16 April 2014 amending Regulation (EU) No 912/2010 setting up the European GNSS Agency. OJ L 150, 20.5.2014, p. 72–92

[43] Consolidated version - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02010R0912-20140523
ELI: http://data.europa.eu/eli/reg/2010/912/2014-05-23

[44] https://www.gsa.europa.eu/gsa/about-gsa

[45] Ibid.
[46] Ibid.
[47] Commission Communication of 26 April 2007 on European Space Policy. COM(2007) 212 Final. Brussels, 26.4.2007
[48] https://www.gsa.europa.eu/european-gnss/galileo/galileo-european-global-satellite-based-navigation-system
[49] GSA-GNSS Market Report No. 6. Accessible via: https://www.gsa.europa.eu/system/files/reports/market_report_issue_6_v2.pdf
[50] Sarah Jane Fox, THE RISE OF THE DRONES: *Framework and Governance – Why risk it!* (2017) *82 J. Air L. & Com.* 683-715
Sarah Jane Fox, POLICING: MONITORING, INVESTIGATING and PROSECUTING: Drones. (2019) European Journal of Comparative Law and Governance 6, 1-57
[51] GSA-GNSS Market Report No. 6. Accessible via: https://www.gsa.europa.eu/system/files/reports/market_report_issue_6_v2.pdf
[52] https://www.gsa.europa.eu/gsa/about-gsa.
[53] Ibid.
[54] http://www.nmspacemuseum.org/halloffame/detail.php?id=108
[55] Often referred to as Galileo Galilei.
[56] D. Whitehouse, *Renaissance Genius: Galileo Galilei & His Legacy to Modern Science*. Sterling Publishing. 2009 p. 219.
[57] C. Singer, A short History of Science to the Nineteenth Century. Clarendon Press (1941) p. 217.
[58] D. Whitehouse, *Renaissance Genius: Galileo Galilei & His Legacy to Modern Science*. Sterling Publishing. (2009) p. 219.
[59] Thomas Hobbes, *Critical Assessments,* Volume 1. Preston King. (1993) P. 59.
[60] http://www.nmspacemuseum.org/halloffame/detail.php?id=108
[61] Galileo: Involving Europe in a New Generation of Satellite Navigation Services
COM (1999) 54 Final, Brussels, 10.02.1999.
https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:51999DC0054&from=EN
[62] Communication 'Towards a Trans-European Positioning and Navigation Network - including a European strategy for Global Satellite Navigation Systems (GNSS),' COM (98) 29 final of 21 January 1998
[63] Galileo: Involving Europe in a New Generation of Satellite Navigation Services
COM (1999) 54 Final,10.02.1999. Brussels
[64] Commission Communication to the European Parliament and the Council On GALILEO, COM (2000) 750 Final, 22.11.2000. Brussels
[65] As explained in the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - GALILEO at a cross-road: the implementation of the European GNSS programmes {SEC(2007) 624}. COM/2007/0261 Final. 16.5.2007. Brussels.
[66] Commission Communication to the European Parliament and the Council On GALILEO. COM (2000) 750 final. 22.11.2000. Brussels.
[67] Council Regulation (EC) No 876/2002 of 21 May 2002 setting up the Galileo Joint Undertaking, published in Official Journal L 138 of 28 May 2002, p.1.
Following its dissolution, the Galileo Joint Undertaking was transferred, according to the relevant rules of its Statutes, to the Authority (European GNSS Supervisory Authority – GSA; the pre-runner of the European GNSS Agency) – under Council Regulation (EC) No 1321/2004 of 12 July 2004 on the establishment of structures for the management of the European satellite radio-navigation programmes. OJ L 246, 20.7.2004, p. 1–9.
[68] Communication from the Commission to the European Parliament and the Council - Integration of the EGNOS programme in the Galileo programme. COM/2003/0123 Final. 19.3.2003. Brussels
[69] Ibid.
[70] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - GALILEO at a cross-road: the implementation of the European GNSS programmes {SEC(2007) 624}. COM/2007/0261 Final. 16.5.2007. Brussels
[71] This was related to the EU-US Agreement on the full interoperability of the GPS and Galileo open signals effectively establishing the global standard for satellite navigation. EU-US Agreement on the promotion, provision and use of Galileo and GPS satellite based navigation systems and related applications, June 2004.
[72] As had been requested in the Council conclusions of October 2006, including a scenario for the earliest possible provision of EGNOS satellite navigation services as precursor to Galileo.
[73] European Parliament Resolution of 26 April 2007 on the Galileo concession contract negotiations.

[74] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - GALILEO at a cross-road: the implementation of the European GNSS programmes {SEC(2007) 624}. COM/2007/0261 Final. 16.5.2007. Brussels.
[75] As referred to within the above:
"*The EU and ESA budgets combined include the IOV contract (1.5 B€), the EGNOS costs (0.7 B€) and ESA and EU research over the years."*
[76] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - GALILEO at a cross-road: the implementation of the European GNSS programmes {SEC(2007) 624}. COM/2007/0261 Final. 16.5.2007. Brussels.
[77] For example:
Communication from the Commission to the European Parliament and the Council - Progressing Galileo: re-profiling the European GNSS Programmes {SEC(2007) 1210} COM/2007/0534 Final. 19.9.2007. Brussels.
[78] The proposal was initially put forward on 14 July 2004, whereby the Commission adopted a proposal for a Regulation of the European Parliament and of the Council on the implementation of the deployment and commercial operating phases of the European programme of satellite radio navigation.
Procedure 2004/0156/COD - COM (2004) 477.
[79] See 1.1. (of this paper) current organisational structure of the European GSA.
[80] Regulation (EC) No 683/2008 of the European Parliament and of the Council of 9 July 2008 on the further implementation of the European satellite navigation programmes (EGNOS and Galileo)
OJ L 196, 24.7.2008, p. 1–11.
[81] Article 23 (Ibid) referred to the repealing of Article 7 (with effect from 25 July 2009) of Council Regulation (EC) No 876/2002 of 21 May 2002 setting up the Galileo Joint Undertaking (OJ L 138, 28.5.2002, p. 1. Regulation as amended by Regulation (EC) No 1943/2006 (OJ L 367, 22.12.2006, p. 21).
[82] Brussels, 12.9.2001 COM(2001) 370 final. The white paper [COM(2001)370, 12/09/2001]
[83] Commission Communication of 26 April 2007 on European Space Policy. COM(2007) 212 Final. Brussels, 26.4.2007.
[84] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the implementation and exploitation of European satellite navigation systems. COM/2011/0814 final - 2011/0392 (COD). Brussels, 30.11.2011
[85] For example: Commission Communication of 17 November 2010 entitled 'An integrated industrial policy for the globalisation era: putting competitiveness and sustainability at centre stage.' COM(2010) 614 final/2.
[86] Communication adopted on 4 April 2011 by the Commission entitled 'Towards a space strategy for the European Union that benefits its citizens.' COM(2011) 152.
[87] For example: Commission Communication of 17 November 2010 entitled 'An integrated industrial policy for the globalisation era: putting competitiveness and sustainability at centre stage.' COM(2010) 614 final/2.
[88] Referred to earlier in 4.1., the Commission Communication to the European Parliament and the Council On GALILEO, COM (2000) 750 Final, 22.11.2000. Brussels.
[89] Opinion of the European Economic and Social Committee on the 'Proposal for a Regulation of the European Parliament and of the Council on the implementation and exploitation of European satellite navigation systems' COM(2011) 814 final — 2011/0392 (COD) OJ C 181, 21.6.2012, p. 179–182.
[90] Luxembourg, 7 and 8 June, 2012.
[91] Regulation (EU) No 1285/2013 of the European Parliament and of the Council of 11 December 2013 on the implementation and exploitation of European satellite navigation systems and repealing Council Regulation (EC) No 876/2002 and Regulation (EC) No 683/2008 of the European Parliament and of the Council
OJ L 347, 20.12.2013, p. 1–24. ELI: http://data.europa.eu/eli/reg/2013/1285/oj
[92] Noting that a Proposal has been made for a new encompassing Regulation:
Opinion of the European Economic and Social Committee on 'Proposal for a Regulation of the European Parliament and of the Council establishing the space programme of the Union and the European Union Agency for the Space Programme and repealing Regulations (EU) No 912/2010, (EU) No 1285/2013, (EU) No 377/2014 and Decision 541/2014/EU' (COM(2018) 447 — 2018/0236 (COD))
EESC 2018/02993. OJ C 62, 15.2.2019, p. 51–55
[93] Communication from the Commission to the European Parliament, the Council, the European and Social Committee and the Committee of the Regions — Space Strategy for Europe (COM(2016) 705 final).
[94] Council Conclusions of 5 December 2017 on 'The Mid-term Evaluation of the Galileo and EGNOS programmes and of the performance of the European GNSS Agency', 15435/17.
[95] Article 34 of the Regulation (EU) No 1285/20131 ('the GNSS Regulation'); whilst an evaluation of the European GNSS Agency was also required by Article 26 of the Regulation (EU) No 912/20102 ('the GSA Regulation'). Regulation (EU) No 912/2010 of the European Parliament and of the Council of 22 September

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2010 setting up the European GNSS Agency, repealing Council Regulation (EC) No 1321/2004 on the establishment of structures for the management of the European satellite radio navigation programmes and amending Regulation (EC) No 683/2008 of the European Parliament and of the Council. JO L 276/11 of 20.10.2010.

[96] COMMISSION STAFF WORKING DOCUMENT INTERIM EVALUATION of Galileo and EGNOS programmes and evaluation of the European GNSS Agency. SWD(2017) 346 final. Brussels, 23.10.2017 https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1589018264167&uri=CELEX:52017SC0346
This accompanied the REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL on the implementation of the Galileo and EGNOS programmes and on the performance of the European GNSS Agency {COM(2017) 616 final} Brussels, 23.10.2017.
https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1589018264167&uri=CELEX:52017DC0616
COMMISSION STAFF WORKING DOCUMENT, accompanying the document REPORT FROM THE COMMISSION ON THE WORKING OF COMMITTEES DURING 2016 {COM(2017) 594 final} SWD/2017/0337 final. Brussels, 16.10.2017
https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1589018264167&uri=CELEX:52017SC0337

[97] In 2014 two satellites were launched into an incorrect orbit, which led to further Galileo launches being put on hold until March 2015.

[98] SWD(2017) 346 final. Brussels, 23.10.2017

[99] Commission Delegated Regulation (EU) 2019/320 of 12 December 2018 supplementing of Directive 2014/53/EU of the European Parliament and of the Council with regard to the application of the essential requirements referred to in Article 3(3)(g) of that Directive in order to ensure caller location in emergency communications from mobile devices C/2018/8383. OJ L 55, 25.2.2019, p. 1–3.
ELI: http://data.europa.eu/eli/reg_del/2019/320/oj

[100] Regulation (EU) 2015/758 of the European Parliament and of the Council of 29 April 2015 concerning type approval requirements for the deployment of the eCall in vehicle system based on the 112 service and amending Directive 2007/46/EC (OJ L 123, 19.5.2015, p. 77).

[101] As reported by the European Space Agency:
http://www.esa.int/Applications/Navigation/Galileo_begins_serving_the_globe
See also:
https://www.gsa.europa.eu/european-gnss/galileo/faq

[102] See - the European Space Agency:
http://www.esa.int/Applications/Navigation/Galileo_begins_serving_the_globe

[103] The New York Time [online] at
https://www.nytimes.com/2019/07/16/world/europe/galileo-outage.html

[104] See press release: https://www.gsc-europa.eu/news/update-on-the-availability-of-some-galileo-initial-services

[105] See report at: https://www.bbc.co.uk/news/science-environment-38664225

[106] See comments within the following website: https://www.dw.com/en/galileo-satellite-navigation-system-back-in-action-after-partial-outage/a-49596058

[107] House of Commons Transport Committee, Galileo: Recent Developments. First Report of Session 2007–08
https://publications.parliament.uk/pa/cm200708/cmselect/cmtran/53/53.pdf

[108] Coronaviruses (CoV) are a large family of viruses that cause illness ranging from the common cold to more severe diseases. The new coronavirus (nCoV) is strain that has not been previously identified in humans.
"On 30 January 2020, the WHO Director-General declared the novel coronavirus (2019-nCoV) outbreak a public health emergency of international concern."
http://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19

[109] On 31 December 2019, WHO was informed of cases of pneumonia of unknown cause in Wuhan City, China. http://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/novel-coronavirus-2019-ncov

[110] Euronews (online): *Coronavirus in Europe: Health and finance impacts from COVID-19 derail roll out of 5G.* https://www.euronews.com/2020/04/06/coronavirus-in-europe-health-and-finance-impacts-from-covid-19-derail-roll-out-of-5g. Reported 6 April, 2020.

[111] See ESA information at:
https://www.esa.int/Applications/Navigation/Galileo_positioning_aiding_COVID-19_reaction

[112] See the GSA site:
https://www.gsa.europa.eu/GNSS4Crisis

[113] "Galileo, Galileo, Galileo, off you go: Snout of UK space forcibly removed from EU satellite trough Brit industry, military locked out." The Register, Monday, 26 March, 2018.

Viewable at: https://www.theregister.com/2018/03/26/uk_struck_off_galileo_project/ [Accessed 31 March, 2020]
[114] Reported in Space News: https://spacenews.com/uk-ends-galileo-talks-says-it-will-explore-a-homegrown-alternative/ [Accessed 2 June, 2020]
[115] https://www.gov.uk/government/news/uk-to-tell-eu-it-will-no-longer-seek-access-to-secure-aspects-of-galileo [Accessed 30 May, 2020]
[116] Ibid.
[117] Reported in Space News: https://spacenews.com/uk-ends-galileo-talks-says-it-will-explore-a-homegrown-alternative/ [Accessed 2 June, 2020]
[118] Ibid.
[119] Sussex University: http://www.sussex.ac.uk/broadcast/read/47866
[120] Ibid. Professor Chris Chatwin and Dr Lasisi Lawal Salami, from Nigeria's Obasanjo Space Center, were reported as having drawn up proposals for a low-cost Satellite-Based Augmentation System (SBAS) as a navigation overlay service (NOS) on a hosted national satellite: http://sro.sussex.ac.uk/id/eprint/81426/ [Accessed 2 June, 2020]
[121] https://www.gov.uk/government/news/uk-to-tell-eu-it-will-no-longer-seek-access-to-secure-aspects-of-galileo [Accessed 30 May, 2020]
[122] Ibid.
[123] BBC Report: https://www.bbc.co.uk/news/uk-politics-44232269 [Accessed 20 May, 2020]
[124] As reported in the Guardian Newspaper https://www.theguardian.com/politics/2018/may/25/what-is-galileo-and-why-are-the-uk-and-eu-arguing-about-it [Accessed 7 June, 2020].
[125] House of Commons Briefing Paper. The Brexit White Paper on future relations and alternative proposals. Number 08387, 28 August 2018. http://allcatsrgrey.org.uk/wp/download/health_services/CBP-8387.pdf
[126] https://www.gov.uk/government/news/uk-to-tell-eu-it-will-no-longer-seek-access-to-secure-aspects-of-galileo [Accessed 30 May, 2020]
[127] As reported in the Guardian Newspaper https://www.theguardian.com/politics/2018/may/25/what-is-galileo-and-why-are-the-uk-and-eu-arguing-about-it [Accessed 7 June, 2020].
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[129] Rusi - https://rusi.org/commentary/brexit-space-will-uk-have-access-galileo-satellite-network
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[131] Ibid.
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[140] Ibid.