



National
Space
Partnership

Strategic Case for Intervention

Intelligent Supply Chains





Contents

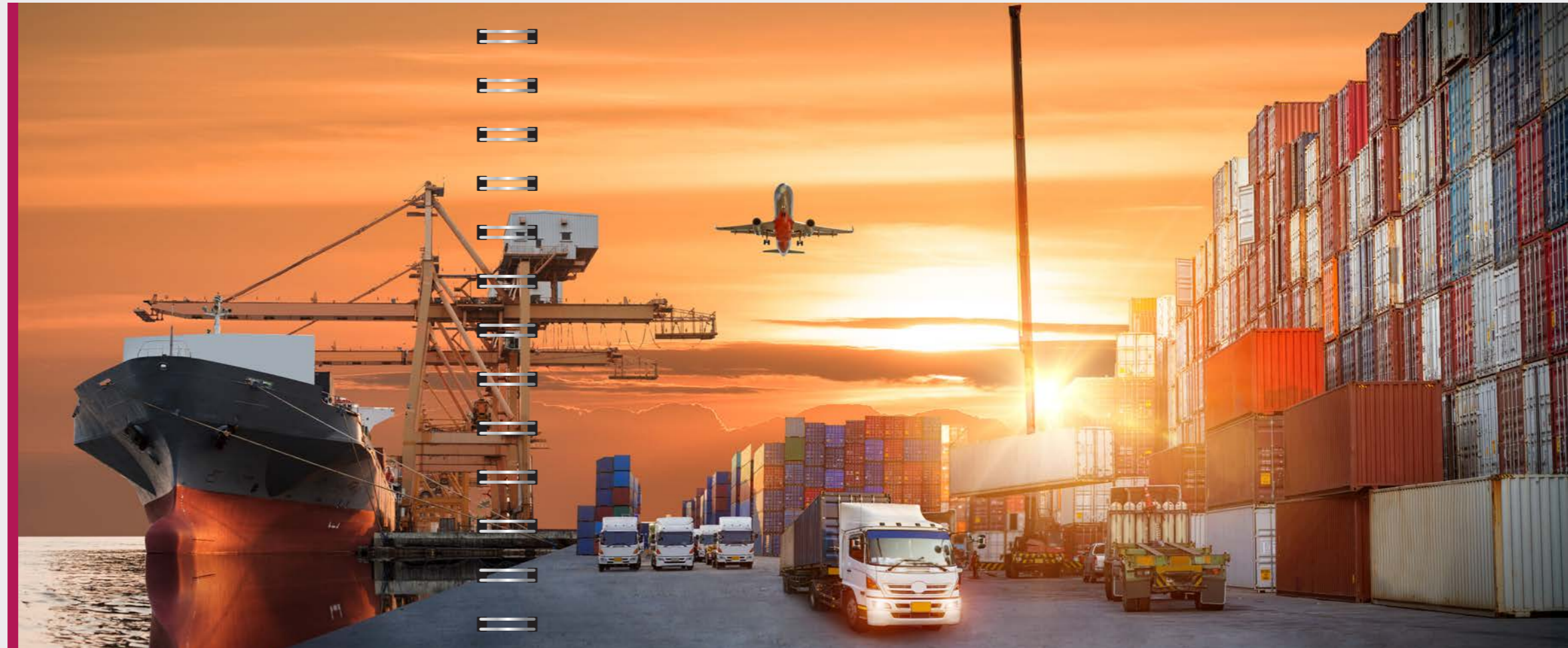
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1 Executive Summary

Within supply chains, digital technologies have transformed the way that we live our lives. Good, functioning supply chains help people get jobs, move goods, access services and enjoy social activities. Logistics and transportation are key to UK supply chains and international import and export supply chains that they connect with. Of UK total output, 5.5% (>£109bn) was generated by transportation and transport manufacturing during 2019 alone. When the logistics sector is included, supply chains employ more than 2.7m people, through 195,000 enterprises, turning over £924bn (2019) per year, providing £124bn gross value added to the UK.



All sections of the UK [and linked international] supply chains are predicted to grow significantly in the next 10-15 years. This growth and associated technological developments mean that future logistics supply chains will be extremely complex and highly integrated with many steps in every chain. The expectation of future road transport vehicles operating cooperatively all demand greater assurance and fidelity, together with greater links to air and maritime transport management systems. More information on the wider range of goods transported including rail freight and assured positional data on road transport – from remote countryside locations to congested urban environments – will add further complexity to the system.

Underpinning all these data functions and technologies is location and timing data. The location of assets, data and money, and the ability to use location and time data to optimise, plan and improve throughput, are key common aspects running through all the UK's supply chain strategies, including food, rail, aviation, manufacturing and maritime. When location and timing data from multiple sources are brought together across land, air and sea, this enables better procurement decisions, improved customer service and supplier management!

The UK needs to rapidly investigate the provision of services to fill the gaps – both current and future – for location (and time) information across the UK supply chains; gaps created by the

advance of technology, the pandemic response and EU exit. For example, replacing the current and future predicted capabilities lost by the UK's exit from the European Geostationary Navigation Overlay Service (EGNOS) is a high impact intervention. This must be combined with data from Earth observation systems and communicated using future 5G and space-based communications to ensure that future supply chains have the most accurate and real-time information available to them as possible.

A collaborative "space in supply chains" programme, specifically designed to improve the precision, availability and resilience of location and time data throughout the supply chain, must be initiated to enable government and industry

to deliver on their aspirations. This programme should also enable satellite communications and Earth observation capabilities.

The National Space Partnership (NSP) will be a core part of the programme, bringing coherence and identifying emerging and developing opportunities in the UK and on the global market. It will map capabilities, highlighting areas for development for the enhancement of location, time and communications data across the UK supply chain.

2 Strategic Case

The purpose of this strategic case is to set the context for intervention by the UK space sector and HM Government, to address opportunities to improve the supply chains ecosystem for goods and services in the UK.

2.1 Strategic Context

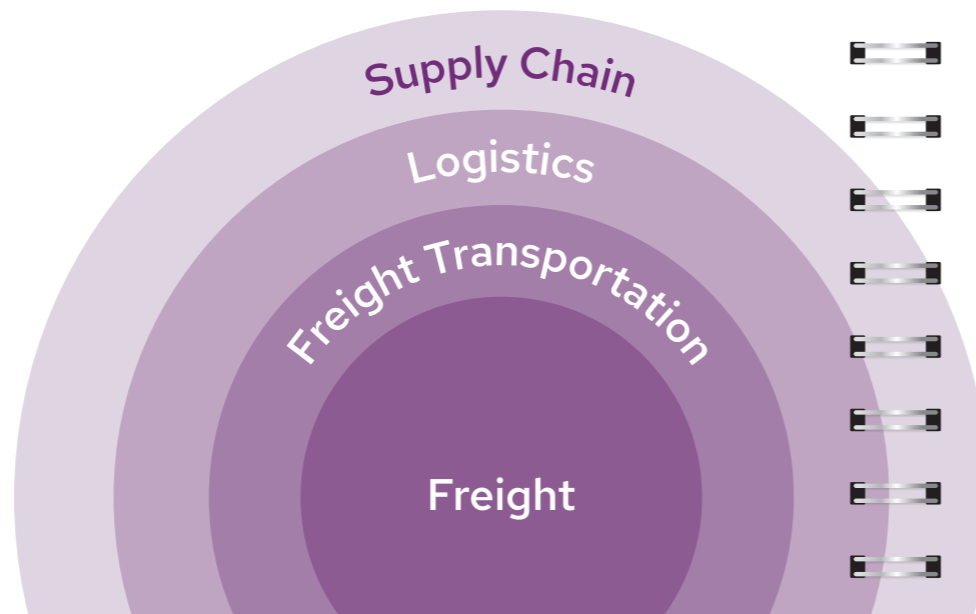
Within supply chains, digital technologies have transformed the way that they are managed, and how we interact with them. Good, functioning supply chains help people get jobs, move goods, access services and enjoy social activities². Logistics and transportation are key to UK supply chains and international import and export supply chains that they

connect with. Of UK total output, 5.5% (>£109bn) was generated by transportation and transport manufacturing in 2019 alone. When the logistics sector is included, supply chains employ more than 2.7m people, through 195,000 enterprises, turning over £924bn (2019) per year, providing £124bn gross value added (GVA) to the UK.



Figure 1 – The supply chain.

The supply chain function within the UK concerns the movement of goods, people and money – from source of a product to consumption of that product, encompassing functions such as packaging, transport modes, operational monitoring, customer service etc. Logistics specifically concerns the position of resources and ensuring that products and assets are at the right place at the right time including storage. Freight transportation is the function used to move the goods, the freight.



The shipping industry is critical to the UK economy. Significantly, about 95% of British imports and exports in goods are moved by sea⁶. The reliable and timely logistical operations to manage this flow is fundamental to the UK's national security. Felixstowe, for example, moves over one million containers each week, arriving from Asia and North America, before being shipped onto smaller European ports. Added value service such as marine insurance and shipbroking contribute a further £2bn GVA to the UK Economy.

The Strategic Road Network (SRN) (motorways and most "A" roads) carries almost two thirds of the UK's heavy goods vehicles, which equates to over three times the amount of goods moved by road than by rail and water combined. Put simply, we depend on our roads for our way of life³. In rail, Great Britain had one of the most intensively used networks in Europe: on average, a mile of track in Britain carried twice as much traffic as in France⁴. Rail freight has been transformed, with diversification from coal and steel enabling the private freight market as the UK's energy mix changed. Rail freight as part of a supply chain linking goods, businesses and imports/ exports together has shown the value of having a dynamic, innovative and customer-driven

business model, and now acts as a key supply line to national priorities such as construction and supply of food and medicines⁴.

The UK has the largest aviation network in Europe and the third largest in the world, directly contributing at least £22bn to the economy and supporting around half a million jobs. It also facilitates global trade with the UK, exporting £85bn worth of goods by air to extra-EU countries in 2017, according to the UK Government's Future of Aviation green paper⁷.

However, transport and supply chains account for 27% of the UK greenhouse gases⁵, which presents both a challenge and an opportunity.

Innovation, technology advances and the digital revolution in robotics, automation and connectivity, new business services and demands will place a huge demand on the transport infrastructure and future UK supply chains. This is reflected in the UK's Maritime Strategy⁶ and the Aviation Strategy green paper⁷ which note the need for future safety and security covering these new modes of operation, new services and the need to overcome barriers such as customer expectations on rapidity, climate impacts, security and resilience of supply, and reduced costs.

Of UK total output, 5.5% (>£109bn) was generated by transportation and transport manufacturing in 2019 alone.

2.1.1 Looking forward

By 2050 there is an expectation that all road vehicles will be capable of fully cooperative operation² (being able to talk to other cars and infrastructure). The volume of freight by ship is expected to continue grow, and the demand for aviation will continue to grow in a post-Covid era⁷. These future advances and growth opportunities also present the greatest safety and security challenges against, for example, cyber-attack⁶. The UK has been a world leader in aviation safety and the green paper for the future of aviation sets out how autonomy, digitalisation and data sharing can enable billions of pounds of growth to the UK economy⁷.

The rail sector also has noted that the challenges of resilience, data sharing and new technology must be overcome if it is to realise a properly functioning future rail system⁸. Reduced emissions optimised and data-driven operations are key pillars of the future of the railway systems in the UK.

All sections of the UK [and linked international] supply chains are predicting significant growth in the next 10-15 years. This growth and consequent technological developments mean that future logistics supply chains will be extremely complex with many steps in every chain.

To address this complexity and achieve the visions set out by the government, the UK will need more reliable and resilient technology, near zero emissions, interoperability in transport modes, sufficient back-up and protected data operations. This vision has been set out by the government in consultation with industry and overall requires more resilience in our supply chains.

The growth in maritime and air transport, the diversifying of rail freight, and the expectation

of road transport operating cooperatively all demand greater assurance and fidelity of air and maritime transport management systems. Higher quality information is required on the wider range of goods transported (what and where) as rail freight and assured positional data on road transport from remote countryside locations to congested urban environments.

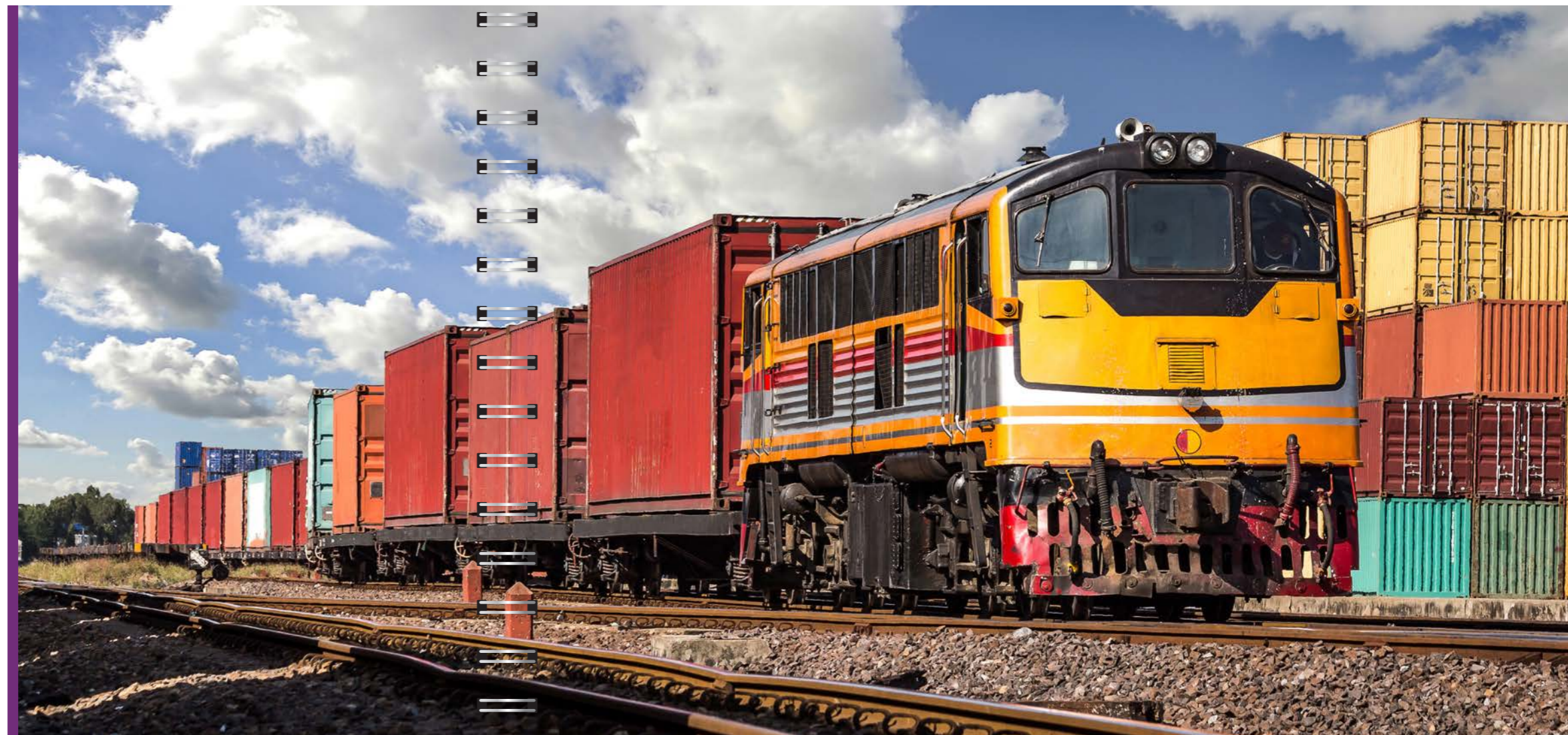
Without improved information management (location and time) and operational optimisation within UK supply chains, future UK objectives cannot be met.

The food and drink sector has recognised these problems; through activities like “Feed UK”⁹ helping to bring all aspects of that sector together, it is becoming well recognised that the poor supply chain information flow in the UK is causing wastage in products and money, leaving society and the environment to take the impact.

Not all sectors recognise or have plans to deal with this growing problem. Failure to address these challenges and capitalise on the opportunities across the whole supply chain is likely to result in supply chain blockages for the

future. Not implementing new technologies and processes will leave the UK unable to benefit from these opportunities including transport system modernisation, additionally noted in the UK National Space Strategy¹⁰.

For example, on location, not addressing these resilience and optimisation issues will put UK supply chains at significant risk, such as noted in the £1bn per day economic impact to the UK from disruption to Global Navigation Satellite System (GNSS) alone from a seminal 2017 report by London Economics¹¹.



2.2 Case for Change

A vital aspect of the need for better information flow across all aspects of supply chains and logistics operations, is access to data. “Big Data” is fashionable, but in the supply chain context it is extremely relevant. The information needed to optimise and protect supply chains includes real-time data sets covering system health, status, goods in transit (including security of goods) and so on. Technologies for the future include Internet of Things (IoT), 5G and satellite communications, Machine to Machine (M2M) communications, artificial intelligence and machine learning.

Underpinning all these data functions and technologies is **location and timing** data. The location of assets, data and money, as well as the ability to use location and time to optimise, plan and improve throughput, is a key common aspect running through all the UK’s transport and supply chain strategies, including food, rail, aviation and maritime.

This is also reflected in the UK National Space Strategy as a growth area. Location is also one of the key components in future autonomous vehicle systems (Vehicle to Everything (V2X)). Services, location and positioning information are indispensable to V2X use cases¹², such as assisted driving, automated driving, traffic monitoring and management, and autonomous parking, enabling a much more efficient and safer transport system.

With the phasing out of petrol and diesel vehicle sales by 2030, the government will need to address how the £37bn per year generated by fuel and vehicle excise duty is to be replaced. The recently published Transport Select Committee report on road pricing concluded that a nationwide replacement is needed, and that work must begin without delay. It also emphasised the



need to treat road users fairly, charging them for the costs that they contribute based on distance travelled, congestion caused and time of travel.

UK supply chains are a significant road user. Therefore, there are clear impacts of inaction, but also very real opportunities to leverage resilient, location-based services to improve efficiency, reduce emissions and overall supply chain costs. Furthermore, the report from the 5G Automotive Association¹³ highlights that every country in the world is facing the same problem – an opportunity exists for the UK to become a world leader in solutions and technology within this domain, boosting future UK exports, by using our expertise in space and satellite applications to capture this opportunity.

The UK Levelling Up White Paper¹⁴ details that local clusters will prioritise local networks and supply chains, rather than sourcing from afar, reducing costs. Therefore, improvements for supply chains will have to be applicable to local supply chains, as well as to international logistics. For location and timing data, this means the need to manage assets on a near real-time basis with more fidelity will increase, if benefits noted in the Levelling Up white paper are to be realised.

Intervention now to improve the availability, reliability, resilience and security of location and timing data all through UK supply chains and

the infrastructure they rely on, is likely to make a large contribution to meeting the objectives in the myriad of UK strategies, the Geospatial and National Space Strategy, in particular. Regarding geospatial data, there is demand for intervention now to improve the availability, reliability, resilience and security of location data across numerous sectors and that supply chain represents only one use-case for investment.

When location and timing data from multiple sources are brought together across land, air and sea, this enables “better procurement decisions, improved customer service and supplier management¹⁶.” A side benefit is that this also enables the tracking and management of emissions across the network.

This need for improved availability, resilience and security is also highlighted in the UK National Artificial Intelligence (AI) Strategy¹⁷. AI is increasingly used for decision-making and in autonomous systems for situational analysis, location and time, which will be essential to future decision-making, and the integrity of the data is

With the phasing out of petrol and diesel vehicle sales by 2030, the government will need to address how the £37bn per year generated by fuel and vehicle excise duty is to be replaced.

vital for those decisions to be made safely and securely.

The National Data Strategy specifically notes the need to improve the availability and security of location data of assets and notes that Transport for London (TfL)’s opening of its data sets to travellers and third-party providers contributed up to £130 million per year to the London economy through time saved by travellers¹⁸. This strategy also details the UK Government’s desire to specifically “unlock the power of location data”, which is the headline for the UK Geospatial Strategy¹⁵.



The role of government policy when addressing these fundamental problems in the supply chain sector, and the role of the space sector within it, should be to be “catalytic, to create and shape markets¹⁹ not just try and fix them. Intervention and change need to provide directions of change, which bottom-up solutions can experiment around. It is this type of leadership intervention that the NSP can provide and move the space sector to start addressing these multi-billion pound opportunities across multiple supply chain and supply chain linked sectors²⁰.”

Improving the resilience and availability of location data within the UK supply chain, more cohesive information sharing between transport agents, more reliable certification, supply chain veracity, intermodal scheduling and optimisation are all ways in which the UK (academia and industrially) can capitalise, and with appropriate leadership, benefit from investments in satellite technology.

2.2.1 Maritime

In the maritime sector, freeports are being established to attract trade to more areas of the UK. These can target the local opportunities and strengths, such as the New Humber Freeport, which can connect the manufacturing industry to the offshore wind power network. A challenge is that the UK regularly sees port delays of four to five days for shipping while bottlenecks are managed, meaning consequential delays downstream in the logistics and transport functions. Better quality and access to location data of assets can be used to optimise the upstream and downstream logistics functions. This can even go so far as the location of a product, the container it is in, the consignment number and purchase order relating.



A capability being planned for insertion into the UK supply chain technology mix to provide location data trust, integrity and accuracy improvements was the European Geostationary Overlay Service (EGNOS). This historically aviation-focused capability is including additional maritime functions in coordination with the International Maritime Organisation to help nations meet the future eNavigation²¹ requirements. Lack of full access to this capability will cause a degradation in the safety, performance and the UK's ability to be fully interoperable with partner nations and allies, as the need for these improvements grows.

The MarRinav²² study assessed these factors in detail and noted not only would future supply chains need more precise and trusted location and time data, but that the UK's ability to support future advanced maritime operations and situational awareness would be degraded from not having access to the capabilities in future EGNOS versions.

As the UK will no longer participate in the EGNOS programme following the EU exit, this means that the UK will experience a reduction of information assurance, integrity and resilience of location and time data within the UK's future [maritime] supply chains, which needs to be mitigated or replaced.

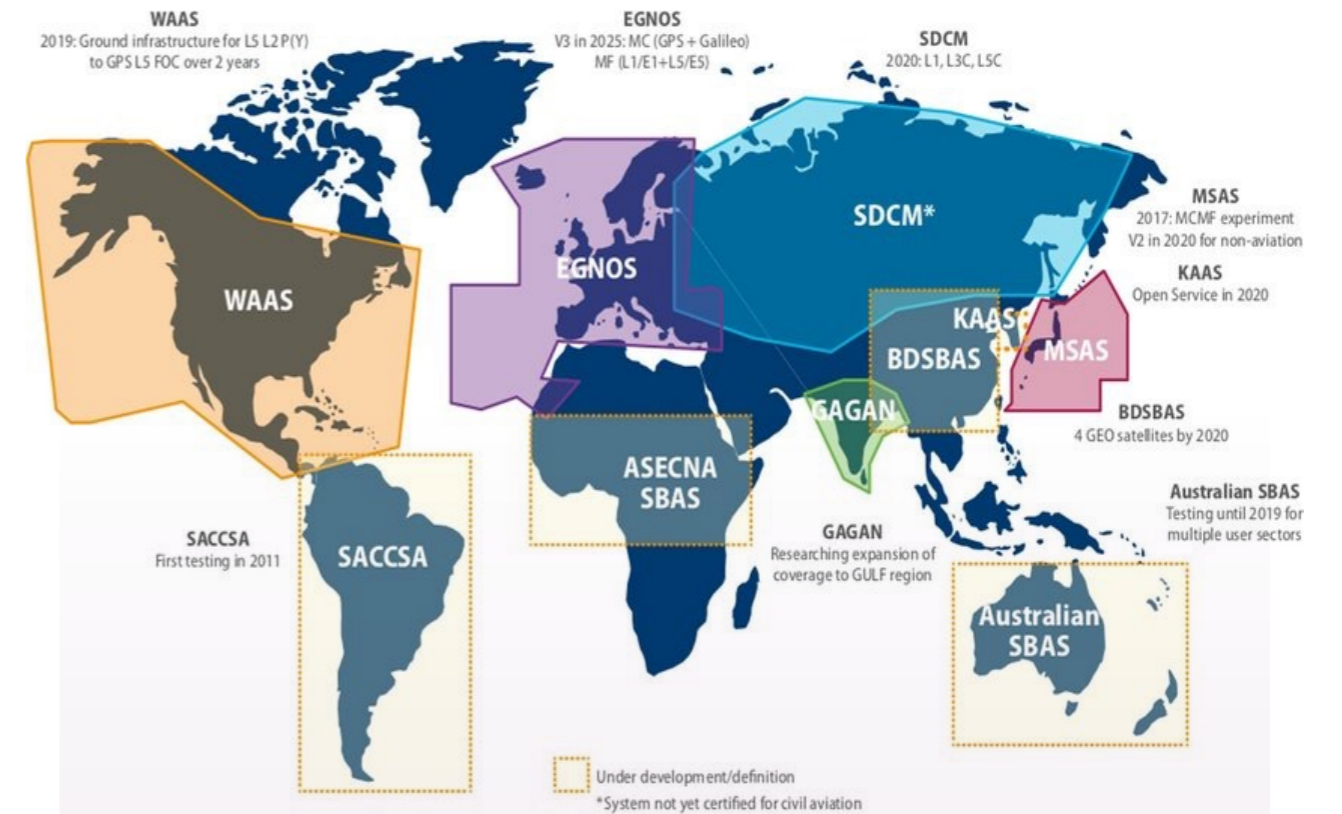


Figure 2 – SBAS Systems globally, inc EGNOS²³.

The Royal Institute of Navigation President recently noted that “The recent withdrawal of [...] EGNOS use in the UK could ultimately affect ships, autonomous vehicles and beyond visual line-of-sight (BVLOS) drones as well, unless a replacement solution can be secured quickly. The shipping industry will need to consider appropriate solutions for UK waters, as future maritime EGNOS Safety-of-Life services will no longer be made available to the UK in 2023.”

2.2.2 Aviation

In aviation, more precise and communicable location of asset data (together with parameters of the asset such as end-user, invoice number, consignment) will enable better optimisation within freight consolidation stations (where freight is organised for airfreight movement). This will give enhanced information about when assets will get to their desired location and allow for real-time decisions.

For the future, unmanned systems (drones) need to know their location, and that of everything around them, precisely and with high confidence⁷. Examples include the work being carried out by the National Beyond Visual Line of Sight

(BVLOS) Test Experimentation Centre (NBEC) which is investigating the safety aspects of drone corridors and has acknowledged the need for precise location data for application development and a safely managed environment.





2.2.3 Road and Rail

Similarly for **autonomous vehicles, road and rail** transportation, the enhancement of location precision and safety management will have a huge impact on operational efficiencies, such as ensuring that the distribution centre

slot times can be optimised and rail network timing can be modernised with GNSS or fibre timing, enabling better data handling, operational safety improvements, fewer delays and better passenger information.

2.2.4 Other sectors

Current supply chains need to achieve net zero and increase automation. For supply chains that have been established for the oil and gas industry, these will have to adapt to a drop in their current target market and pivot to address new markets. Better understanding of the location of assets, to a higher fidelity than currently available, can lead to a reduction of the UK greenhouse gases that those UK supply chains contribute to, by optimising operation and management of asset movement and storage. It should also be noted that in the advent of Brexit, additional technical methods to reduce friction in cross-border supply chains are urgently needed.

The **UK Border Strategy**²⁴ discusses how location data can be used to prevent crime and illegal supply chains, therefore reducing the impacts that these aspects can have on society, since knowing what is on all transports, the goods origin and all points for potential tamper or inclusions could improve security.

Other sectors where the positive impacts of intervention will be felt are construction and food and drink, as consumers of supply chains.

The UK needs to rapidly investigate the provision of services to fill the current and future gaps for location and time information across the UK supply chains; gaps created by events such as the EU exit. Replacing the capabilities lost by EGNOS is a high impact intervention.

For the UK Exclusive Economic Zone (EEZ), this intervention could be a series of capabilities to provide enhanced location and time accuracy and resilience; integrity to improve safety and security aspects and provide future capability upon which to launch the UK supply chains into meeting the 2050 ambitions set out by HM Government. These capabilities, together with an improved understanding of the role of location and time data in supply chains, must be a mix of space and non-space capabilities, and there will also need to be the means to test, simulate, model and prove these capabilities.

By doing this, the UK will be set on a path to take maximum benefit from the opportunities that better use of location, timing and geospatial data can provide.

2.2.5 Strategic Fit

A programme or programme portfolio providing a strategic intervention to the UK supply chain infrastructure will be centred around three core principles:

1. Focus on outcomes and impact, not spend and activity
2. There is no growth without investment
3. Success can be measured

The National Space Strategy¹⁰ notes that if the “UK were deprived of access to global navigation satellite systems, for example, the impact on our economy could be as high as £5.2bn lost in just five days.” This figure is likely to be higher as the analysis was carried out in 2017. This shows the importance of location and timing data to the fundamental economic structures of the UK. It goes on to detail that navigation applications (location and time) are high growth areas and that “satellite-derived position, navigation and timing (PNT) signals underpin services such as banking and transportation, as well as almost all the UK’s CNI (including energy, policing and healthcare) and defence operations”, in addition to the use of location data in our supply chain infrastructure.

A programme focussing on the improvement in accuracy, integrity and resilience of location data²⁵ across the UK will directly address challenges well described in:

- ✿ Road Investment Strategy 2: 2020–2025, Department for Transport, 2020
- ✿ The Williams-Shapps Plan for Rail, Department for Transport, 2021
- ✿ Maritime 2050, Department for Transport, 2019
- ✿ Aviation 2050, The future of UK Aviation, green paper, HM Government 2018
- ✿ Transport Vision 2050, InnovateUK, 2021

- ✿ Rail Technology Strategy, Rail Safety and Standards Board 2020
- ✿ UK Food strategy 2020 (recommendation 11, better data use)
- ✿ Global Britain in a Competitive Age, the Integrated Review of Security, Defence, Development and Foreign Policy, 2021. “The Integrated Review”
- ✿ Unlocking the power of location: The UK Geospatial Strategy 2020–2025
- ✿ 2025 UK Borders Strategy
- ✿ National Data Strategy, 2020
- ✿ National AI Strategy, 2021



In addition, the aspects of more resilient, safe and secure location data are key to delivery of the National Cyber Strategy (2022) which means that security of the location information will be a large part in the success of delivering against these goals. Safe and resilient location also means **collaboration and sharing with other aspects of the space environment such as satellite communications and Earth observation**, to provide routes in addition to terrestrial, to communicate and link the parts of the supply chain together, 5G backed up by LEO communications; and Earth observation to provide the crucial reference frames and mapping needed to ensure location is understandable to all in the real world.

2.2.6 What needs to change?

The importance of location, timing and geospatial data across the supply chain, and the opportunities presented by greater precision and trust, must be recognised, including by government, and communicated much more effectively.

- The National Space Strategy¹⁰ brings out the market opportunity regarding navigation applications. Developing it further through allocating budget priorities in a similar way to the Defence Space Strategy would focus the market and coalesce support around those priorities.
- A capability, commercially or nationally operated, within the UK is needed that can improve the accuracy, resilience, availability and integrity of location data versus currently available open GNSS services. This capability needs to be a system-of-systems, with space-based and non-space-based elements, since no single technology will address the full range of the supply

chain changes needed to deliver the future aspirations.

- This capability needs to exhibit interoperability with non-UK systems – or have a means to cater for maritime, aviation and road users and elements of the supply chain that operate beyond UK borders.
- Enabling data-centric future cities through precise PNT for autonomous vehicles and targeted city improvement projects, as well as the ability of broadband communications from LEO to provide resilient communications when combined with terrestrial communications, needs to be greater understood.
- Innovative methods to fuse location and geospatial data (e.g from Earth observation systems) need to be developed, perhaps through a national innovation programme for space.
- Supply chains must be treated in a similar way to critical infrastructure in resilience planning and business continuity aspects.



2.2.7 Why now?

Leading multinationals will look to do business where they can see efficiencies from approaches such as this approach to intelligent supply chains, considering the need for more seamless goods movements following the UK exit from the EU. This is only feasible if the infrastructure is in place domestically to support it. Other leading economies in Europe, the US and Far East either already have or are taking steps to develop the necessary infrastructure, including in the form of resilient positioning and timing solutions.

These will pave the way for vast improvements in supply chain efficiencies and optimised operations, and other use cases. For example, the US, Europe, Russia, China, Japan, India and Australia/New Zealand either already have or are developing satellite-based augmentation systems.

The means to tax UK road users is set to change, and with the move to EV-only vehicle sales by 2030, this change is needed urgently. The type of solution needed for future supply chains has many synergies with that for road charging. An opportunity exists to introduce resilient PNT capabilities that can underpin both use cases, and many more besides,

but time is of the essence to prevent the UK lagging behind its competitors and seeing key skills and technologies being moved overseas.

The UK has got some of the most forward-thinking strategies in the world, but the action plans to deliver on the visions are not in place. The National Space Partnership can drive forward the use of space and satellite technologies and data to make a real difference to UK prosperity.

The UK has world-class expertise in space-based PNT systems and in non-space PNT. Following the UK's exit from the EU and consequential exit from the Galileo and EGNOS systems, the ability to deliver capabilities that provide supply chains and beyond with resilient, accurate and high availability location data, fused with geospatial and communications systems, still exists in the UK. But the **current UK skills pipeline is not robust enough to assure future delivery** of the serious economic benefit from exploitation of location data derived from PNT across the value chain.

By acting now, we can strengthen and deepen the skills required to realise the aims outlined in this document.



2.2.8 UK Capabilities and Skills

In the short-term, the UK is heavily reliant on a late-career and even post-retirement skills base in the locations data and PNT technology domains.

Although the demographics for Earth observation and satellite communications are less reliant, there is still a strong reliance on late-career skills. We must act now to build a skills pipeline for the medium- and longer-term to assure the UK's ability to deliver.

The UK has an opportunity to innovate and lead in the provision of resilient and trusted location and timing data for commercial systems and applications such as drones, consignment tracking, communications systems and autonomous vehicles. The too-thin skills pipeline is a key constraint to the UK realising these benefits.

It is correct to draw parallels between the skills gap for space (PNT, geospatial etc) with those identified and actioned for High Speed 2 (HS2) rail and UK cyber protection with the National Cyber Security Centre (NCSC). Action is now needed to address these critical skills gaps.

There are short, medium- and longer-term actions that can be taken; and they cover tactical yet powerful "quick wins" through to strategic imperatives for the medium- and longer-terms which will establish the UK's skills base to enable future delivery.

The National Space Strategy itself provides the foundation for increased confidence in both industry and academia. The stimulus this provides for investment will form the start of a virtuous circle. The desire for a Space Skills Advisory Panel (SSAP) and a National Space Skills Institute is a step forward. However, more can be done.



2.3 Action:

- ✿ A collaborative "space in supply chains" programme specifically designed to improve the precision, availability and resilience of location and timing data throughout the freight transport and logistics functions, allowing supply chain management operations to be optimised.
- ✿ This programme will enable government and industry to deliver on the strategies referenced in this case, while still enabling satellite communications and Earth observation capabilities to play a significant role, as well as PNT.
- ✿ Creation of a National Innovation Programme for Space, to complement European Space Agency (ESA) activities, and to stimulate and develop technology and business models across the whole range of technology and commercial readiness.
- ✿ Inclusion of the power of location and timing into the National Space Skills Institute by occupational map which identifies the pipeline of required skills to support the National Space Strategy, focussing on PNT and geospatial aspects should be developed, showing the projected level 4-8 qualifications required over a 2, 5, 10 and 20-year time horizon. This activity should be led by government, including the UK Space Agency with support from the SSAP.

✿ A UK PNT Skills, Education and Training Unit should be established within government as part of the National PNT Office, with a plan to embed topics and qualifications for location, PNT geospatial data and other aspects of space capabilities throughout the educational hierarchy from GCSE all the way through apprenticeships to focussed Masters and PhD programmes.

The NSP will:

- Be a core part of the programme, bringing coherence and identifying emerging and developing opportunities in the UK and on the global market relevant to the UK space sector.
- Map capabilities relevant to the UK supply chain as an ongoing, live activity referenced to market opportunities, highlighting areas for capability development.
- Create strategies for market access and uptake with stakeholders.
- Determine the portfolio of R&D activities required to enable the enhancement of location data across the UK supply chain, advising stakeholders on gaps and overlaps.

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The National Space Partnership (NSP) aims to be an independent, trustworthy moderator for government, industry and academia to accelerate the implementation of the National Space Strategy, which was published in September 2021. The NSP is a progression from the Space Growth Partnership in response to a changing UK space sector landscape. It will establish a trusted forum to exchange ideas and address issues, create and implement appropriate programme strategies, and build unity of approach across the entire UK space sector.

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