INTERVENTION DASHBOARDS

FUTURE OF FREIGHT

Evidence Base

This report by WSP was commissioned as part of the evidence base for the National Infrastructure Commission's study on the future of freight.

As with all supporting evidence commissioned by the National Infrastructure Commission, the views expressed and recommendations set out in this report are the authors' own and do not necessarily reflect the position of the Commission.

NATIONAL INFRASTRUCTURE COMMISSION

April 2019

FREIGHT DEINTENSIFICATION

Reducing the volume of goods transported or the distance that goods are transported. This doesn't necessarily mean producing less. It could include moving goods in a more compact form (for example concentrated liquids), or collocating businesses to reduce distances for goods to travel.

<table>
<tr><td>Intervention Title</td><td colspan="2">CIRCULAR ECONOMY</td><td>Intervention Number</td><td colspan="2">D1</td></tr>
<tr><td>Intervention Description</td><td colspan="5">A circular economy is an alternative to a traditional linear economy (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life (WRAP, 2018). "Instead of discarding assets after only one product cycle, companies are developing ways to continually re-acquire and reintroduce these assets to market...A circular economy goes beyond the pursuit of waste prevention and waste reduction to inspire technological, organisational and social innovation across and within value chains” (Deloite, 2016).

A circular economy is, perhaps, the ultimate objective of a series of options to reducing, reusing, and recycling materials.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="4">There are theoretical examples of how this can help reduce the demand for transport, but this is not evidenced extensively. Examples exist in construction; however, this is not the full extent of what a circular economy could deliver.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="4">Over time a more circular economy could reduce the movement of goods.</td></tr>
<tr><td>TRL</td><td colspan="3">N/A</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="5">Transport of waste and recyclates accounted for 14% of the tonnage of goods transported by road in 2016.
A circular economy could mean that instead of long distance, one-way supply chains, distributed manufacturing and circular economy approaches reduce complex and expensive multiple border crossings for materials and components (Weetman, Date Unknown).</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="5">There is limited evidence to show how circular economy and re-use is reducing empty running, although efficiency is implied. The best examples of this to date are within the construction industry where onsite reuse of materials for example: reusing excavation materials - for example, by stabilising soils using hydraulic binders, or manufacturing quality soils by adding 'green' compost or processing demolition arisings on site - for example, using mobile crushing plant to provide recycled aggregates for fill, capping and sub-base layers. Thus, saving vehicle miles for the removal of waste product and inbound vehicles bringing in new materials for which reused materials could be used. Transport accounts for 10-20% of construction costs (BRE, 2003). In 2002, construction transport accounted for 13% of UK fuel use (BRE, 2003) - whilst this is out of date it is indicative of the size of the prize for reducing construction transport. Data shows a great range of 50-600 movements per £100,000 of project value, indicating significant opportunities to reduce transport and cost.

Other objectives for waste which have associated decongestion benefits are waste minimisation, and dealing with waste as close as possible to the origin (for example local Mechanical Biological Treatment plants rather than regional Energy from Waste plants.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="5">• Research into the consequences of circular economy on empty running.
• Qualification of transport benefits in construction industry for re-use, more case studies to demonstrate the effectiveness of Construction Logistics Plans (CLP) as a tool.
• How can the principles applied in the construction industry can be applied to other areas such as waste and recycling or manufacturing maybe through groups such as WRAP.</td></tr>
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<table>
<tr><td>Intervention Title</td><td colspan="2">CLUSTERING AND CO-LOCATION</td><td>Intervention Number</td><td colspan="2">D2</td></tr>
<tr><td>Intervention Description</td><td colspan="5">Co-location is a location or area where synergic businesses are located together to allow for a reduction in mileage, sorter lead times. This can be based around an industry such as car manufacture but could also be based around a service such as logistics. For logistics, co-locating can be called a freight village - a defined area within which all activities relating to transport, logistics and distribution of goods, both for national and International transit are carried out by various operators. It is effectively a specialised industrial estate that allows for greater collaboration and asset sharing. As well as reducing freight miles, co-location could be an enabler to consolidation, shared warehousing space rather than a solution to empty running in itself. It may help reduce freight congestion on other areas of dedicated roads are created as part of the process.

Clustering is similar to co-location but refers to a broader concentration of businesses within a region. The economic benefits of clustering are well understood, but transport benefits are rarely cited in economic plans.</td></tr>
<tr><td>Quality of Evidence</td><td>-1</td><td colspan="4">Much of this is theoretical rather than extensive examples of how this could reduce congestion.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="4">Evidence suggests that this could have a positive impact on reducing the number of vehicles on the SRN.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td colspan="2">Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="5">Moving less freight, or freight over shorter distances could be seen as the first step to reducing congestion and emissions, having synergistic businesses located close to each other offers benefits such as:

• Reducing truck volumes on some roadways / reducing truck miles of travel
• Encouraging collaboration and load sharing
• Improving traffic operations on some roadways
• Increasing rail mode share in the region
• Promoting economic development
• Improving environmental quality
• Creating a more efficient and cost-effective freight delivery system.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="5">There are relatively few examples, but these include supplier parks around car factories (notably Nissan), food parks and clustering of industries which some LEPs are seeking to do. Some of this happens naturally as markets develop eg Grimsby focus on fish supplies, however there may be the opportunity to encourage this through planning.

The transport impacts of reducing journey lengths are obvious, but little or no research has been done to quantify this. Similarly, the degree to which clustered businesses can collaborate and share load space has not been researched.

Where externally encouraged these locations can also be known as logistics centres, or freight centres. The IGD note that in this case it is vital that a Logistics Centre/Freight Village be managed as a single and neutral legal body (preferably by a Public-Private-Partnership) if synergy and commercial cooperation are to be ensured (IGD, 2015).</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="5">• Integration into Local Plans.
• Assess transport benefits of clustering policies
• Further research needed on this as an intervention as it relates to congestion.</td></tr>
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Intervention Title	**LAND USE PLANNING**	**Intervention Number**	**D3**
Intervention Description	Land use planning plays an important role in ensuring the logistics facilities can be located where needed. Currently, certain types of logistics sites are difficult to develop, and in urban areas logistics facilities are under threat from more lucrative development.		
Quality of Evidence	0	There is evidence for the importance of new logistics facilities in cities, and theoretical backing for the impact of sub optimal locations on transport demand.	
Potential Impact on Freight Congestion	2	Reducing unnecessary mileage can play an important role in reducing overall freight mileage.	
TRL	N/A	**Stakeholder Acceptability**	-1
Freight Congestion Impacts	Logistics land availability and affordability has an impact on congestion by virtue the fact it affects location of warehousing and logistics facilities and therefore impacts stem distances. Lack of available and affordable land forces businesses to locate to sub optimal locations, increasing journey lengths. Around cities businesses will increasingly need to transfer from large trunking vehicles into smaller delivery vehicles. This needs to take place close to the city centre to reduce wasted mileage.		
Evidence of Effectiveness	*“It is no exaggeration to say that even in 2013 warehouses were seen as the Cinderella of property, with the greater appeal and perceived glamour of mainstream office and retail assets often leaving logistics and industrial properties neglected among investors”* (CMS Legal , 2018). The CILT in their response to NICs call for evidence suggest *“Capacity, congestion, emissions, conflicts. Freight is an exclusively private sector commercial operation that runs on public sector road and rail networks; it is constrained by that capacity and land use planning which may impede its access to suitable sites for terminals and warehouses: ports, rail, distribution centres”* (CILT, 2018). The University of Westminster in their response, also identified land use (and land prices) especially in urban areas price logistics out of the market and therefore need to be protected (Freight Traffic Control 2050 project, 2018). As the capital continues to experience a shortage of land, the issue surrounding the sustainability of freight transport operations looks set to accelerate unless appropriate action is taken. A CILT article examining the impact of land use on freight and logistics showed how inextricably linked land availability and freight operations are (CILT, Land availability in London, 2017) . **Urban** From an urban perspective it is even more difficult to protect existing land for logistics, let alone develop the new facilities required for consolidation and cross docking before final delivery in smaller, more sustainable, vehicles. In areas where water freight is a possibility, for example in London, protecting wharfs from development for non-freight use is also a challenge, *“There is a clear policy imperative to support London’s logistics sector and recognition of the importance that urban logistics plays in the functioning of the economy. The London Plan acknowledges the importance of the logistics sector and sets land release targets. However, in practice these targets have been significantly exceeded. Policy targets have been effectively breached without any compensatory mechanisms to provide alternative industrial land supply. This is clearly an important contributory factor in the problems that logistics operators face in sourcing land in London to meet their location requirements. Left unaddressed this trend of rapid loss of land for industrial uses is unlikely to abate, worsening choice for the logistics sector and compromising its ability to help London function effectively.”* (SEGRO, 2017) **Strategic**		

	Well-connected logistics centres are critical for the economic development of areas and as a result freight is increasingly (although not consistently) being considered as part of regional, sub regional and local strategic planning. The evidence to directly relate land use and freight congestion is implied and anecdotal, by virtue that there is evidence to suggest that land is not available for logistics development, leading to sub optimal transport planning, increasing mileage and use of the road network. There is evidence to suggest that if there was more sympathetic land use planning then there would be more protected space for logistics operations, reducing local congestion (see analysis on consolidation centres). The Centre for Sustainable Urban Freight Systems has a number of project examples that illustrate, from an urban perspective, how land use has had a positive impact on freight congestion, which include Paris who have created a freight master plan that supports efficient freight movements (Coe-sufs, 2017).
Opportunity to Develop Further	• For land use planning, providing land for industrial and distribution use is recognised as being economically important. The CILT notes that *"the provision of cost effective capacity (road space, rail paths and land for holding and transit) priced consistently to its users across modes to reflect the externalities caused by freight: e.g. congestion, emissions and air quality"* is key to delivering a successful freight strategy (CILT, 2018). • Integrated land use planning and safeguarding key sites particularly in urban peripheries and inner cities. • Freight data does not allow for adequate planning for logistics facilities – therefore a focus on gathering useful data is key to supporting an effective land use policy that address freight and congestion issues.

<table>
<tr><td>Intervention Title</td><td colspan="2">ROUTE PLANNING, NAVIGATION AND OPTIMISATION</td><td>Intervention Number</td><td>D4</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Route planning is an essential tool for logistics operations to reduce their empty running via enabling back and forward hauling, reducing stem mileage and avoiding HGV inappropriate routes (restricted routes) and re-planning. Route planning can range from a manual map process through too much more sophisticated and connected technological solutions. Route planning, navigation and optimisation enables backhauling, reduced costs through reduced stem mileage and ensuring the most appropriate route is established (e.g. avoiding restricted areas). Route planning tools can be free of change, but also and be highly bespoke tools for specific companies. Technology can range from simple sat navs through on live dynamic scheduling and route planning facilitated by connected data.</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="3">There is plenty of evidence to suggest a reduction in mileage can be avoided (5% to 10% is cited in several academic studies) however the direct impact on congestion is implied.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">Potential 5% to 10% reduction in mileage on introduction of optimisation, but the benefits will be reduced because most businesses already use this software.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">Most haulage businesses already use logistics route planning and optimisation software. Some operators have HGV sat navs, although there is some evidence that drivers may still revert to using mobile phone based satellite navigation which may not be appropriate for HGVs. Take up is lower among the smaller operators. This means that the potential mileage savings impact will be reduced.

Appropriate route planning, navigation and optimisation have a number impacts on congestion:
• Plan the most direct route to final delivery, if necessary via multiple stops en route
• Has the potential to provide on road changes to route providing dynamic routing
• Can avoid restricted areas and plan the best alternative route</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">Improving routing is key to a logistics operation. There is some evidence of an increasing use of measures to improve routing amongst HGV operators. Between 2003 and 2010 the proportion of vehicles fitted with on-board computer systems, GPS systems and/or telematics in the freight sector grew sharply, increasing year on year for all measures (Greening, 2015). This has potentially had a direct bearing on how empty running has been reduced (see dashboard for back/forward hauling).

The technology is widely adopted in developed countries but there are low levels of market penetration in emerging markets.

Greening estimates that the use of telematics to optimise vehicles will increase from 8% in 2010 to 68% in 2030. This was based on Greenings stakeholder interviews in 2015. This implies that technology is not only fitted to vehicles but that they are actively used to manage vehicle routes and schedules (Greening, 2015). However, this figure appears to be small and could be an indicator that telematics are used by larger logistics organisations, whereas the industry is predominately SME. It may be if a similar survey was undertaken on the use of sat navs this would be a larger percentage adoption than the percentage for full telematics which may be cost preventive with organisations relying on a more manual process. As telematics come down in price this picture may well change. Beyond this many companies already use GPS tools linked to live traffic updates with routing increasingly reliant on them. The IGD studies also indicated that organisations felt there was greeter gains to be made in other areas, aside from telematics. There will be less centralised planning and more dynamic routing, allowing for avoidance of congested areas (IGD, 2015), but the study does not indicate the level of adoption.</td></tr>
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	The level of adoption and potential adoption estimates vary. Whilst the CSRGT data suggests similar to the above studies and show that between 2003 and 2010 the proportion of vehicles fitted with on-board computer systems, GPS systems and/or telematics in the freight sector grew sharply (CSRGT, 2010). However, a report in 2017 suggests the uptake is much greater and is perhaps an indication of the reducing cost of telematics. RAC Telematics Report 2016 suggests that 65% of businesses are making use of telematics (arise form 38% in 2015), of which 85% are HGVs (RAC Foundation, 2016). Onboard tracking and monitoring devices it allows for better reporting of mileage achieved versus the plan and therefore ultimately reduce excess miles and potentially ‘on road’ response to opportunities to backhaul. Supporting this, respondents in FTA Logistics Carbon Review suggested that the more efficient deployment of fleet was extremely important in the effort to reduce empty running, and as such vehicle routeing and tailored transport plays a significant part in back and forward hauling (FTA, 2015). Nearly half of participants currently use vehicle telematics (FTA, 2015). To make the best, responsive decisions on routing and sharing of loads requires data to be updated and available live to all parties impacted by or with impact on the situation (see also dashboard on data sharing from telematics) (IGD, 2015) McKinnon suggests that vehicle routing upgrades are a quick win for business that could yield cost savings and suggests a 20% improvement carbon intensity as a result of improvements to routeing efficiency (McKinnon, 2018).
Opportunity to Develop Further	Satellite navigation systems have become so widespread that they are almost taken for granted. However, the fact that they are so useful is leading to an expansion of available systems. Several countries are working on systems so product selection may become more complicated. The Local Government Association and other campaigners have called for the use of lorry specific satellite navigation equipment to be compulsory for all goods vehicles.

<table>
<tr><td>Intervention Title</td><td colspan="2">3D PRINTING</td><td>Intervention Number</td><td>D5</td></tr>
<tr><td>Intervention Description</td><td colspan="4">3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object. 3D printing is the opposite of subtractive manufacturing which is cutting out / hollowing out a piece of metal or plastic with, for instance, a milling machine. 3D printing enables you to produce complex (functional) shapes using less material than traditional manufacturing methods.</td></tr>
<tr><td>Quality of Evidence</td><td>-1</td><td colspan="3">Emerging views, but no solid view on the extent of the impact on congestion</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="3">There are mixed views about the potential, but a consensus it may be too early to assess.</td></tr>
<tr><td>TRL</td><td colspan="2">5</td><td>Stakeholder Acceptability</td><td>0</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">One of the scenarios in DHL’s future think piece, identified as ‘Customised Lifestyles’ envisaged the widespread adoption of 3D printing at a household level. This level of home-based production could substantially reduce the amount of freight movement. It would still be necessary to deliver the materials used in the printing process, but they could be delivered in bulk through supply chains much simpler and shorter than the ones through which household products are currently distributed (DHL, 2012). McKinnon suggests that this is some time in the future and that an intermediate stage, consumers may outsource 3D printing to local set ups equipped with 3D kit. This would still permit some rationalisation of upstream supply chains, but require delivery of the 3D printed items to the home.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">In his article in ‘In Focus’ Alan McKinnon highlighted “A recent Dutch survey revealed just how divided expert opinion is on this matter. When asked about the likely effects of 3D printing on transport, experts gave ‘a scattered array of answers ranging from large positive impacts to large negative impact’ with a majority of experts anticipating “either moderate or no impact”’ (McKinnon A. , 2018).
Taniguchi and Thompson in their study suggest “emerging technologies such as 3D printing and electronic media could reduce the demand for goods movements” (Taniguchi, E. and Thompson, R G., 2015) this has implied consequences for congestion – but as yet it is unproven.
There is a need for gaining more insights into the impact of 3D printing on supply chains. Current literature on 3D printing and transport studies does not provide a systematic model of the impact of 3D printing on transport and related (policy relevant) areas (Wouter Boon & Bert van Wee, 2018) .
There are plenty of speculative studies into the role of 3D printing, however the extent to which it will impact UK transport networks and markets is unproven.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="4">Whilst widespread domestic 3D printing could be a game changer in the nature and type of freight movements, the domestic adoption is rare and therefore predictions of mass adoption is unclear.</td></tr>
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IMPROVE VEHICLE UTILISATION

Reducing the number of vehicles (including wagons and trains) used/needed to transport remaining demand. Increase vehicle payloads through use of larger vehicles or and improved capacity utilisation.

<table>
<tr><td>Intervention Title</td><td colspan="2">ALTERNATIVELY FUELLED HGVS</td><td>Intervention Number</td><td colspan="2">V1</td></tr>
<tr><td>Intervention Description</td><td colspan="5">The propulsion of HGVs using on and off-board low emission fuels beyond the traditional use of diesel.</td></tr>
<tr><td>Quality of Evidence</td><td>-1</td><td colspan="4">There is some evidence of alternatively fuelled HGV operating performance from industry studies although nothing that makes a link between the means of propulsion and the impacts on freight congestion.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="4">Considered have a negligible impact on congestion and may in fact increase congestion if weight remains an issue for alternatively fuelled vehicles.</td></tr>
<tr><td>TRL</td><td colspan="2">3</td><td colspan="2">Stakeholder Acceptability</td><td>2</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="5">There is a consensus that the adoption of alternatively fuelled HGVs will not bring about changes in freight congestion as there is no evidence to support otherwise.

The Road Haulage Association (RHA) outlined concerns on the current limitations of many alternatively fuelled HGVs which are only capable of operating at lower payloads and as such could potentially cause an increase to congestion costs. (Road Haulage Association, 2017).

Some solutions, such as using overhead electric power supplies and some types of battery power supply, could improve the way that power is delivered, improving acceleration and hill climbing performance, and so potentially reduce the impact of HGVs on congestion.

Indirect impacts related to alternatively fuelled HGVs are linked to the policy direction, for example for Clean Air Zones (CAZ), where priority measures for electric vehicles at traffic lights or financial incentives could impact route choice and therefore have an impact on congestion (Vaughan, 2016).</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="5">There is limited evidence of vehicle performance due to a lack of available technology on pure electric HGVs. A number of EV Electric Vehicles (EV) HGV manufacturers with models currently in production have made unsubstantiated claims of HGV performance such as Tesla with the Tesla Semi consuming less than 2 kWh/mile (Arcus, 2018).

The use of alternative fuelled vehicles such as EVs is likely to lead to fuel consumption savings, that in turn will equate to reduced operator costs. Ricardo claim an alternative fuel technology (using a thermal power engine cycle), CryoPower, could cut fuel consumption by up to 30% against the average fleet. The fuel could also enable long-haul HGVs to fully comply with inner-city emission restrictions, saving hauliers thousands of pounds per year. This might also lead to changes in routes as hauliers possess the flexibility to provide a more point-to-point service (Ricardo, 2018).

Currently EVs are limited to smaller vehicles therefore the requirement to use EV for freight could result in more (albeit cleaner) vehicles to move the same amount of goods and therefore increase congestion.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="5">• Engagement with industry and relevant stakeholders to consider research and incentives for fleets to adopt new means of propulsion as well as incentives for the supporting charging infrastructure or fuel supply chain.
• Research is also needed to consider the impact of EVs on congestion and if EV HGVs reduces payload due to the weight of the batteries.</td></tr>
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<table>
<tr><td>Intervention Title</td><td colspan="2">BACK AND FORWARD HAULING</td><td>Intervention Number</td><td>V2</td></tr>
<tr><td>Intervention Description</td><td colspan="4">"Backhauling to reduce empty running - the objectives of this is to minimise the amount of empty running through returning from a delivery with a load. An extension of this may be "forward hauling" where a vehicle is empty whilst 'en-route' to pick up a load and therefore the objective of forward hauling is to reduce the amount of time this leg of the trip is empty" (TRL, 2017). It can be used to fill completely empty loads or to reduce filling under capacity. This can be arranged within the supply chain of one company, between organisations independently, or using a third-party freight exchange. Consolidation represents a natural extension to backhaul operations and can be undertaken with or without out a consolidation centre or freight exchange. Effective route scheduling/planning is an enabler to allow for opportunities for backhauling and consolidation.</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="3">The use of back and forward hauling is well documented.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>2</td><td colspan="3">Evidence suggests that this could have a major impact on the number of vehicles on both the SRN as well as in urban areas. The principle of reducing empty running remains the same for HGVs and vans and therefore can be use a technique to reduce the number of both types of vehicle on the roads.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>2</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">The DfT Industry Collaboration study estimated that savings of between 1 and 5% in mileage could be achieved using back and forward hauling, implying a reduction in empty running, and potentially having a positive impact on congestion (TRL, 2017).</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">Whilst 29% of vehicles are believed to run empty, studies have shown the actual potential to reduce this percentage is low due to issues such as load incompatibility, or short journeys making backhauling uneconomic. (For a short journey it is usually more efficient to return directly to the origin to collect another load. For a longer journey it is more worthwhile to drive a short distance after unloading to find a return load.)

McKinnon and Ge concluded that approximately 2% of empty journeys could be backhauled resulting in a 2% reduction in kms driven (McKinnon & Ge, 2006).

In contrast, research by Starfish identified a perceived opportunity to reduce kms driven by 7.9% through backhauling (Palmer and McKinnon, 2011). This could be achieved if time constraints were relaxed, permitting a greater coordination of delivery and pickup windows and hence greater exploitation of backloading opportunities. Time constraints can be imposed by restrictions such as noise restrictions in stores, or customer and practice from organisational requires. This is discussed in the Dashboard on the Reduction of HGV restrictions.

Outside of grocery, FMCG and construction there is little evidence of the extent to which other industries can back and forward haul. Larger organisations undertake this systematically within their own supply chains often, as do hauliers who need to make money on every leg. However, there are fewer opportunities for SMEs.

Effectiveness is also impacted by the level of data gathered and sharing. This activity is often undertaken as a result of and in combination with other interventions such as consolidation centres, freight exchanges, retiming and could be enhanced by new technologies such as blockchain, route planning and optimisation and data sharing. Respondents to the FTA survey also reported that more efficient deployment of their core fleet on existing flows is the most effective way to reduce empty running, followed by collaboration with suppliers. There are many examples of where this is being undertaken, together with a vast array of technology available to facilitate this.

As part of the back and forward hauling process, 55% of IGDs survey responders said that sharing trucks was in the top three opportunities to reduce miles and 42% of retailers and 32% of suppliers in IGD’s survey suggested that sharing transport is the</td></tr>
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	biggest opportunity to reduce costs and improve efficiency (IGD, 2015). This then could mean a reduction in empty running. **ForFarmers** improved levels of vehicle utilisation by using Paragon scheduling and route planning software. ForFarmers saved £250,000 in just one region. The business was able to plan its national logistics operations at regional level which has dramatically cut empty mileage and transport costs. By routing and scheduling all the vehicles within each region as an integrated resource, the plans enable vehicles to interchange between feed mills, collecting and distributing loads in the most efficient way possible. This focus on maximising efficiency means that, at ForFarmers, backhauling is second nature and empty running is significantly reduced (Paragon, 2018). **Arla Foods** routinely sends refrigerated trailers full of processed milk to supermarkets at night and, in the early mornings, its tankers collect raw milk from farms. This means a substantial amount of empty running. It has solved the problem with a unique trailer-tanker combination. The new vehicle leaves the dairy at night with its top half loaded to its maximum 44-tonne weight with fresh, processed milk. Once this has been delivered, the vehicle then proceeds to neighbouring farms to fill its bottom half, also to its weight capacity, with raw milk. Hence, the single vehicle completes almost as much work as two separate vehicles, and virtually eliminates empty running entirely. Although there is a payload penalty, this is more than off-set by the substantial fuel and operational savings the vehicle creates. Arla has suggested that for each tanker-trailer combination, they save 155 tonnes of CO_2 per year. Compared to two conventional vehicles on the same routes, once deployed, this will equate to 3,225 tonnes per annum (Arla, 2018).
Opportunity to Develop Further	• Industry standards: there are currently little or no industry standards within the telematics sector. With at least 15 significant vehicle tracking suppliers and more than 100 providers in total, transport operators face serious challenges when it comes to effective supply chain communications. Previously, there has been no means for partners to share vehicle positioning and other important data unless they are using the same tracking tool (and even this offer requires costly integration of some kind) (Haulage Exchange, 2018). • Development of working parties that encourage SME and other non-grocery industries, through recognition schemes, incentives, grants to implement technology and/or training.

<table>
<tr><td>Intervention Title</td><td colspan="2">BLOCKCHAIN</td><td>Intervention Number</td><td>V3</td></tr>
<tr><td>Intervention Description</td><td colspan="4">“…is a database designed to be distributed among many users, to be immutable, to work without oversight from any central authority, and to dispense with the need for its users to trust each other” (The Economist, 2018).

The underlying principle is the provision of secure environment where encrypted business transactions can happen without third party intervention. This is epically useful in long supply chains. It would allow fast and more accurate tracking of product, reduction in errors, sharing of information to allow for process improvement, and a complete audit trail.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">Early days for blockchain and the evidence linking this to congestion is limited at the moment.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="3">Potential to reduce supply chain costs through speeding up administrative processes, reducing turnaround times.</td></tr>
<tr><td>TRL</td><td colspan="2">3</td><td>Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">Cause efficiency rather than congestion improvements – could make improvements in turnaround times and therefore resulting in a reduction in the time to access to delivery points. Blockchain will make it easier to operate complex supply chains and transport arrangements, for example load sharing or intermodal transport. As such it can be a key enabler to more efficient supply chains, which could reduce congestion through improving payloads.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">For supply chains, the benefit of a widely distributed database containing incorruptible records is a considerable streamlining of the supply chain resulting in considerable cost savings. Industry analysts see blockchain as a future essential technology and suggest “…that by 2043, the fundamental drivers behind value creation will be data and analytics, with companies that are able to utilise blockchain technology being able to outcompete their rivals” (TT Club and McKinsey, 2018).

The main advantage is for administrative functions, but it could have an impact on congestion by allowing for greater consolidation due to accurate shared information, quicker turnaround times which improves congestion at access points at the point of delivery. Especially in the marine environment there are plenty of examples of where Blockchain is being trialled including
Container Logistics Pilot – Port of Rotterdam, Samsung SDS, and ABN Amro
Port Connectivity Pilot – Associated British Ports, Marine Transport International
Completion of the world’s first bunker delivery and transaction using blockchain – GoodFuels Marine
Supplier Management System – DB Schencker, VeChain
Efficient and secure global trade platform – IBM, Maersk
Shipment of almonds from Australia to Germany – Commonwealth Bank of Australia
However, none of these give an estimation of view on the impact of congestion outside of the port.

In his recent article ‘A congestion free future will require blockchain’, Tim Sandle suggests blockchain is required to alleviate congestion, however, there is no evidence to explain how this may occur or to what extent. The article highlights the Mobility Open Blockchain Initiative (MOBI) Grand Challenge which is a competition inviting organisations to show how blockchain and other technologies can be used to alleviate congestion (Mobihacks, 2018). The implication of the challenge is that blockchain would be implemented with CAVs which would encourage a reduction in congestion.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="4">Further research is needed to understand the implication on congestion however, this is fast moving area in which industry is leading. The role of other stakeholders may more be to govern and regulate if necessary the sharing of data.</td></tr>
</table>

	• The sharing of data is an enabler to improved efficiency of the movement of goods, hence Blockchain has the potential to unlock this potential.

<table>
<tr><td>Intervention Title</td><td colspan="2">CARGO BIKES</td><td>Intervention Number</td><td>V4</td></tr>
<tr><td>Intervention Description</td><td colspan="4">The use of bikes or e-cargo bikes for last mile deliveries is increasing. As well as sustainability benefits use of non motorised transport can play a role in reducing road congestion.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">Evidence of sustainability benefits is strong, but evidence of the impact on congestion is poor.</td></tr>
<tr><td>Potential impact on freight congestion</td><td>1</td><td colspan="3">In the urban environment, cargo bikes could replace some vehicle movements, and therefore improve congestion.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>0</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">The Government has supported using e-cargo bikes through the 2015 Shared Electrically Assisted Pedal Cycle (EAPC) Programme and the 2017 Innovation Challenge Fund under the belief that they can play a key role in last mile deliveries (DfT, 2018).

Bikes can be used along roads which are not suitable for or accessible to motorised transport. Bikes occupy a smaller space at loading bays or at the kerbside.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">The DfT’s call for evidence on the last mile recognised that there are barriers to the use of cargo bikes:

• Commercial viability – there is a potential trade-off between cheaper vehicles (e.g. the purchase cost of an e-cargo bike is the fraction of that for a delivery van), and higher labour costs (e.g. more e-cargo bike delivery cyclists would be required than van drivers). There is also a trade-off between the higher purchase costs of e-vans against their lower running costs compared to diesel vans.
• Vehicle/bike limitations – electric forms of delivery have capacity limitations and are not suitable for delivery of some types of specialised loads. E-cargo bikes can carry up to approximately 100-125kg.
• Insurance & licensing – there is some complexity over insurance and licensing requirements for different e-bikes, micro vehicles and e-vans.
• Training & operations – more sustainable forms of last mile delivery require investment in rider / driver training and different operational procedures and equipment (e.g. the establishment of local partnerships for delivery hubs).
• Current infrastructure – urban infrastructure to date has not been designed for use with electric solutions and would require major changes to the way goods are currently distributed, which is typically from large, out-of-town warehouses. There are opportunities to improve the logistical efficiency of urban road freight and last mile deliveries through urban consolidation centres, which could lead to financial savings for operators, congestion benefits and emission reductions (DfT, 2018).

"Although they have less capacity than more conventional forms of delivery, they can make many deliveries in one day if supported by a local hub or micro-hub. This means … economic benefits through the delivery of smaller but higher value freight in cities, such as electrical components and medical supplies. E-cargo bikes can also carry refrigerated goods in specifically designed courier boxes" (DfT, 2018)

There is a lack of structured research into the use of cargo cycles within city logistics. In principle, however, one study has suggested that in the future e-cargo bikes could form 25% of city centre commercial traffic, whilst another has suggested that 51% of all motorised trips in European cities that involve transport of goods could be moved to bikes or cargo bikes (Schliwa, G., et al, 2015). This could have a significant impact on urban congestion, although may be offset to some degree with a risk of increased accidents as traditional vehicles compete with an increasing number of bikes which in turn increases incident related congestion.

There is limited evidence to suggest how much congestion could improve as a result of cargo bikes, although evidence suggests that it has a role to play. That said, operators</td></tr>
</table>

	Gnewt Cargo the first cycle only delivery company noted that they have had to move to electric vans as bikes do not have the capacity for the deliveries needed (Robert Wright, 2016). A recent Dutch study showed that e-cargo bikes could be an alternative for some 20 percent of all delivery vans currently operating in large cities. The Dutch study showed that the 350kg capacity is adequate given in the Netherlands, the average van carries as little as 130kg per trip (Amsterdam University of Applied Sciences, 2018) . As a result, while individually replacing a diesel van with a cargo bike or EV may have a positive impact on emissions, increasing the number of vehicles or trips will cause more issues – increasing congestion, reducing journey time reliability (for both freight and buses), and increasing emissions from any remaining diesel vehicles. The overall impact of safety is unlikely to be beneficial as a result. More urban logistics centres and micro-hubs would reduce the trip length and impact of cargo-bikes and lightweight EVs creating a new logistics 'system'. However, the relative financial returns on urban land means it will be difficult to safeguard and create the requisite number of such centres, without direct Government intervention. (CILT, Call for Evidence on Last Mile Logistics, 2018)
Opportunity to develop further	• UCC in a city centre location as a base represents a necessary precondition to shorten final delivery distances sufficiently to provide these services in an economically competitive way. Therefore, if this is to be promoted it needs to be done in conjunction with urban and micro consolidation centres. • Review of the DfT's call for evidence could inform the development of cargo bikes as an urban solution.

<table>
<tr><td>Intervention Title</td><td colspan="2">CONSOLIDATION CENTRES</td><td>Intervention Number</td><td>V5</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Logistics consolidation is a term that describes the use of a physical location that involves multiple inbound part vehicle loads being merged together to create fewer but fuller vehicles for the final delivery to the end destination (whether that be a supermarket, airport, large municipal building such as a town hall, hospital, university or a whole area such as a shopping centre). In recent years the term consolidation has taken on a wider context including procurement (for example shared buyer initiatives), however the purpose of this research is to concentrate on logistics consolidation and the use of a centre or facility.

There are three types of consolidation centre:
• Regional consolidation centres (RDC) which have been established by large supermarkets for their own goods, that also house a large warehouse facility and serve a wide geographical area.
• Urban consolidation centres (UCC) which are run by third party logistics operators and are located on the outskirts of a large town or city. Such centres are often located within close proximity to the strategic road network to promote ease of access for visiting supplier or courier vehicles.
• Micro consolidation centres provide a more contemporary operating model and by their nature only require a small operating space and are often situated very close to or inside the area being served. Cargo bikes (and sometimes small electric vans) are the vehicle type of choice for micro consolidation centres, due to the lower operating range of these vehicles. The centres may be characterised with the use of a used shipping container to store a small quantity of goods and the cargo bikes on a small piece of land which is a much smaller scale operation compared to the regional or urban consolidation centres mentioned above.</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="3">In the examples found, many were able to demonstrate a reduction in vehicles as a result of UCC and therefore, evidence is mixed.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">Where used, the potential in reducing vehicle miles and numbers is positive. There is a concern that the use of UCC could increase the use van traffic by swapping HGV’s with smaller vans – this is discussed below.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>0</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">Consolidation has the potential to:
• Reduce distances travelled and congestion, promoting air quality and carbon emission improvements
• Reduce empty running in local, urban and regional environments
• Deliver end user benefits in terms of fewer deliveries, fewer interruptions
• Increase vehicle utilisation
• Be an additional revenue stream
• Facilitate intermodal transport solutions (rail, barge, short sea) which are now hindered by a lack of stable base volumes to make them economically viable. This is especially the case for the SME environment.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">There are existing examples of publicly promoted and successfully run consolidation initiatives, and whilst last mile logistics savings are possible, there does remain some concerns as to whether they can run without public subsidy (SINTEF, 2015).

Other research such as BESTUFS work indicates that successful development of urban consolidation centres is more likely where city authorities provide incentives to encourage the use of Urban Consolidation Centres through regulatory differentiation in favour of vehicles operating from Urban Consolidation Centres, rather than direct capital and operating subsidies to private sector operators. Research also proposes policy makers should also consider how the planning system could be used to encourage consolidation of loads, without city authorities requiring deliveries to be made via a UCC (Independant Transport Commission, 2014). This could include incentives such as the reduction of restrictions night as night time deliveries, lifting of lorry bans.</td></tr>
</table>

Financial viability has been the main barrier to successful adoption, with Urban Consolidation Centres often requiring public sector subsidy to maintain operations. However, by creating an economic model which shows the financial value of the benefits for all stakeholders, the Transport Systems Catapult was able to show that the benefits can significantly outweigh the costs (Transport Systems Catapult, 2015).

An extract from the TSC report usefully highlights why, given the positive examples being seen, businesses are still resistant: *"Finally, delegates suggested that despite the business case put forward by this project, one of the main challenges that remains is convincing decision makers to support and provide funding for UCC strategies. While the results from this project have monetised the costs and benefits to all stakeholders for this particular case study, it was suggested that not all of these benefits would be returned as direct cash benefits which is what decision makers look for when making an investment. In this regard, some of the benefits refer to the potential operating savings of reallocating existing resources to serve other activities, but not monetary cash savings. However, delegates did feel that if the business case is presented to decision makers via a third party such as the TSC, it would likely carry more weight, since the TSC is a not-for-profit organisation"* (Transport Systems Catapult, 2015).

TSC identified a number of reports that concluded that there were reduced freight vehicle movements (Allen, Browne, TRL) as a result of UCC, in addition to Choongh-Campbell's assertions of the reduction in demand for kerbside space which in itself is a cause congestion (Transport Systems Catapult, 2015).

Having said that, a report undertaken in 2017 by TfL had a recommendation to *"Develop a London-wide integrated system of consolidation centres to meet both strategic and localised freight needs, developed in partnership between the public and private sectors. Through the London Plan and specific Borough Local Plans, industrial land and other appropriate development sites in Central, Inner and Outer London should be safeguarded for consolidation activity".* (TfL, 2017)

By their very nature consolidation within organisations such as RDCs need to be proven financially otherwise they wouldn't be introduced, however, externally managed consolidation (such as urban consolidation centres) are much more difficult to sustainably operate. Within Greening's analysis of the impact of demand side fuel savings, consolidation centres were seen to be one of the highest hitting potential interventions he assessed as part of his modelling (Greening, 2015). It is unclear if this consolidation relates to urban or strategic consolidation.

There is a lack of available data on the benefits of strategic collaboration. This could be due in part to the perceived confidentiality of information, as well as a lack of comparable standard data that can be shared. This issue was noted by the Centre fpr Sustainable Road Freight, who highlighted that a lack of comparable data restricts the ability to undertake joint planning. The report identified that local authorities can struggle to see the benefits of consolidation centres, as local vehicle flows are not always understood, making benefits harder to identify (Greening, 2015).

That said 22% of suppliers and 21% of retailers in IGD's 2015 survey suggested that sharing facilities presents the greatest opportunity to reduce costs (IGD, 2015).
In reducing congestion and empty running, Greening identified potential savings of 4.3% in mileage from using consolidation centres (Greening, 2015). Using this as a basis, the DfT collaboration study concludes that this could mean a saving of £3000 per vehicle in fuel for rigids, and £4000 for articulateds over a six year period (TRL, 2017). The impact on empty running was not identified in this report.

Urban consolidation in some cases has been seen as the key driver in the increase in use of smaller vehicles (vans, e-cargo bikes etc) which could have a negative impact on congestion if more smaller vehicles are used to do the same job has full HGVs. It can however have other benefits such as improvements in air quality if the use of smaller vehicles enables using cleaner vehicles. There is little evidence of HGV freight fill in cities and therefore it is unclear of the benefit urban consolidation can bring. Some argue that the increase in van use is not related to the rise in urban freight demand. In his presentation, 'The Rise and Rise of Vans in Cities' Braithwaite suggests that the rise of vans is not just about freight deliveries, in fact van use is hugely diverse. The report suggests only 4.8% of vans are used for freight – although this doesn't indicate the change over time (Braithwaite, 2018). Aside from this there is little evidence of the impact of freight van use on congestion versus freight HGVs.

Urban consolidation

Bristol & Bath Freight Consolidation Centre was the first public sector consolidation centre initiative in the UK and the longest running, having opened in 2004, and is operated by DHL. It is focussed on reducing the number of retail deliveries into the city centres. The current status of this facility is unknown and it is thought that Bristol City Council have withdrawn their funding (BESTUFS, 2011).

Houses of Westminster urban consolidation centre was set-up primarily for security and operational reasons and has been operated by Ceva Logistics for over 10 years. The Houses of Westminster pay for the service provided by Ceva which includes full security scanning of the goods destined for Parliament as well as providing a bonded warehouse.

Freight Consolidation Service (LB's Camden & Islington) opened in Jan 2014, and was fully funded through EU Commission and London Mayoral funding for the first three years (Camden, 2015).

Southampton Sustainable Distribution Centre, operated by Meachers Transport and partnered with the university, hospital and council as part of the CityLab project – Meachers received no public funding but have been able to secure additional fee paying business (Meechers, 2017).

Norwich Transhipment Centre – in 2007 a trial was established to consolidate loads and in 2008 it reported those involved enjoyed a reduction in journey time by virtue of the fact that vehicles using the transhipment centre were allowed to use the bus lane. This resulted in marginal gain in fuel consumption (SINTEF, 2012). It was not seen as a huge success with a lack on industry interest. It is unclear if the centre is still operational.

Regent Street - Regent Street represents the largest concentration of value in The Crown Estate's portfolio. The area attracts over 7.5 million tourist visits each year. The area also experiences heavy road congestion which can impair the shopping experience for visitors. Therefore, the Crown Estate initiated efforts to improve the visitor and shopper experience, which would increase a retailer's turnover and ultimately result in a higher rental value for the property. Regent St. is within London's congestion charge area, thus city distribution for receivers that operate their own distribution can be considered expensive. The results suggested a measured reduction in congestion as a result. They report a 74% average trip reduction (Transport Systems Catapult, 2015).

In terms of reduction in congestion, all the examples cited have been able to demonstrate a reduction in congestion as the number of vehicles delivering to the destination area were reduced by between 50-75%. There are a number of international examples of UCCs including Monoco, Stockholm and Nijmegen (Netherlands).

Construction consolidation centres

London Construction Consolidation Centre was established by TfL in 2008 to act as a distribution centre for construction materials to four major buildings in central London. That output suggested there was a 70% reduction in the number of delivery vehicles to the construction sites (SINTEF, 2015).

	Supply chain consolidation - strategic Sainsbury's has been working with third party logistics provider NFT for over 15 years in both primary and secondary distribution. NFT approached Sainsbury's with a proposal to collect and consolidate suppliers' products through one of three transhipment hubs strategically located within the UK. This enabled a reduction in inbound RDC deliveries by optimising vehicle fill on each load as well as utilising the same vehicles to collect suppliers' products en route following an RDC delivery. Over 240 manufacturers across 120 collection points were involved in this process and, as a result, average vehicle fill has increased by 20% during that time, therefore reducing empty running substantially. By utilising Sainsbury's secondary store fleet to undertake primary collections and deliveries, which now account for 26% of all journeys, this initiative has further reduced Sainsbury's carbon footprint. 5.4 million km have been saved per annum, equivalent to 4.6 million kilograms of CO_2. Using some of the primary NFT fleet to undertake store deliveries has further reduced km and CO_2 emissions (2.2 million km, equivalent to 1.9 million kg of CO_2) (TRL, 2017). Conclusions from the SINTEF report suggest the benefits of urban consolidation centres are difficult to achieve without public incentives and their success depends on getting operators involved, therefore the benefits to the freight operators need to be clearly identified in order to get their engagement (SINTEF, 2015). Those that have been most successful have been those that are very specific to an industry or specific area with a small number of committed operators – e.g. the London Construction Consolidation Centre. The effectiveness of UCC is considered further in the accompanying Evidence Report/
Opportunity to Develop Further	• Consolidation centres can be effective in the right circumstances. Therefore, guidance could to be developed and promoted to help operators, developers, planners and local authorities on what variables needs to be considered to make consolidation centres a financially effective solution and drive a reduction in vehicle movements. • Development of data on freight flows to allow for the benefits of urban consolation to be seen. • Consider how to protect land suitable for the use of urban consolidation centres. • The use of targeted subsidies and investments could encourage the development of sustainable urban distribution, and provide cost advantages for private sector stakeholders. • Incentivise the use of consolidation centres by providing preferential access to urban centres.

<table>
<tr><td>Intervention Title</td><td colspan="2">CONSTRUCTION LOGISTICS PLANS (CLP)</td><td>Intervention Number</td><td colspan="2">V6</td></tr>
<tr><td>Intervention Description</td><td colspan="5">A Construction Logistics Plan (PLP) is a tool, originally developed and a requirement in London, for planners, developers and construction contractors to establish how a construction site impacts the road network, focusing on how that can be reduced. The construction supply chain covers all movements of goods, waste and servicing activity to and from site and a CLP provides the framework for understanding and managing construction vehicle activity into and out of a proposed development. As the CLP typically forms part of a planning application, Local Planning Authorities are responsible for approving the CLP. For applications where TfL has an interest, TfL will provide comments to the LPA. LPAs must make a judgement on a case by case basis as to whether a development proposal will generate significant impacts on the road network. Included in CLPs are measures such as offsite construction, which refers to the planning, design, fabrication, and assembly of building elements at a location other than their final installed location to support the rapid and efficient construction of a permanent structure. (Ace, 2018).</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="4">Whilst there is a connection with CLPs and reduced mileage and efficiency, little evidence could be found of the true extent it contributes to a reduction in vehicles outside of individual examples.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="4">There is an implied indication that CLPs could have a impact on the number of vehicles in the specific urban area in which it is implemented.</td></tr>
<tr><td>TRL</td><td colspan="3">N/A</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="5">In specific areas where CLPs are implemented could have a general positive improvement on congestion, which in turn will help freight congestion. This is particularly the case where deliveries are taken out of peak times and use construction consolidation centres thereby reducing congestion for time critical deliveries and vehicle movements. Reducing the frequency of deliveries could result in a reduction in van use if they are used to services sites with more frequent but smaller deliveries.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="5">Whilst CLPs are sited as a means to significantly improve logistics operations of a construction site – few case studies or evidence was suggested as to the effectives of CLPs to reduce empty running or congestion.
Evidence suggests that CLPs:
Reduce site traffic by 60-70%
Provide better storage for materials than on site meaning that stock can be held reducing the delivery frequency needed
Allow for the removal of excess packaging off site, reducing clutter at the work site
Allow for the sequencing of materials, encouraging overall efficiency and flexibility
Serve as a project management centre and place to test materials/arrange timetables etc (Ace, 2018).
That said, it's the measures implemented as a result of the CLP which will deliver benefit rather than the CLP itself. There are examples that show how the movement of construction materials by water or rail have taken HGVs off the road – for example in 2011 the historic decline in the use of water started to reverse and volumes of construction materials handled at wharves within Greater London increased by 35% compared to those handled in 2010. In 2012 construction materials transported on the Thames increased by a further one million tonnes (Steer Davies Gleeve, 2017). Whether this is as a result of CLPs however is unclear.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="5">The requirement for all new developments to have a CLP in place which monitored rigorously. A must for all public-sector buildings.
Understanding how elements of CLP can be used in other industries e.g. off-site design/assembly.
Development beyond a London requirement.</td></tr>
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<table>
<tr><td>Intervention Title</td><td colspan="2">DELIVERY AND SERVICING PLANS (DSP)</td><td>Intervention Number</td><td>V7</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Delivery and Servicing Plans (DSPs) are another tool developed in London and designed to reduce the number of HGV trips generated by a premises or wider areas of multiple premises. It includes polices/actions that change procurement choices, delivery times, lead-times, consolidation, personal deliveries to reduce vehicle numbers. This could mean collaboration (procurement, delivery times, waste management) with other businesses in the building/area.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">Whilst there is a connection with DSPs and reduced mileage and efficiency, little evidence could be found of the extent it contributes to a reduction in vehicles outside of individual examples.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">There is an implied indication that CLPs could have a impact on the number of vehicles in the specific urban area in which it is implemented.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">In specific areas where DSPs are implemented they could have a general positive improvement on congestion, which in turn will help freight congestion. This is particularly the case where deliveries are taken out of peak times, thereby reducing congestion for time critical deliveries and vehicle movements. Reducing the frequency of deliveries could result in a reduction in van use if they are used to services sites with more frequent but smaller deliveries.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">Business Improvement Districts (BIDs) have led the way in DSPs, working with businesses to show them benefits as well as with individual businesses undertaking DSPs unilaterally. DSPs are required for certain buildings alongside travel plans and CLPs but the effectiveness of their implementation is unclear.

The findings from a study undertaken by Southampton University suggest that the average high street business could expect up to 10 core goods and 7.6 service visits per week, in non-peak trading periods with 25% additional activity during the build up to Christmas. Vans were the dominant mode, responsible for 42% of delivery activity with a mean dwell time of 10 minutes (Cherrett, 2012).

• The Emirates Stadium example suggested that they had reduced their deliveries by two thirds (TfL, Undated) because of developing a DSP.
• Paper supplier, James McNaughton have worked with its suppliers to install an online delivery booking system. This has eased congestion on the site. (TfL, Undated)
• The offices of Almo have moved £40,000 worth of orders to one of their suppliers that deliver outside of peak hours, resulting in reduced congestion both on-site and locally. Almo also worked with its suppliers to consolidate deliveries. This led to deliveries being reduced by two-thirds. (TfL, Undated)
• The Natural History Museum shares several services and suppliers with their neighbours. The joint procurement of cleaning and waste services with the Science Museum resulted in reducing the number of vehicles coming to the site. (TfL, Undated).

There is limited evidence through cases studies of the benefits of DSPs. Case studies often talk about what they will do, not what was achieved. DfT's collaboration study assumed that the benefits would be similar to consolidation centre as the principles remain the same – ie 4.3% saving in mileage. (TRL, 2017)

"DSPs have the potential to mitigate potentially serious congestion issues across all street types from high streets to residential roads. But until now their use has been scant and their performance remains unknown". (Westtrans, 2017)</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="4">• A must for all public-sector buildings which importantly, must be monitored.
• Training for planners on how to use and monitor DSPs.
• Availability of urban space for urban consolidation centres.</td></tr>
</table>

	• Investigation of mechanisms to incentivise the preparation, implementation and monitoring of DSPs.

<table>
<tr><td>Intervention Title</td><td colspan="2">DISTANCE BASED HGV CHARGING</td><td>Intervention Number</td><td>V8</td></tr>
<tr><td>Intervention Description</td><td colspan="4">There are four main models of road pricing: location specific (cordon and area charge), corridor specific, partial network and whole-of-network charging schemes. Within these models, pricing can be targeted for the time of day, a particular vehicle fleet type, or distance travelled.

Within the UK the potential for distance based charging of HGVs has been considered in the past. Objectives include:
Linking road taxation more clearly to use of road space
Creating a level playing field between overseas and UK based hauliers
Encouraging modal shift
Encouraging better utilisation of vehicles and less empty running over long distances
Potentially moving away from fuel based taxation, particularly given long term objectives to move away from diesel fuel</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="3">There are examples of this as an intervention. The connection to reducing congestion clearly identified in examples in other countries.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>2</td><td colspan="3">Evidence suggests that there is potential for HGV distance based charging to reduce congestion by encouraging a true cost of transport to be implemented. There may be an impact on increased van use of HGVs are seen to be unfairly charged and therefore this intervention needs to be considered across all freight movements.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">A distance based HGV charging scheme may reduce congestion and could be an efficient road charging approach. Charging could have beneficial effects of road freight operations by reducing journey times and improving reliability. Some believe that no sensible way forward for freight infrastructure can be found without addressing the issue of marginal external cost pricing and that if HGVs are charged for the distance they are travelling this will better encourage less empty running and drive efficiency.

DfT have summarised the impact of road charging (generally) and include: Congestion, Accidents, Noise, Pollution, GHG, Infrastructure costs, Nature and Landscape, Community severance and Visual intrusion. (DFT, 2009)</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">There is an argument that HGVs specifically should be targeted because of the disproportional impact of maintenance. For example, the heaviest HGV axle does over 150,000 times more damage than a typical car axle (Campaign for Better Transport, 2014). Freight industry commentary suggests that in principle road charging is an effective means to manage the cost of road infrastructure however, it needs to be combined with offsetting other kinds of HGV tax.

This may reduce congestion; however it needs to be backed up by effective enforcement and compliance monitoring. (Challenge Panel, 2018).

Germany: With the introduction of HGV tolling on federal motorways in 2005, the Federal Government ushered in a step change, moving away from the funding of federal trunk road construction through taxation and towards the user pays principle. Since then, the tolling scheme has been extended in two stages (on 1 August 2012 and 1 July 2015) to cover around 2,300 km of four-lane federal highways. In addition, on 1 October 2015, the weight threshold for vehicles subject to tolls was lowered from 12 to 7.5 tonnes maximum permissible weight. Starting on 1 July 2018, HGVs will have to pay tolls for the use of all the approximately 40,000 km of federal highways (Federal Ministry of Transport and Digital Infrastructure, 2018). Research showed that the charge in Germany would encourage no more than 10% of freight to make the shift from road to rail (Eiband, 2009). It has been said that empty running has reduced from 29% to 18%. (Edmunds, Undated)</td></tr>
</table>

	McKinnon (McKinnon P. A., 2006) in particular has produced several papers in response to the UK proposal in 2005 to introduce lorry road user charging (LRUS). He questioned the effectiveness of the proposal based on: • HGVs make up only a low percentage of total traffic on UK motorways. • Opportunities to reschedule freight journeys may be more limited than expected.
Opportunity to Develop Further	Needs further research within the wider economic impact beyond congestion and considered as part of a wider HGV/fuel tax review as well as developing a clear understanding of how a distance based charging system would work.

<table>
<tr><td>Intervention Title</td><td colspan="2">DRONES/AIR-BASED DELIVERIES (HEAVY PAYLOADS/HUB-TO-SITE OR HUB)</td><td>Intervention Number</td><td>V9</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Cargo deliveries of heavy payloads using unmanned aerial vehicles (drones). Drones have several varied applications, can be remotely piloted or fly autonomously and come in a variety of shapes and sizes. Based on their flight mechanisms they can be divided into three categories (Ramalingam et al., 2016):

- Multirotor Unmanned Aerial Vehicles - can take off/land vertically, perform quick manoeuvres capable of hovering in a fixed position and flying in any direction. Slower maximum speeds and shorter flight times than fixed-wing drones.
- Fixed-wing Unmanned Aerial Vehicles – similar to an aeroplane; can fly for longer, at higher speeds and carry heavier payloads over longer distances. However, must take off horizontally and can only move in a forward direction (Beard et al., 2005).
- Hybrid Unmanned Aerial Vehicles – can hover but also transition into fixed-wing flight, however very few on the market at the moment (Cetinsoy et al., 2012).</td></tr>
<tr><td>Quality of Evidence</td><td>-1</td><td colspan="3">The potential of large unmanned cargo planes is being explored by the military in several countries and commercial fixed-wing drones carrying large payloads are being developed, however there are no large-scale operations ongoing. The technology for multi-rotor drones capable of carrying heavy payloads is still in development, with only prototypes launched. Thus there is no evidence on the wider impacts on congestion.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">Drones avoid delays and congestion on roads and railways and therefore do not exacerbate the problems however there is no guarantee that drones will displace existing surface deliveries (in turn reducing congestion) but in turn may initially generate new growth as result of increasing the accessibility of more remote areas or premium service offerings. If drones require infrastructure for horizontal take-off/landing, they could have negative impacts on congestion around hubs.</td></tr>
<tr><td>TRL</td><td colspan="2">3</td><td>Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">- Air-delivery services avoid surface congestion and delays and therefore do not exacerbate them
- They allow fast, customised and consistent delivery (however weather dependent)
- Freight drones improve market access to remote/congested/inaccessible places
- Increase/cause airspace congestion</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">The International Transport Forum's 2018 report states that unmanned freight transport could lower the cost per unit of freight significantly due to lower personnel and fuel costs as well as increased flexibility of schedules (International Transport Forum, 2018). Van Groingen in turn investigated the efficiency of using a drone to transport a 5000kg automotive payload from Germany to China weekly (Van Groningen, 2017) . The report found that it would be 35% more cost effective than sea travel and 17% more effective than a Boeing 777, illustrating that economically drones can compete with other modes.

Drones for larger payloads can be designed like large aircraft with fixed wings or have rotary wings like a helicopter. The infrastructure requirements for both vary, with fixed winged drones requiring airport-like infrastructure and rotary wings facilitating vertical take-off and landing. Development of fixed wing freight drones include those being developed by Astral Aerial Solutions in Kenya, which can carry 2,000kg of cargo and</td></tr>
</table>

	fly a range of 1,300km, who intend to have a commercial operation running by the end of 2018 (Bekele, 2018). As outlined in a report by SESAR JU in 2016, it was proposed that initially drones deliveries would likely to be available in *“remote areas with low accessibility first and generate new growth rather than displacement of surface deliveries”* (SESAR JU, 2016). In the case of Africa drones are named as an ‘ideal solution’ to getting cargo to remote areas (Whiteman, 2018). Fixed-wing drone operations however are limited to ground infrastructure for take-off/landing and capacity and therefore are more limiting as to their impacts on freight congestion (the cargo still has to be transported to airports). Boeing revealed a prototype electric unmanned cargo air vehicle which it says could haul as much as 500lbs in early 2018 (Davies, Boeing's Experimental Cargo Drone is a Heavy Lifter, 2018). Boeing has not announced a timeline for commercialisation however has suggested that it could be used to replace costly time-sensitive, high-value helicopter operations (International Transport Forum, 2018). Thus it is not necessarily a use case that reduces surface transport. As outlined in the International Transport Forum’s 2018 report, it is important to bear in mind that ground transport is under significant concurrent development (autonomous vehicles, barges, ships etc.) which may alter the business case for drones before drone delivery becomes feasible and commercially operational.
Opportunity to Develop Further	• Investigations into existing airport infrastructure which could be retrofitted for fixed-winged freight drones. • Regulation is needed to outline where delivery drones can legally fly and land. As drones fly Beyond Visual Line of Sight (BVLOS) there are concerns about the invasion of the privacy of private airspace and resident disturbance from any noise generated by flights (Nesta, 2018). In addition to airspace management rules, guidance with regards to operational limitations and administration rules need to be outlined (International Transport Forum, 2018).

<table>
<tr><td>Intervention Title</td><td>DRONES/AIR-BASED DELIVERIES (LAST MILE/HUB-TO-CUSTOMER)</td><td>Intervention Number</td><td>V10</td></tr>
<tr><td>Intervention Description</td><td colspan="3">Last mile deliveries of payloads under 5kg to customers using unmanned aerial vehicles (drones) aiming to provide same-day order-to-delivery services. Drones have several varied applications, can be remotely piloted or fly autonomously and come in a variety of shapes and sizes. Based on their flight mechanisms they can be divided into three categories (Ramalingam et al., 2016):

- Multirotor Unmanned Aerial Vehicles - can take off/land vertically, perform quick manoeuvres capable of hovering in a fixed position and flying in any direction. Slower maximum speeds and shorter flight times than fixed-wing drones.
- Fixed-wind Unmanned Aerial Vehicles – similar to an aeroplane; can fly longer, at higher speeds and carry heavier payloads over longer distances. However, must take off horizontally and can only move in a forward direction (Beard et al., 2005).
- Hybrid UAVs – can hover but also transition into fixed-wing flight, however very few on the market at present (Cetinsoy et al., 2012).</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="2">Small scale trials occurring globally that are investigating several different business models for a variety of different applications (inclusive of residential deliveries, disaster relief, temperature sensitive medicine and food and humanitarian deliveries). Evidence suggests operational cost savings however there is a lack of investigatory studies into wider externalities of technology. Many sources simply state that drones could ‘reduce congestion’, yet supporting evidence is absent.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="2">Drones avoid delays and congestion on roads and railways and therefore do not exacerbate problems.
Initial drone services are expected to increase the accessibility of more remote areas and therefore generate some organic growth rather than displacing existing surface deliveries. Longer-term drone operations in urban environments however, are estimated to cause low vehicle displacement due to the proportion of total packages that will be delivered (SESAR JU, 2016). If drones require infrastructure for horizontal take-off/landing, they could have negative impacts on congestion around hubs.</td></tr>
<tr><td>TRL</td><td>5</td><td>Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="3">• Air-delivery services avoid surface congestion and delays and therefore do not exacerbate them
• They allow fast, customised and consistent delivery (however weather dependent)
• Freight drones improve market access to remote/congested/inaccessible places
• Increase/cause airspace congestion</td></tr>
</table>

Evidence of Effectiveness	Small freight drones with a payload less than 5kg are being trialled for scaled use in many different applications in several countries around the world. Despite media attention focusing on some high-profile drone experiments such as those carried out by Amazon, FedEx, DHL and UPS, the most prominent use case for small freight drones is for humanitarian projects. In 2016 for example, a national drone medical delivery system became operational in Rwanda, cutting the average delivery time for blood from 4 hours to 45 minutes (McVeigh, 2018). Drones for medical use have also been found to offer large savings to journey times in the UK. A study by the University of Southampton considering patient sample movements from seven clinics in London to a main hospital suggested time and emissions savings of 61% and 93% respectively over the conventional courier operation (Cherrett et al., 2017). A number of combined drone-van concepts are being investigated for small payload freight delivery, where drones are not planned to completely replace delivery vans. UPS intends to use their vans as moving warehouses, bringing packages closer to their destination, with the onboard drone going the last mile. Daimler in turn is testing use of drones for the transport of products from the merchant to their vans, from where the van driver takes possession of the package and delivers it to the customer (Postal Hub, 2017). Although the combined use of both drones and delivery vehicles has been found to increase cost savings when jointly delivering parcels, the impact on congestion is less understood (J. Scott & C. Scott, 2017). This is a general focus of most trials occurring currently, with attention on the operational side of how the delivery services would feasibly work and less regard for the positive externalities that may bring about. A report by SESAR JU in 2016 set out the case that initially drones deliveries are likely to be available in 'remote areas with low accessibility first and generate new growth rather than displacement of surface deliveries'. Therefore it can be suggested that consumers could just be using a different way of receiving their goods e.g they would have to go to pick up a takeaway rather than get it delivered, but it could makes them less likely to order it in the first place? The growth of drone services could enable customers to access that takeaway more readily and therefore spur growth? There are also arguments for a low replacement rate for current urban freight delivery, with initial growth expected for more premium services. A presentation given by Prof Alan McKinnon in 2017 in turn questions the potential of drones to provide traffic congestion relief to densely populated cities by reducing the amount of vehicle movements (Mckinnon, 2017). He calculated that 600,000 drones would be required to cut total urban traffic by 1% contesting the 2,000 reported in the 2016 SESAR study. As outlined in the International Transport Forum's 2018 report, it is important to bear in mind that ground transport is under significant concurrent development (autonomous vehicles, barges, ships etc.) which may alter the business case for drones before drone delivery becomes feasible.
Opportunity to Develop Further	Delivery reception facilities in commercial and residential buildings would need to be redesigned so to accommodate drone deliveries, as drones cannot readily navigate inside buildings, cannot post small parcels/letters through post boxes etc. Regulation is needed to outline where delivery drones can legally fly and land. As drones fly Beyond Visual Line of Sight (BVLOS) there are concerns about the invasion of the privacy of private airspace and resident disturbance from any noise generated by flights (Nesta, 2018). In addition to airspace management rules, guidance with regards to operational limitations and administration rules need to be outlined (International Transport Forum, 2018). Traditionally, last mile delivery services keep costs low by delivering many packages over a short period of time/distance. The economic viability of drone delivery depends on packages being light and delivered over short distances. Thus supply centres or

	hubs throughout a service area are required (Lohn, 2017). In turn the number of hubs or vehicles required could be reduced if drones can each deliver multiple packages.

Intervention Title	**FREIGHT EXCHANGES**	Intervention Number	V11
Intervention Description	A freight exchange is an online service for haulage companies, logistics providers, freight forwarders and transport companies. Freight exchanges create platforms where opportunities for backhaul can be shared, complementing more formal and permanent arrangements between companies. An example of a recent development in freight exchanges is *“Uber Freight”*. A development of this is the enhancement of the exchange through better digital platforms is an online platform that allows buyers and sellers to have clear visibility of the market demand and supply. This could be about sharing loads, space, or people.		
Quality of Evidence	1	There is evidence that apps such as Uber Freight (Uber Freight, 2018), Convoy (Convoy, 2018) and Transfix provide a new digital platform for freight services to organise journeys and loading. There is research backed evidence, such as the information on Transfix, that give data on the effect of digital freight marketplaces (Transfix, 2018).	
Potential Impact on Freight Congestion	1	There is evidence that shows there is a reduction in empty running due to digital freight exchanges, and that this reduction in empty running leads to fewer HGVs (or empty vans) on the road and thus less congestion. There is no actual data on digital freight marketplaces’ impact on freight congestion, but the evidence showing the reduction in empty running and an increase in co-loading supports the idea that congestion would be decreased.	
TRL	TRL8	**Stakeholder Acceptability**	2
Freight Congestion Impacts	DfT freight collaboration study estimated that savings of between 1 and 5% in vehicle mileage could be achieved using freight exchanges, implying a reduction in empty running, and potentially having a positive impact on congestion. (TRL, 2017)		
Evidence of Effectiveness	Improved collaboration through freight exchanges was reported to be enabling members to reduce empty running on average to just nine per cent, compared with an industry average of around 27 per cent (TRL, 2017). TfL’s FORS scheme suggests that *“The benefit of collaboration for FORS members is the chance to reduce their empty running by around 60%, extend their real-time network capacity, and get lower cost access to TEG services, such as Haulage Exchange”*. (FORS, 2018) Molden, who founded Emissions Analytics, commented in an article in The Pan European Transport and Logistics Magazine: *“Load matching platforms which facilitate consolidation are unambiguously a good thing. Through collaboration, members using them are burning less fuel and emitting fewer greenhouse gases in the atmosphere. Even if maximising the loads carried by each vehicle increases C02 emissions, if the empty miles saved more than compensates for the higher laden journeys, then operators using collaborative platforms will continue to do so”* (Pan European Transport and Logistics Magazine, 2017). Armstrong & Associates Inc. identifies five common business models for digital marketplaces: *“Uber-Like: Apps have characteristics such as GPS-based alerts for nearby loads, track-and-trace, task automation, algorithmic/single pricing, digital document storage, and elimination of third-party interaction.* The key benefit of digital freight marketplaces is that freight can be brokered, managed and monitored instantaneously with a single click on a smartphone. Rather than drivers waiting for a load, carriers can actually post their location, availability, trailer capacity and capabilities into apps such as Uber Freight, Convoy and Transfix and have it automatically sorted, classified and offered. Convoy, for example, tips off drivers to loads for possible pickup near their delivery destination, and as data is collected on the driver’s past loads, the app gets smarter, and allows the driver to receive the best loads on the routes they prefer (Barnett, 2018). Traditional brokers tend to be slower, less flexible and more expensive in comparison with efficient platforms that can instantly match freight capacity with shipping demand and can provide transport rates instantly (Baron et al. , 2017).		

	Returnloads.net was set up as a noticeboard to help haulage companies around the UK advertise their excess loads and find return loads for their empty vehicles. It evolved into a fully functioning online freight exchange, including developing an intelligent load and vehicle matching system, automatically alerting members to available loads/vehicles that match their needs. There are now over 90,000 available haulage loads posted on the platform every month and over 1,500 users. In 2016 loads totalling over 16.5 million miles were covered on the platform result in a potential saving of 25,514 tonnes of CO_2. (TRL, 2017) Data from 2015 suggests the UK freight exchange 'Returnloads.net' reduced the number of empty miles travelled in the UK by 251 million miles (based on 2,000 users), resulting in a saving of over 381,000 tonnes of CO2 (Newbold, 2016). Another example of how an alternative digital freight platform can reduce congestion is Transfix, which claims the following: *"25 trucks travelling to pick up 25 loads of goods over the course of a single day using a traditional industry approach - manually pairing drivers and freight - a few matches are short and efficient, but many require drivers to go well out of their way. The result is 1,752 wasted miles that increase congestion. Using .. Transfix, which pairs drivers and loads using an automated matching system, cuts those 1752 wasted miles down to 274 - resulting in less congestion, less cost, drivers being less tired and many more benefits. Expand the use of this app, or similar apps like Uber freight or convoy, and the amount of wasted miles that can be eliminated will have a huge impact on reducing congestion"* (Jaffe, 2015).
Opportunity to Develop Further	• Nurture freight exchange concept to support SME involvement and to promote other sectors that currently don't collaborate. • The next level for the freight industry would be to link freight exchange type facilities for dynamically arranging shared transport. Developments include integrating freight exchanges into customer systems to remove manual searching and allow optimal opportunities and matches to be identified. • Encouraging more live, app-based approach could accelerate adoption and stimulate additional benefits. (IGD, 2015) • Blockchain would accelerate the potential shown from digital freight marketplaces as it enables direct shipper to carrier relationships, strengthens market position and increases competitive edge (Mueller, 2018).

<table>
<tr><td>Intervention Title</td><td colspan="2">FREIGHT QUALITY PARTNERSHIP (FQP)</td><td>Intervention Number</td><td>V12</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Freight Quality Partnerships (FQPs) work to develop a shared understanding of freight, delivery and servicing issues between different organisations. The FQPs aim to promote constructive local solutions that reconcile the need for access to goods and services and the economic benefits that brings together with environmental and social concerns.</td></tr>
<tr><td>Quality of Evidence</td><td>-1</td><td colspan="3">There are plenty of examples of this as an intervention however, the connection to reducing congestion is implied rather than demonstrated.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">Whilst there is little evidence there is an implied positive impact on the number of vehicles on the SRN/urban environments where schemes are adopted.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>2</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">FQPs can be used as a means to facilitate best practice and specifically as it relates to congestion:
Route scheduling/planning that allow for more efficient supply chains
Backhauling to reduce empty running
Promotion of freight exchange
Use of freight sat navs to provide real time and short term predictive traffic conditions and incidents allowing diversions that can support HGVs
Use of traffic information tools such as Traffic England and Waze to better plan routes and journey times
Use of vehicle telematics to improve driving standards, fuel efficiency, safety and potentially reduce insurance premiums
Adoption of safety feature improvements such as encourage quicker roll-out Advanced Driver Assistance Systems for HGV
Driver training to improve safe standards</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">There is no evidence of how FQPs and the adoption of best practice schemes specifically reduce congestion however, the implication is that reduced empty running is best practice and therefore these schemes encourage efforts to reduce congestion.

There are several FQPs within the UK. These include North East Freight Partnership and Thurrock Freight Quality Partnership. They meet regularly (often quarterly), supported by websites to share news and events, local relevant information and best practice. In some cases, subgroups have been set up to investigate solutions to specific issues, for example driver shortages.

Benefits are seen as:
Operator and road user benefits: fewer, more efficient HGV journeys reducing congestion and pollution through collaboration and improved communications
Operator and road user benefits: fewer accidents through improved awareness of best practices
Operator specific benefit: improved operational efficiency through improved collaboration and planning.
Operator specific benefit: improved fuel efficiency and safety
Operator specific benefit: improved ability to respond to congestion and incidents and determine alternative routing
The University of Westminster understood a survey of the effectiveness of FQPs and concluded:
FQPs can potentially lead to actions and policy measures that would never have been contemplated if the FQP had not existed.
In the case of policy issues and measures already identified by a policy administration, FQPs can potentially result in better policy measures being devised and implemented than would otherwise have been the case.
The FQP members can also potentially help to identify policy measures or specific aspects of measures that should not be considered for implementation</td></tr>
</table>

	due to adverse or unintended consequences that they would result in (Allen. J et al , 2010). Therefore, whilst the specific effectiveness of FQPs in reducing congestion is unevidenced, they can act as an enabler for other interventions to be implemented within industry.
Opportunity to Develop Further	• Promotion of FQPs as part of local (sub national, regional, local) freight management plans.

<table>
<tr><td>Intervention Title</td><td colspan="2">HEAVIER HGVS</td><td colspan="2">Intervention Number</td><td>V13</td></tr>
<tr><td>Intervention Description</td><td colspan="5">Various options have been proposed to increase the weight of HGVs in the UK from the current 44T GLW to as high as 63T or 88T with 11 axles.</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="4">Research was undertaken in the UK into the potential benefits and impacts of heavier goods vehicles in 2008 and there are European examples.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="4"></td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td colspan="2">Stakeholder Acceptability</td><td>-2</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="5">Only a proportion of HGVs move fully laden to their payload limit. It has been estimated that only around 5% to 10% of trips would benefit from the much higher payloads studied (DfT, 2006). In contrast, huge investment might be required to strengthen roads and bridges.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="5">A study in 2006 by DfT concluded that HGVs could not be operated in the UK without changes to infrastructure, developing dedicated routes, and changing certain speed limits (DfT, 2006). A study on the effects of longer heavy vehicles on traffic congestion in 2013 concluded that:
heavier HGVs should reduce congestion, however, potential low take-up levels will limit this effect to be almost negligible;
heavier HGVs can significantly improve the energy efficiency of freight fleets, giving up to a 23% reduction in fleet energy consumption at high take-up levels;
the small reduction in congestion caused by HGVs could improve the fuel consumption of other road users by up to 3% in dense traffic, however in free-flowing traffic an opposite effect occurs due to higher vehicle speeds and aerodynamic losses; and
underpowered HGVs have potential to generate severe congestion, however current manufacturers’ recommendations appear suitable (Graeme Morrison, Richard L Roebuck, David Cebon, 2013).
Advocates of heavier HGVs argue that two heavier lorries would replace three lorries of currently permitted weight and thus reduce road traffic. It must however be ensured that these gains are not cancelled out over time by increased traffic. Appropriate road user pricing including cost-internalisation must be a prerequisite to avoid rapid dramatic increases in transport volumes, and hence worsening congestion (European Federation of Transport and the Environment, 2007).

The European Study in 2013 into megatrucks concluded that there was widespread agreement that heavier HGVs would reduce operating costs for road freight and greenhouse gas emissions per tonne-km of goods transported as fewer vehicles would be used to transport the same amount of goods (Directorate General For Internal Policies, European Parliament, 2013). There are case studies in Sweden, Finland and Demark that demonstrate the value of longer and heavier vehicles in these areas.

In terms of cost, consideration needs to be made of the structures that would need to be upgraded (some bridges etc.) and at what cost. In the event that vehicles use inappropriate structures and cause damage, what is the knock-on effect on congestion when a particular structure has to be closed for repair and diversions implemented (Challenge Panel Feedback, 2018).</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="5">Given the significant change required to UK infrastructure, further opportunity for heavier or longer (outside of the existing longer trailer trial) is limited.</td></tr>
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<table>
<tr><td>Intervention Title</td><td colspan="2">HIGHER CUBE HGVS</td><td>Intervention Number</td><td colspan="2">V14</td></tr>
<tr><td>Intervention Description</td><td colspan="5">Whilst there are limits on the weight of trailers, trailers often ‘cube-out’ or ‘floor-out’ before they reach the maximum weight limit. Therefore, there is opportunity to increase vehicle load factors. This intervention focuses on opportunities for taller trailers as opposed to longer trailers considered elsewhere.</td></tr>
<tr><td>Quality of evidence</td><td>0</td><td colspan="4">There is plenty of evidence that high cube double deck road trailers have delivered reductions in vehicle mileage, however the benefits of even higher cube is less clear without needing significant infrastructure changes i.e. bridges.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="4">Evidence suggests that this could have a further small impact on the number of vehicles in on the SRN. There is no reported impact on congestion directly but, as with the other longer, heavier interventions the there is a reduction in vehicle kilometres, which has an implied reduction in congestion.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td colspan="2">Stakeholder Acceptability</td><td>-2</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="5">By allowing for higher cube vehicles payload would increase, effectively reducing the number of vehicles needed to undertake the same tasks. However, the UK already has very limited restrictions on the height of vehicles. Effectively lorries are limited by the standard height of motorway bridges. Any increase in height would require significant investment in bridges and may introduce safety disbenefits.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="5">Holter et al concluded that “Double-deck distribution offers substantial financial and environmental benefit. Double-deck trailers could be a key contributor towards the UK’s commitment to reducing CO_2 emissions” (Andreas Holter, Heikki Liimatainen, Alan McKinnon, Julia Edwards, Date unknown). The CSRGT shows a steady rise in the use of double deckers: he uptake of double deck trailers amongst articulated vehicles increased between 2004 and 2010, from 2.7% of vehicles to 4.1%. (CSRGT, 2010)

McKinnon’s work has revealed significant underloading of lorries both in terms of weight and volume, suggesting the potential exists to increase vehicle load factors by between 30-50% (McKinnon and Piecyk, 2009). This is supported by CSRGT data on the proportion of HGV tonne-kms subject to weight and/or volume constraints in 2010; around 70% of tonne-kms moved in trucks were constrained by weight and / or volume, increasing from 61% in 2001 (CSRGT, 2010). In terms of fuel consumption per tonne kms or pallet-km, double-deck vehicles are much more energy efficient than single-decks (Andreas Holter, Heikki Liimatainen, Alan McKinnon, Julia Edwards, Date unknown).

Transdek UK has said better use of urban double-deck trailers could play a significant role in reducing congestion, lowering emissions and tackling noise associated with city centre deliveries. Transdek say that urban double decking could save up to 520 million road miles each year as each unit is able to carry twice as much load per delivery as a standard trailer. “Based on DfT statistics, we’ve calculated that if just 10% of the UK’s 18 tonne rigids were changed for urban double-deckers, this would save 104 million road miles a year, mainly in urban centres. “Converting half of the trucks would see a reduction of 520 million miles” (Freight in the City, 2018).

Evidence shows that over 70% of operators within the voluntary LCRS have taken action to improve vehicle fill on laden trips, over 50% have made greater use of double deck/high cube vehicles, and just under 40% have consolidated loads on longer and/or heavier vehicles (FTA, 2015). However, LCRS membership covers only a small fraction of the HGV fleet.

Evidence of impact of vehicles higher than double deckers has not yet been found.

In addition to double deck trailers, “same outside more inside” trailers allow you to fit an extra 31% more pallets (26 to 34) into a standard size trailer by utilising the space between the wheels. These are currently being trialled by a leading UK retailer, with others awaiting trial or actively reviewing it (IGD, 2015).</td></tr>
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Opportunity to Develop Further	• Any further increases in height would not be possible without significant changes to the road infrastructure e.g. bridge heights on motorways and therefore there is little opportunity to develop beyond existing sizes.

<table>
<tr><td>Intervention Title</td><td colspan="3">LOGISTICS NETWORK PLANNING</td><td>Intervention Number</td><td>V15</td></tr>
<tr><td>Intervention Description</td><td colspan="5">The configuration of supply chain networks is generally framed as an optimisation problem with the objective function of minimising overall costs. Supply chain costs are generally considered to comprise inventory, storage (warehousing) and transport elements. Optimising the number of warehouses in a logistical system involves trading off these three cost elements to minimise total costs within customer service constraints (Greening, 2015). Today this is as much about optimum location of stock in the network, regardless of ownership of the warehouses (IGD, 2015). There are links with data sharing, asset sharing (vehicles, people, warehouses). Network planning also links with backhauling, and consolidation centres.

To some degree all operators undertake network planning, but this may only happen infrequently, for example in reaction to a merger or expiry of a lease. Fully optimising networks is hindered by land availability and cost.</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="4">There is plenty of evidence however, it is limited improvements in efficiency and stem mileage as opposed to congestion specifically.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="4">Better network optimisation could have a positive impact on the number (and size) of vehicles on both the SRN as well as in urban areas.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td colspan="2">Stakeholder Acceptability</td><td>0</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="5">The potential to reduce stem mileage has a direct impact on freight movements and the opportunity for collaboration to reduce empty running and therefore congestion.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="5">“The ultimate efficient network would require total collaboration with all partners and competitors in the UK sharing all of the available transport and facility assets in their networks and using a central UK control tower approach to coordinating the flows. The bigger the network, the more likelihood there is of the overall flows being omni-directional and balanced which leads to greater opportunities. In practice, the barriers to this are significant which means that collaboration is taking place on a smaller, more tactical scale, often bi-laterally, which is more manageable but misses out on a bigger prize because of its inherent constraints” (IGD, 2015).

When asked survey respondents in IGD’s Reducing Waste Miles, White Paper highlighted the importance of the following factors they consider when designing their networks:
Proximity to customers /consumers (83%)
Proximity to motorways /highways (53%)
Property costs (51%)
Central location in the market (50%)
Multichannel requirements (47%)
Local labour market – skills and proximity (44%)
Access to expansion space (43%)
Risk and resilience (40%)
Opportunities to share warehousing (36%)
Learnings from other networks (36%)
Opportunities to share transport (26%)
Proximity to rail (26%)
Different inventory models (20%) (IGD, 2015)
This highlights the opportunity for collaboration as part of an organisation’s logistics network planning.

Tesco have reported an 8% improvement in CO_2 emissions as a consequence of reorganising their distribution network. In the absence of alternative generalisable evidence this study assumes that most supply chains are routinely optimised and reductions in kms driven because of restructuring are modest (1.5%) (Greening, 2015).</td></tr>
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Opportunity to Develop Further	• Identification and protection of land use to be sympathetic to freight needs • Development of standardisation of systems to allow for better collaboration. • Provision of clarity of legal position (colluding). • Review of planning impacts on logistics efficiency.

Intervention Title	**LONGER FREIGHT TRAINS**	**Intervention Number**	**V16**
Intervention Description	Freight operators try to operate trains which are as long and heavy as can be accommodated on the rail network. For intermodal traffic the constraint is typically length, while for bulk traffics, and aggregates in particular, the constraint is typically related to the total weight of a train and the type of locomotive used. Network Rail is committed to increasing length capability on the Strategic Freight Network to at least 775m from the current 600m and the standard maximum length for aggregates trains to 450m with a 2,000T payload and ultimately to 600m with a 2,700T payload.		
Quality of Evidence	1	Strong body of supporting evidence	
Potential Impact on Rail Freight Capacity	2	Key step to reducing paths required.	
TRL	3	**Stakeholder Acceptability**	2
Rail Freight Capacity Impacts	Network Rail has a programme of increasing train length on key freight corridors to eventually provide 775m capacity on all strategic freight corridors (Network Rail, 2017). Extending all intermodal train lengths to 775m could provide an additional capacity of 25% per train. This, in turn, would reduce unit costs leading to some additional modal shift, so the benefit in terms of reduced requirement for paths would be lower than 25%. Currently the WCML is cleared for 775m from London to Crewe, and the connecting routes from Felixstowe (via London only), and Southampton are also 775m capable. Priority routes for upgrade are the direct route from Felixstowe to the Midlands, and links from the WCML to Liverpool and Scotland. Additionally, not all rail terminals can accommodate longer trains. Most new rail terminals, and all new SRFIs, are designed to accommodate 775m trains, but older terminals cannot. Nodal Yards could be used to join shorter trains before congested sections of track and divide them at the end. This approach could be used for very long trains of >1,000m in selected locations.		
Evidence of Effectiveness	Freight operators on busy routes want to operate longer trains to reduce unit costs. The benefits for capacity are clear. When the route from Southampton northwards was cleared for 775m long trains there was an immediate increase in traffic, despite some constraints which are now being addressed.		
Opportunity to Develop Further	Providing 775m freight trains is a key feature of NR's FNPO Route Strategic Plan.		

<table>
<tr><td>Intervention Title</td><td colspan="2">LONGER HGVS</td><td>Intervention Number</td><td>V17</td></tr>
<tr><td>Intervention Description</td><td colspan="4">DfT began a trial of longer semi-trailers (LSTs) for articulated goods vehicles in January 2012. The operational trial aims to see if using longer semi-trailers brings about anticipated environmental and economic benefits. The trial is expected to save over 3,000 tonnes of CO_2 with overall economic benefits estimated at £33 million. The trial involves longer semi-trailers of that are up to 2.05m longer than the current standard semi-trailers on roads (15.65m instead of 13.6m). The trailers must operate within the UK’s existing domestic weight limit (44 tonnes for vehicles of six axles).</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="3">There is plenty of evidence in other countries and together with the long running UK LST trial, more evidence is being published.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="3">Evidence suggests that this could reduce the number of HGVs on the SRN but is limited to particular markets.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">By allowing for longer vehicles payload would increase, effectively reducing the number of vehicles needed to undertake the same tasks.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">In the first five years, 1775 LSTs were involved in the trial, operated by 161 operators undertaking 2.6 million journey legs covering 319 million km (Brand, 2017).

The following data is from the 2016 LST Annual Report. The 2017 report is due to be published but at the time of writing was still being drafted. The impact on congestion can be derived from key material gathered by the LST trial:

• The trial estimated that 125-150,000 legs / 15-18 million km were ‘saved’.
• 34% of all vehicle km used 100% of the extra length used, and 50% used some of the extra length.
• 18% of km were empty legs vs 29% national average (Brand, 2017).

It is worth noting that the results are not based on a stratified sample of the UK freight industry. The Autumn results which involve even larger numbers of vehicles will reflect that.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="4">The 2017 report will forecast potential take up of longer semi-trailers. The market for such vehicles is limited as not all commodities can use the additional length. The length and increased turning circle of the longer trailers can’t be accommodated at all premises. Outside of the SRN the opportunity to develop is limited due to the changes needed to the urban infrastructure.</td></tr>
</table>

<table>
<tr><td>Intervention Title</td><td colspan="2">OPTIMISING VEHICLE CHOICE</td><td>Intervention Number</td><td>V18</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Using the most appropriate vehicle for the activity being undertaken is a key feature of logistics activities, ie fewer larger vehicles or smaller vehicles to allow better access to city centres. However, in some industries, for example the construction industry currently use rigid HGVs rather than larger articulated vehicles, therefore perhaps not working as efficiently as possible. Working with contractors, developers should be encouraged to specify the use of articulated vehicles where possible. In other cases, it may be appropriate to use smaller but fuller vehicles that allow for a reduction in road space use and improve safety and delivering at different times that HGVs may not be able to, such as the use of electric vans at night which impose less noise.</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="3">There are positive examples of making more use of articulated vehicles in the construction sector.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="3">Could reduce goods vehicle mileage by 32% for bulk commodities. Total potential take up has not been quantified but the main benefits will be in the transport of bulk construction materials (WSP, 2018). Could mean a rise in van use as a result of reducing the use of under-utilised HGVs in urban areas.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">Traditionally the construction industry favours bulk materials to be transported in rigid vehicles. The two main reasons for this are concerns about the reduced manoeuvrability on constrained sites, and concerns about the perceived higher risk of articulated tippers toppling over when unloading.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">TfL undertook extensive research in early 2018 which confirmed that the rigid vehicles dominate bulk construction movements in London. This was true for both tippers and mixers. While the industry and its decision-making processes are complex, the reason for the dominance of rigid vehicles can be summarised as industry concerns about safety and access within sites.

However, clear evidence was provided that the turning circle of articulated vehicles is similar to rigids, and that articulated vehicles can be unloaded safely by applying best practice at the site, or by using trailers which can unload without needing to tip, such as moving floor trailers.

The report concluded that the benefits to the construction industry are clear: potentially a 30% reduction in the cost per tonne for transport when using standard articulated tippers compared to standard rigid tippers and potentially a 37% reduction in vehicle numbers (30% for moving floor), and a 32% reduction in CO_2 emissions (25% for moving floor). Fewer vehicle movements will result in lower emissions, reduced congestion, and improved highway safety (WSP, 2018).

Several contractors have already started to use articulated vehicles. TfL is publishing best practice advice and will use its significant influence to encourage greater take up, including advice in Construction Logistics Plans.

In other examples the use of vans has increased allowing for better access, either at night or in areas where HGVs can’t access (e.g. noise restricted locations). In some cases, using smaller vehicles may help operators to work outside of peak operating times and thereby reduce congestion. Congestion improvements as a result of out of hours deliveries has been shown (see Removing HGV Restrictions and Consolidation Centres dashboard).</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="4">There is a strong opportunity to develop this through guidance:
- CLPs (update guidance)
- DSPs (using less, but larger consolidated vehicles)
- Best practice sharing/advice, using local FQPs
- CLOCS (site assessment ratings) review</td></tr>
</table>

Intervention Title	**PARCEL/PERSONAL DELIVERY MANAGEMENT**	Intervention Number	V19

Intervention Description	There are a range of last mile logistics solutions to assist the final delivery stage. These include
	• Porterage
	• Personal delivery management
	  ○ Click and Collect
	  ○ Parcel lockers
	This is in addition to the following that have been considered in their own right:
	• Consolidation centres
	• Cargo bikes
	• Removal of restrictions (kerbside challenges)
	• Drones
	• Optimising vehicle choice
	• Retiming deliveries
	• Delivery and Servicing Plans		

Quality of Evidence	0	There are many examples and case studies however, consistent and ongoing evidence of the impact of congestion is limited.	
Potential Impact on Freight Congestion	1	The growing trends in online shopping (personal as well as business) and missed deliveries have contributed to van traffic (although the scale of this is debated – see evidence below). However, regardless of scale, solutions to better manage personal deliveries both in the work place and at home should have an impact on local urban congestion.	
TRL	N/A	**Stakeholder Acceptability**	0
Freight Congestion Impacts	The increase in e-commerce is having an impact on the volume of both HGV and van traffic, in particular in urban areas. Making deliveries is challenging due to issues of kerb space, receivers not being in and facilities not being adequate for the volume of traffic e.g. loading bays in shared offices.		
Evidence of Effectiveness	In 2016, the total UK market for e-commerce deliveries was 2.7 billion packages of which 1.8 billion were for the business-to-consumer segment. e-Commerce parcel volumes are growing at 9% annually, a rate that is expected to fall to 6% a year over the next four years. Whist this may be the case it still pays a part in urban congestion, with vans for example used by package and grocery e-commerce delivery operators comprise less than 4% of the van parc but make up close to 10% of van traffic. (RAC Foundation, 2016) Other sources suggest that e-commerce will grow further over the coming years, albeit at a slower pace. Of course, not all of e-commerce results in increased parcel movements in urban areas as online includes large white goods for example. Small-scale research in central London suggests that personal parcel deliveries can represent up to 40-60% of parcel throughput in medium-larger sized multi-tenanted offices, and up to 90% of parcel throughput at these building during the Christmas peak (Browne et al., 2017). Edmund King of the AA told the Transport Committee: *“One of the major problems in London is people having stuff delivered to their offices in London, which is very inefficient and causes immense congestion. I know some companies have actually banned it because it is causing congestion at their reception areas, let alone on the roads. That is something we have to look at.”* (Transport Select Committee, 2017) • Porterage. TfL’s study into Understanding and Managing Congestion in 2017 highlighted the promotion of human powered freight deliveries as being one of the elements of a future freight strategy. (TfL, 2017). Portering has been trialled as part of the FTC2050 project (FTC2050, 2018). • Personal delivery management. TfL report that 30-40% of deliveries to businesses are for personal items (TfL, 2018). • Click and Collect. Studies show that 67 per cent of people are willing to use collection points, so raising awareness of this facility may encourage them to		

	make a change. Collect Plus is a network of 5,800 convenience stores where orders can be collected, Royal Mail allows collections at thousands of post offices and inquiry offices and Doddle has 37 pickup locations, mostly at railway stations, where items can be picked up or returned. (The Times, 2015). Petrol stations are also being used. • Parcel lockers. Amazon has lockers where shoppers can pick up goods 24 hours a day at more than 300 sites across Britain. (The Times, 2015) The Transport Committee recommended a couple of actions specifically around personal deliveries: • TfL should pilot a ban on personal deliveries for staff. Based on the findings, the Mayor should consider extending this to all GLA Group premises, and promote this change in practice to other large employers in London. We ask that TfL write to the committee setting out plans for a pilot by the end of April 2017. • TfL should reconsider its approach to ‘click and collect’ at Tube and rail stations. Stations should be identified for a pilot programme in which multiple retailers and/or freight operators can deliver packages to a station for collection. We ask that TfL write to the committee confirming plans to seek partnerships of this type by the end of April 2017. (Transport Select Committee, 2017) There is little evidence to suggest the improvement in congestion as a result of these interventions however intuitive they may feel.
Opportunity to Develop Further	• The use of consolidation centres (urban and micro in particular) would facilitate the appropriate use of vehicles. • Promotion of use of larger vehicles, where appropriate (e.g. construction site).

<table>
<tr><td>Intervention Title</td><td>PIPELINES AND TUNNELS</td><td>Intervention Number</td><td>V20</td></tr>
<tr><td>Intervention Description</td><td colspan="3">Transport of goods by pipeline or freight tunnels. While transport by pipeline traditionally applies to bulk liquids, proposals have been made over the years to transport a wider range of commodities in pipelines. Proprietary systems can be used to transport refuse in urban areas in pipes.
Freight tunnels include: movement of bulk products by conveyor belt in tunnels; freight delivery tunnels in urban areas (such as the Post Office Underground Railway), and proposals for longer distance freight tunnels including high speed tunnels.</td></tr>
<tr><td>Quality of evidence</td><td>0</td><td colspan="2">Many technical feasibility studies and pilot operations, but little analysis of the true potential.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="2">Strong impact for current operations. Uncertain longer term potential.</td></tr>
<tr><td>TRL</td><td>4 to 6</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="3">Data for pipelines ceased being published in 2013, at which point they accounted for 8% of tkm. Typically, UK pipelines fall into two groups: short distance pipelines between neighbouring plants; longer distance pipelines transporting petroleum products or liquid natural gas. Pipelines continue to be developed and can provide an important alternative to road or rail transport.

Proposals to transport solid goods in capsules in pipelines date back several decades but have yet to be operated commercially. These can be seen as larger scale versions of the capsule systems used in hospitals or commercial premises to move medicines, cash, or documents. Egbunike and Potter (Potter, 2011) presents a history and discussion of such technology in the UK and internationally. At a local level, systems such as Envac are used to transport domestic waste from homes to transfer points, significantly reducing refuse collection vehicle movements on city streets and allowing developers to plan for vehicle free communities.

Freight tunnels also have a long history, with the Post Office Underground Railway carrying mail beneath London streets between 1927 and 2003. On a completely different scale, a 16’ diameter tunnel will be used to transport potash from the new Sirius plant in North Yorkshire to Teesside. The 23-mile-long tunnel will carry up to 20 million tonnes of material per year on a conveyor system.

Alphabet subsidiary Sidewalk Labs is working on proposals to develop an area of Toronto to include access tunnels which will use autonomous vehicles to deliver goods to every building and to remove waste.

More recently, schemes such as Virgin Hyperloop One promise to provide a high capacity, high speed, alternative to road and even air freight. Such systems are at the stage of engineering feasibility studies and test beds.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="3">Movement of very high volumes of material between two fixed points by pipeline or tunnel is well proven, and an effective alternative to other modes. All other applications need to overcome the twin obstacles of extremely high capital costs and very low flexibility, plus any costs involved in intermodal transfer at each end of the transit. While operating costs per tonne promise to be low, the payback period for any investment would be long.

While there is a wealth of reports of feasibility studies, and test operations, there is little or no published research on the potential demand for each system, and no research into potential congestion benefits.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="3">• At an urban scale, systems such as Envac and even goods tunnels for deliveries are likely to be features for completely new developments. Opportunities to retrofit such systems into historic urban areas may also be investigated.
• High capacity inter urban pipelines may become a technical possibility, but more research is required into the role that they would fulfil and competitive position against other modes.</td></tr>
</table>

Intervention Title	TRACKING/INTERNET OF THINGS (IOT)	Intervention Number	V21
Intervention Description	IoT is simply a networked connection of physical objects. The IoT extends connectivity beyond computers to physical objects such as street lights which can sense the presence of vehicles. This can provide information to drivers or road operators for route planning and to optimize the flow of traffic. Furthermore, individual goods can be tracked to understand estimated time of arrivals in real-time. A further example is smart parking. Despite being an important source of Government revenue, bringing in £765 million to local councils in England in 2016 (RAC Foundation, 2016), parking is frequently cited as a serious problem across the UK, costing individuals and businesses time, money and fuel as well triggering frustration and driver stress. According to the British Parking Association, motorists in the UK spend four days a year on average searching for a spot to park which can have detrimental effects on traffic flows (British Parking Association , 2016). By embedding sensors or cameras in the surrounding infrastructure, real-time information on space availability, where they are located and how much parking costs can be provided to drivers via phone applications and electronic signs, so to direct them more efficiently to a space. For councils, real-time parking information can help to direct parking wardens to where parking violations are taking place and improves the effectiveness of parking enforcement. The aggregated data also provides city planners with an insight into usage patterns and enables a more agile, intelligent and adaptive approach to parking provision (Chan, 2017). Since the first implementation in the UK in the City of Westminster in 2014, there has been increase interest in their implementation. A freight and logistics adaption of the smart parking solution is proposed by firm 'Kerb', which could enable cities to dynamically manage their kerb space using real time dynamic data. Kerb allows commercial vehicle operators to opt to book and pay to park/load unload on previously unavailable kerb space in high density, urban areas or to extend loading periods in time restricted locations. 'Virtual Loading Bays' could allow drivers to carry out deliveries near their destination without causing congestion, without risk of receiving a fine whilst saving time and fuel. The bays can be time and vehicle specifically and ultimately be used to incentivise behaviour change into off-peak periods (Grid Smarter Cites, 2016). Parcel tracking services in turn are getting more intelligent by attaching IoT sensors to packages to provide information on the following: • Location • Temperature • Humidity • Tilt and Orientation • Box Opened • Package mishandled Tracking of freight fleets is also predicted to become the norm by 2021 with the growth in telematics technologies. Usage based insurance, will use telematics to gain a 'live' insight into how drivers behave on the road, ADAS features and footage in the event of an incident and enable insurers to price individual drivers and fleet policies. Implementation of the technology provided by VisionTrack by one insurer has seen a 24% reduction in frequency of incidents (Ryan, 2018).		
Quality of Evidence	0	There is evidence to suggest the benefits of tracking however, as it relates to congestion this is limited. Limited evidence on the impact of IoT to manage last mile logistic trips due to absence of large scale applications.	
Potential Impact on Freight Congestion	0	The benefits of IoT tracking extend across the entire logistics value chain, including warehousing operations, freight transportation, and last-mile delivery. With benefits in optimising capacity utilisation and routing along with journey time reliability improvements.	

		Typical use cases involve monitoring, measuring, controlling, automating, optimising and learning.		
TRL	9		**Stakeholder Acceptability**	2
Freight Congestion Impacts	It is likely to have minor benefit impacts on freight movements, however as more operators start using this technology the predictability of demand will change as dynamic re-routing occurs.			
Evidence of Effectiveness	One such example is HanHaa (https://www.hanhaa.com). This type of IoT tracking can aid with just in time delivery planning and optimisation of space within vehicles, supporting digital freight exchanges and back and forward hauling. Many IoT last mile solutions in the UK are still in development or at provisional piloting stages, others are siloed and not occurring holistically which reduces the potential for evidence of effectiveness in reducing congestion.			
Opportunity to Develop Further	Tracking of origin and destination of goods allows optimisation of deliveries, reducing the need for multiple deliveries per customer from the same organisation.			

Intervention Title	WIDER SUPPLIER CHAIN SOLUTIONS	Intervention Number	V22
Intervention Description	Although products themselves are key components in improving the overall efficiency of the supply chain and removing wasted miles their impact on transport efficiency is often overlooked. Streamlined Stock means ensuring you are only moving products you need (including a range/portfolio for growth) and in the most efficient form possible. This includes but is not just about redesigning the product itself or reducing/improving packaging but about the stage of processing the products are moved at. Late customisation / differentiation allows you to move the product in a less finished form, which may be more efficient, and then locate your stock to be processed closer to customers. Different models for the ownership of stock throughout the chain – including increasing consignment stock – can reduce miles through allowing fuller loads and optimised production. Sourcing: Whilst this has more relevance to reducing mileage, reviewing the procurement of materials to potentially differently locations that better meet the end customer, could allow for greater opportunities to back and forward haul. There are links here with Circular Economy. Packaging: Having less packaging helps to ensure you can fit more product on each pallet and delivery, thus reducing miles. However, if packaging is too stripped back there is a serious risk of damage and waste. Many companies are revising package and product designs to reduce weight and increase shipment density. For instance, some have reformulated products such as laundry detergent, dishwashing liquid, dairy powder, and fruit juice to make them concentrated and physically more compact. Some manufacturers have redesigned rolled consumer products like aluminium foil and toilet paper so that the cardboard tube in the centre is smaller. Packaging is being redesigned to optimize package size and weight for the contents through package reconfiguration. The supply chain impact of a packaging design approach which endorses not shipping air helps to reduce shipping weight, size, and materials while maintaining the products' appeal and convenience for consumers. These changes translate into savings in freight costs, packaging costs, and space utilisation. Whilst Circular Economy is wider than waste minimisation, it is part of the concept. Simplified supply chains (reduced range/leadtimes): reducing the range choice delivers transport efficiencies by rebalancing loads towards fewer, faster moving items rather than lots of slow moving, potentially high wasting products. Flexible flow: a major concept underpinning flexible flow is the ability to locate stock around the network in the optimum locations, regardless of who owns the facility. One example is the use of 3rd party run consolidation centres into which (often slower moving) products are stored and owned by suppliers and from where the retailer can then get a consolidated load of mixed supplier products. Another example is the use of consignment stock which can be a win-win for both suppliers and retailers. This is where a supplier stores and owns their stock within a retailer distribution centre. This enables them to deliver full, more efficient loads because it is not based on a retailer's demand which may translate to infrequent part loads. Standardisation: Better standardisation of merchandisable units (MUs) / display pallets –would help to improve vehicle fill but would require an industry wide solution and result in potentially costly changes to production lines as an investment. Product returns rates: 30% of all products ordered online are returned as compared to 8.89% in brick-and-mortar stores, and having an efficient an easy return process is an important part of customer service with 92% of consumers surveyed said that they will buy again if product return process is easy. (Invesp, 2018) This requires an efficient freight system to manage this and could result in extra vehicles if not managed effectively through backhauling. This has the potential to increase congestion.		

<table>
<tr><td></td><td colspan="4">Postponement is cited by McKinnon (McKinnon, 2018) as an effective way to reduce freight moved. By delaying despatch of goods to regional distribution centres until they are needed and requirements are clear, over ordering is reduced.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">There are examples of this as a package of interventions however, the connection to specifically reducing congestion is implied rather than demonstrated in all cases.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">Whilst there is little evidence there is an implied positive impact on the number of vehicles on the SRN/urban environments.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">In principle these initiatives can reduce the demands on transport, potentially reducing miles and therefore congestion.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">In the IGD’s reducing wasted miles report, they noted that 20% of their survey respondents highlighted that reviewing range and reducing complexity was one of the top three things that would reduce miles in their supply chains.
According to a Grocery Manufacturers Association (US) survey of its members, the number of packaging improvements implemented by companies in the consumer products industry has been increasing each year, resulting in more than 1.5 billion (weight) pounds of packaging avoided from 2005 to 2010 (The Manufacture, 2012) this then implies reduced transport costs and potentially miles. In their survey one company reported a 35% reduction in transport distance as a result of reduced packaging.
Catherine Weetman, on behalf of SCALA suggests that 10% savings in vehicle space can be achieved when Logistics teams are involved in choosing the design and product packaging (Weetman, Date Unknown). There are now examples such as DS Smith made2fit that is trying to find solutions to appropriate packaging sizes.

It is critical to include the whole chain in the thinking of the impact of global sourcing, because, otherwise, any initiatives or concepts to reduce miles in one area could simply move costs elsewhere (e.g. moving manufacturing closer to the customer has to consider the potentially increased costs of transporting raw materials to ensure an overall benefit). (IGD, Reducing wasted miles - Your roadmap to success in a new world, 2015)

WRAP, The Co-operative and Farmcare. (WRAP, 2018) The study found that there is potential for considerable savings in transport cost and emissions through greater packing efficiency. The need for review on a line-by-line basis was identified, with one example highlighting potential savings of more than £80,000 and 0.5 million pallet/kilometres through increasing the number of units within a tray. This needs to be carefully balanced against individual store needs, to prevent shifting waste to point-of-retail.

WRAP and Budgens. (WRAP, 2018) Applying lean-based thinking across the whole supply chain, from apple orchards to retail stores, helped Budgens reduce store-waste, carbon emissions & packaging materials, whilst improving information flows and product quality. A range review was undertaken and identified 15 fruits that together contributed to fewer than 2% of sales. Supplying these very low volume products caused complexity in the supply chain, with part pallet loads, high store waste or rejections, and increased quality control (QC) checks. The range was reduced by 30%, driving improvements in store waste levels. The project workshop identified transport inefficiencies, resulting mainly from insufficient pallet volumes. A minimum number of pallets was therefore identified to enable direct drops from Newmafruit to Budgens depot. This change has been rolled out for the start of the UK season and is predicted to deliver potential transport savings of £240,000 per annum, and a total saving of 3,550 kg/COe annually.

Amazon. (IGD, Retail Analysis, Date Unknown) A good example of flexible flow in the network is Amazon’s Vendor Flex program which sees it operate within its suppliers’ warehouses by taking some space and, with the help of a small team of Amazon employees, packing and shipping supplier products directly to its customers</td></tr>
</table>

	(drop shipping). Through this initiative both Amazon and the supplier reduce costs. Suppliers cut out the cost of transportation – since they no longer need to deliver to Amazon's warehouse. **The Beddington Zero Energy Development (BedZED**) in Sutton sourced 52% of its materials (by weight) from within 35 miles of the site. Compared to a traditional site, this resulted in an average of 40% fewer miles per tonne of materials. This was considered a cost neutral achievement, through thoughtful management. (BRE, 2003).
Opportunity to Develop Further	• Opportunity to develop working industry groups based on the process used by the IGD ECR Working Groups – industry lead, using highly credible individuals and organisations to gather evidence, best practice and action. • WRAP has undertaken significant work in packaging and waste reduction – extending the industry focus of this organisation could develop the successful approach already used.

USING NETWORKS EFFICIENTLY

Reduce the impact of freight movement on congested networks, particularly at peak times. Including be selecting the most efficient mode or vehicle type.

<table>
<tr><td>Intervention Title</td><td>APPLICATION OF ARTIFICIAL INTELLIGENCE (AI)</td><td>Intervention Number</td><td>E1</td></tr>
<tr><td>Intervention Description</td><td colspan="3">

Artificial Intelligence (AI) is the ability of a machine to perform any intellectual task a human can. The definition of artificial intelligence includes a ‘general’ definition where machines are as smart as humans and a ‘narrow’ definition where AI is being applied to solve specific problems.

A subset of the ‘narrow’ AI approaches are categorised as machine learning techniques requiring large training datasets and a need to tell the software what it is looking for. However, recent advances in machine learning algorithms are now allowing ‘deep learning’ neural networks to be applied to datasets where the system can identify the data points or objects required without being told specifically what to look for. Typically, these ‘narrow’ AI approaches involve sensing the environment, processing data and learning from the results iterating upon new information and updating the results as things change.

It is worth noting that AI can take significant computer processing power depending on dataset size. The graphics below provides an overview of the types of AI and processing frameworks used.

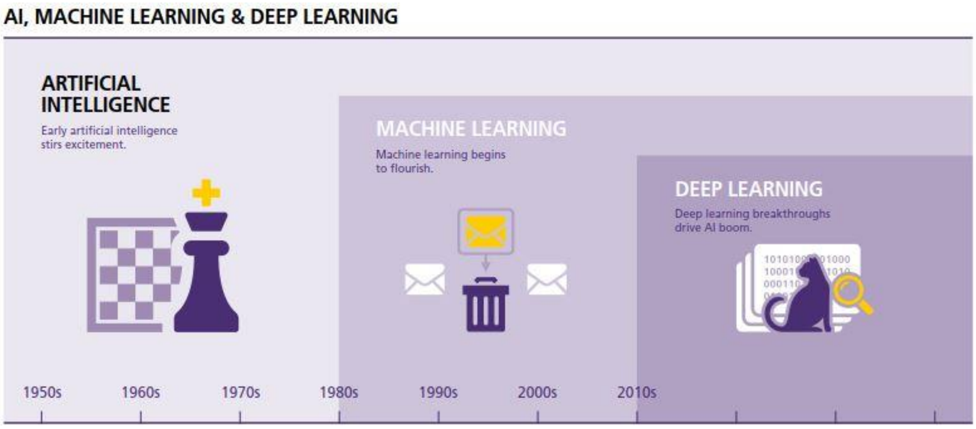

Figure 1: Visual Representation of AI. (Jha, V., 2018)

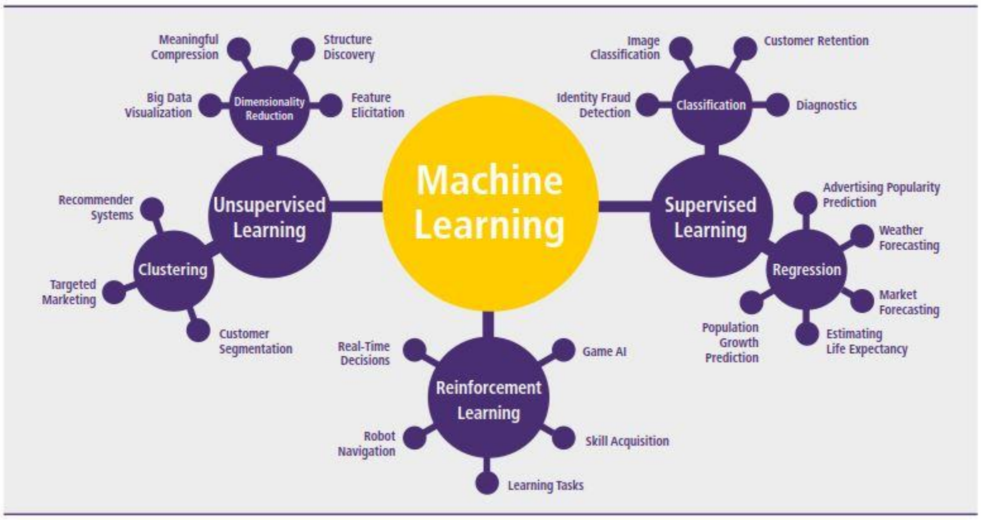

Figure 2: Visual Representation of AI Processing Frameworks (Jha, V., 2018)

Whilst traditional routing and scheduling software (such as ‘track & trace’ solutions) has existed for a long time and included optimisation algorithms, the application of Artificial Intelligence (AI) has only emerged in recent years. As such, there is limited quantifiable

</td></tr>
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evidence of effectiveness and to what extent benefits are exclusively derived from the application of AI or through openness of data.

In terms of where AI may impact freight transport and congestion, numerous use cases have been proposed or are actively being developed (DHL, 2018). Areas include:

- **Object detection and classification** in autonomous driving helping the vehicle identify potential hazards and act accordingly. This application is typically being developed by the automotive industry and is expected to reduce the frequency and severity of accidents.
- **Route optimisation** across transport networks including distribution, reducing time for deliveries, fuel use and costs. This use case is typically being developed in the logistics industry and involves optimisation of distribution centres, support for alternative modes such as Unmanned Aerial Vehicle (UAV) delivery systems and route optimisation with real-time data inputs.
- **Transport operations** use cases involving the following functions (see table 1).

AI Function	**Typical use-case**
Nonlinear prediction (Prediction of the behaviour of systems in which inputs and outputs are non-linear)	Traffic demand modelling, or in modelling the transportation infrastructure health as a function of traffic, construction and weathering.
Control functions	Signal control of traffic at road intersections, ramp metering on motorways, dynamic route guidance, positive train control on rail networks
Pattern recognition	Automatic incident/object detection from in vehicle radar and image processing systems as well CCTV image processing for traffic data collection and for identifying cracks in pavements or bridge structures and transportation equipment diagnosis.
Clustering	Identifying specific classes of drivers based on driver behaviour.
Planning	AI-based decision support systems for transport planning.
Decision making	Deciding whether to build a new road, how much money should be allocated to maintenance and rehabilitation activities and which road segments or bridges to maintain, and whether to divert traffic to an alternative route in an incident situation.
Optimisation	Designing an optimal transit network for a given community, developing an optimal work plan for maintaining and rehabilitating a pavement network, and developing an optimal timing plan for a group of traffic signals.

Table 1: AI Functions in road operations (Techemergence, 2018).

Whilst there are numerous use cases the most active area for development related to reducing freight congestion are in autonomous driving.

<table>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">There is plenty of evidence on artificial intelligence but it is limited in terms of benefits for freight congestion. The evidence tends to focus on maximising return on investment from customer sales rather than optimisation of operations.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">Evidence suggests that this could have a minor positive impact on the optimisation of freight movement across modes and networks however it is very early in its development and application. A more beneficial area of impact is likely to be in the reduction in frequency and duration of accidents resulting from in vehicle assistive technologies. AI can be especially useful in difficult conditions such as poor weather and lighting conditions.</td></tr>
<tr><td>TRL</td><td colspan="2">5 (for congestion management)</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">There is some evidence that AI approaches can be used to adjust planned routes in advance of and during journeys. The efficiencies using enhanced AI algorithms are assumed to:

improve delivery efficiency with increased driver productivity
reduce vehicle km travelled through an overall reduction in delivery routes
maximise vehicle utilisation and coverage
reduced errors and misrouting through a support mechanism for driver decisions.

However, the majority of evidence is around autonomous vehicle SAE level 2,3,4,5 assistive technologies used to support improved safety through autonomous breaking and steering after hazards have been identified by AI systems. Currently this technology is in development and until significant penetration rates of this technology exists the congestion benefits are likely to be limited.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">Limited evidence for effectiveness on the reduction of congestion.

Artificial Intelligence brings benefits to freight operators, consumers and business. Case studies:

Brings higher profit margins of between 3% and 6% for AI adopters compared with non-adopters (McKinsey, 2017). It can be assumed this is demonstrating improved vehicle utilisation and efficiency leading to reduced vehicle km travelled.
Applications can use the data and statistics gained to plan transport routes in real time, including the weather and the current volume of traffic flow into the tour planning. The AI algorithm should reduce idle miles and long waiting times, or at best avoid them altogether (Hannover Messe, 2018).
Voice-enabled Customer Interactions such as DHL Parcel: a voice-based service to track parcels using Amazon Alexa with further planned enhancements to include information on outlet locations, opening hours etc (DHL, 2018).

While this has minimal impacts on congestion currently the market potential in the future is significant.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="4">
Develop an industry standard for applying artificial intelligence to routing.
Consider measures that allow smaller companies to adopt the technology as it is currently reserved for largest companies that can afford dedicated team of data science professionals (such as UPS).
Consider resistance from regulatory bodies or workforces affected by automation.
</td></tr>
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<table>
<tr><td>Intervention Title</td><td colspan="2">AUTONOMOUS HGVS</td><td>Intervention Number</td><td>E2</td></tr>
<tr><td>Intervention Description</td><td colspan="4">An HGV that uses a combination of sensors, cameras, radar and artificial intelligence amongst other technologies to travel between destinations without a human operator. In this definition, automated HGVs are taken to include SAE Level 4 (i.e. that no human interaction is required although manual override is an option) and Level 5 (i.e. human driving is eliminated). Automated HGV Platooning (level 4-5) would be an application of autonomous HGVs if there is no human driver in any of the vehicles. HGV Platooning is considered as a separate intervention.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">The quality of evidence for Autonomous HGVs is limited since even for HGV platooning, the stepping stone to fully automated HGVs of SAE Level 4 and 5, pilot tests and demonstrations are ongoing with comprehensive results from the trials still pending.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="3">Autonomous HGVs could bring efficiency to freight movements helping to reduce freight congestion albeit this is likely to be limited in the near term due to the complexities of operating in mixed traffic and congestion could worsen during this period due to cautious driving behaviours.</td></tr>
<tr><td>TRL</td><td colspan="2">5</td><td>Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">
Fewer restrictions to on-time delivery, such as driving hour restrictions. Freight operator could more readily utilise ‘off’ hours overnight to deliver products.
Reduction in the headways between autonomous trucks could significantly increase road capacity (dependent on penetration of autonomous trucks and other road vehicles).
Autonomous trucks will be able to anticipate the actions of preceding vehicles through their on-board communications and therefore they can contribute to the stabilisation of traffic flows.
Potential for less accidents and therefore impacting HGV accident related congestion.
Autonomous HGVs could also lead to supply chain efficiency improvements (aligned to just-in-time delivery). Automation could enable end-to-end movements whereby by vehicles are integrated with warehousing loading operations (removing humans from a large section of the distribution).
</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">Between March and July 2018, Uber Freight used self-driving trucks to haul freight in Arizona via its freight-hauling app, although all autonomous trials were put on hold after a fatal accident as part of the company’s autonomous car tests (BBC, 2018). AV truck start-up Embark has also been using autonomous trucks to haul fridges on 650-mile routes from Texas to California since 2017 (Davies, 2017). Waymo launched a pilot in Atlanta for delivering freight to Google’s data centres (Kahn, 2018). Each has used a transfer hub model where trucks are driven autonomously on highways, but driven by humans for the last miles.

Tesla have also revealed the Tesla Semi, an electric, self-driving truck although the detail of the autonomous driving technology is yet to be revealed. Apart from these small-scale trials of the technology, autonomous truck trials have been limited across the globe and therefore analysis of the effectiveness of the technology at combating freight congestion is also limited.

Investigations into autonomous vehicles in general however are more extensive and numerous studies have been undertaken which indicate an increase in road capacity from reduced headways between vehicles and the stabilisation of traffic flows due to vehicle communications. A report by the Department for Transport that recognises the benefits attributed to autonomous vehicles will only be realised when there is significant vehicle fleet penetration (approximately 50%) of autonomous technologies. The report outlined:</td></tr>
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	• On major roads where traditional vehicles outnumbered automated vehicles benefits are relatively small, but increase as the percentage of driverless cars on the roads increases – when measuring peak traffic periods with a maximum of up to 100% of driverless vehicles we saw journey times reduced by more than 11% and delays cut by more than 40% • On urban roads benefits are seen in peak traffic periods even with low levels of automated vehicles on roads – benefits include a 12% improvement in delays and a 21% improvement in journey time reliability (DfT, 2016). For conventional HGVs, critical risk factors are driver reaction time and concentration. Many studies, starting with the 1979 Tri-Level Study of the Causes of Traffic Accidents through NHTSA's 2008 National Motor Vehicle Crash Causation Survey (NMVCSS), have found that human error is responsible for approximately 90% of accidents which is also considered applicable to the UK. Autonomous HGVs will bring zero reaction time compared with human breaking and more predictive driving and therefore are seen to reduce this significantly however this does not account for the non-collisions that do not occur (i.e. how human driving avoids other potential hazards in difficult conditions or new hazards introduced by autonomous vehicles) (National Highway Traffic Safety Administration , 2008). In terms of safety benefits and the reduction in number of incidents caused by HGVs, a study by The Casualty Actuarial Society suggests 49% of these human-error accidents would still be unlikely to be solved through application of autonomous vehicle technology considering its near term capabilities (Casualty Actuarial Society, 2014).
Opportunity to Develop Further	• A roadmap for Autonomous HGV testing needs to be developed to outline pilot applications to test within specific environments. This will provide a focus on proving specific automated applications that lead to L4+ autonomous HGVs e.g. identification of initial pilot focusing on auto-park HGVs within a controlled environment such as a logistics hub. • Development of policy for re-training existing drivers and investment in education and future skill development for new staff roles such as remote operators of HGV fleets. • Engagement with industry and relevant stakeholders to consider the relevant changes to laws on liabilities that come from the introduction of autonomous HGVs.

<table>
<tr><td>Intervention Title</td><td colspan="2">AUTONOMOUS ROAD FREIGHT VEHICLES SAE LEVEL 2 (ADAS)</td><td colspan="2">Intervention Number</td><td>E3</td></tr>
<tr><td>Intervention Description</td><td colspan="5">Advanced Driver Assistance Systems (ADAS) are used to describe active safety systems on a vehicle that can identify safety-critical situations and act, either automatically or by sending warnings to the driver.

ADAS systems use sensing technologies such as cameras, radar and laser technology referred to as lidar. This technology also supports connected and autonomous vehicle systems and are typically regarded as SAE Level 1 and 2 type systems.

ADAS systems can aid freight congestion by reducing the frequency and severity of accidents thereby reducing delays caused by reduced capacity as a result of these situations.

A limited amount of ADAS is mandated through European law, and ADAS are rapidly being developed and fitted by vehicle manufacturers, often to high-end vehicles, and further regulation is being considered by the European Commission (Brake, 2016).

The list below highlights the existing systems mandated on new HGV vehicles that will provide benefit in terms of reduced Road Traffic Collisions (RTC).
Autonomous Emergency Braking Systems (AEBS) senses the likelihood of a collision ahead and automatically brakes to mitigate or avoid it. EU General Safety Regulation 661/2009 requires medium and heavy commercial vehicles to be fitted with it. Different systems exist with different sensing and vehicle speed ranges. Also some systems include rapidly blinking brake lamps and lane changing manoeuvres (less likely for HGVs).
Lane Departure Warning Systems (LDW) senses an unintended lane departure and provides a warning to the driver. EU General Safety Regulation 661/2009 requires medium and heavy commercial vehicles to be fitted with it.
Electronic Stability Control (ESC) detects and reduces loss of traction (skidding) through automatic braking of specific wheels and/or engine braking. EU General Safety Regulation 661/2009 requires all vehicles to be fitted with it.
It should be recognised that although the above mandatory ADAS systems have been in legislation since 2014 there is still a significant timescale to increase the penetration rates in terms of vehicle fleet take up. This is primarily driven by the vehicle average age which in the last 10 years has seen an increase from 6.6 to 7.5 years. However, this is an average and the distribution in terms of vehicle age may look quite different especially when smaller operators are analysed separately from all operators. Technology benefits are not realised so quickly as a result of this lead time. The primary factors which impact decisions whether to change vehicles are believed to be price and mileage i.e. how far the vehicle has travelled since purchase. Manufacturers accept that longer lifecycles have proven to be cost effective (this may be related to improved build quality and increased cost of new vehicles).

Other technologies also exist in the SAE level 1 and 2 autonomy scale. For example, Intelligent Speed Adaptation (ISA) which modifies vehicles speeds based on the speed of the vehicle in front or from speed limits detected from signage.</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="4">The strength of evidence is significant enough for the regulatory fitment of this technology to mandatory for new vehicles since 2014. However, this is predominantly on a safety related benefits case.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="4">The main benefit and impact on freight congestion is because of the expected reduction in frequency and severity of accidents therefore freeing up road network capacity that would otherwise have been reduced due to sever accidents including freight vehicles.</td></tr>
<tr><td>TRL</td><td colspan="2">5</td><td colspan="2">Stakeholder Acceptability</td><td>2</td></tr>
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Freight Congestion Impacts	Reducing the frequency and severity of freight related incidents results in more efficient transport of goods and monetary savings as vehicles are less likely to be included in accidents and insurance premiums will not be as high.
Evidence of Effectiveness	The evidence is generally strong in terms of the safety benefits of these technologies. However, the time to increase the penetration rates to levels which will show significant benefit are long. This is primarily due to the cost of upgrading freight vehicles. In 2018, WSP analysis of Highways England critical incidents, (Wickenden, 2018) identified that 36% of all critical incidents involved HGVs and of these 43% lasted between 5-10 hours. This analysis also noted that of the eight fatal RTCs that have occurred following nearside lane vehicle stops on smart motorways since 2014, six have involved HGVs colliding with the stopped vehicle and one has involved a Passenger Carrying Vehicle (PCV) doing so. This is despite HGVs making up only 11% of traffic on motorways in Great Britain (Wickenden, 2018). In 2014, TRL carried out in-depth investigations for Highways England into most of the fatal crashes on England's strategic road network (all England's motorways and most of its A roads), using crash investigation teams. TRL estimated how many deaths in these fatal crashes would have been prevented if certain ADAS systems had been mandated. TRL concluded: • More than a third (34%) of deaths studied could have been prevented if Autonomous Emergency Braking Systems had been mandatory on all vehicles, and (TRL, 2015) • One in seven (14%) could have been prevented if advisory Intelligent Speed Adaption (ISA) had been mandatory. (TRL, 2014) Other transport academics have also estimated reductions in deaths through fitment of ISA. It has been estimated that nearly one in three fatal crashes could be prevented by ISA. After a successful trial on its bus fleet, Transport for London is required ISA to be installed in its new buses by 2017 (Motortransport, 2016).
Opportunity to Develop Further	Incentivising fleet operators to upgrade vehicles more quickly so benefits can be realised more quickly may have some congestion benefits. Ways this could be incentivised include: • Early scrappage scheme such as those used to move operators to cleaner vehicles. Whilst having environmental benefits this approach also has safety benefits due to the improved technology. • Financial incentives such as low interest loans may result in quicker adoption of HGVs with ADAS. Use existing and/or develop new standards recognition schemes for example ECO Stars, FORS and ESOS to encourage quicker adoption of ADAS.

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<tr><td>Intervention Title</td><td colspan="2">COASTAL SHIPPING AND MOTORWAYS OF THE SEA (MOS)</td><td>Intervention Number</td><td>E4</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Coastal shipping is the movement of goods between ports in Great Britain. This includes bulk liquids between plants and domestic feeder operations between container ports.

In contrast, the Motorways of the Sea concept refers to making greater use of maritime routes between UK ports and other European ports, and aims to introduce new intermodal maritime-based logistics chains in Europe, which should improve transport organisation within the years to come. These chains will be more sustainable, and should be commercially more efficient than road-only transport. Funding has been made available to encourage the achievement of the programme’s objectives.

This could have congestion benefits to the UK markets if goods are received at ports around the country, closer to their destinations, rather than predominantly in the South East.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">Opportunities to grow coastal shipping and motorways of the sea have not published forecasts of impacts on road traffic.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">There is potential to reduce the number of vehicles on the road by encouraging the development of business cases for marine transport.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">The European Commission proposed the development of Motorways of the Sea as a real competitive alternative to land transport. The three main objectives for the sea motorways projects:
(1) freight flow concentration on sea-based logistical routes;
(2) increasing cohesion;
(3) reducing road congestion through modal shift.

The benefit within GB would be to potentially shift the port of entry from the South East (Dover / Channel Tunnel) to locations closer to final markets, reducing traffic on the M20/M25/M1 corridors.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">It was envisaged as a way of reviving short sea shipping and thus alleviating some of the congestion and the pressure on bottlenecks in the European road and rail networks. The concept has evolved to include the integration of maritime transport in the logistics chain and pursuit of wider benefits such as improving environmental performance, administrative procedures, training, safety and traffic management (EU, 2017).

The evaluation concludes that, overall, the effectiveness of MoS projects has been mixed. Performance needs to be seen in the context of the economic crisis that impacted on all transport sectors across Europe. There have been some successes in encouraging a modal shift (from road to shipping) but the quantitative evidence is poor. Only in the EU Marco Polo project was modal shift a measurable target (and in the three completed projects modal shift targets were not fully met). The data on the impacts on road congestion are weaker still, with baseline information scarce and comparison across the EU infeasible. The project data suggests that the road congestion reductions attributable to MoS are minimal (EU, 2017).

In addition, suggestions have been that clustering, cargo bundling and piling of freight volumes in specific ports will result port congestion and in the end a Sea Motorway could just transfer the road transport externalities to ports (Hellenic Institute of Transport, Undated).</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="4">Whilst there have been limited examples of MoS improving UK road congestion, there may be wider benefits for increasing the take up of opportunities of MoS funding. Therefore this could continue to be promoted, depending on the availability of funds post Brexit.</td></tr>
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<table>
<tr><td>Intervention Title</td><td>CONGESTION CHARGING - URBAN</td><td>Intervention Number</td><td>E5</td></tr>
<tr><td>Intervention Description</td><td colspan="3">The term road pricing itself only came into common use however with publication of the Smeed Report in 1964 which considered how to implement congestion charging in urban areas as a transport demand management method to reduce traffic congestion. It can be defined as: "Charging of vehicles entering a specific zone, with “the objective to reduce congestion by bringing about a modal shift away from single passenger vehicles" (Deloitte, Unkown).</td></tr>
<tr><td>Quality of evidence</td><td>0</td><td colspan="2">There are well documented examples of the impact of congestion charging in cities around the world, notably London. However, there is less evidence about the impact on goods volumes.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="2">Typically, congestion charging schemes have a strong impact in reducing congestion, although the impact is known to decline over time. The impact on freight is less clear, as many or most urban freight journeys cannot avoid daytime or peak hours.</td></tr>
<tr><td>TRL</td><td>N/A</td><td>Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="3">This intervention could have two impacts – reduce congestion, allowing freight to flow more freely (at a financial cost) and/or push freight into off peak to take advantage of less congested times and avoid the charge. A general charging programme could result in the public shifting to public transport, cycling or motorcycles instead of single occupancy journeys and could there be an increase in road risk as a result with more congestion as a result of collision.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="3">Opinion remains divided over its effectiveness. There are two examples in the UK, London and Durham, and two in Europe, Milan and Stockholm.
The London congestion charging scheme (not HGV specific) was successfully implemented in 2003 and has measurably reduced traffic flows in central London (Sean D. Beevers, David C. Carslaw, 2005). Evidence suggests that following the introduction, traffic fell 15% leading to a 30% improvement in journey time. It was feared that a congestion charge would lead to more congestion in the area surrounding the congestion zone, however, this hasn’t materialised (TfL, 2007). However, despite fewer cars being on the roads, congestion rose markedly between 2005 and 2006 (The Independent, 2008). According to TfL figures, traffic levels over the past 10 years have gone down by 10.2% but journey times for drivers have remained flat since 2007 (The Independent, 2008). In an article on the BBC website the level of contradiction is clear: Barry Neil, whose east London-based company Ambient Computer Services travels into central London daily delivering computer equipment, claims this is evidence the congestion charge has failed. He said: "We said when it launched it wasn't going to make any difference and unfortunately it hasn't. If it made it easier to drive through London, then great. But it doesn't. The jams are just as bad and it costs us £5,000 a year." However, Elliot Jacobs, managing director of office supplies firm UOE, disagrees. "Getting deliveries on time is really important and the congestion charge means we have a consistency of traffic flow and a reliability that we know where the traffic's going to be, and that's important. It means we can get there on time and that's worth £10 every day (BBC, 2013).
TfL argue that the most successful aspect of the scheme is the large reduction in Heavy Goods Vehicle (HGV) volumes in the area (up to 75 percent). The results would tend to show that HGV movements in the area have been reduced to only those actually delivering in the area, and HGV ‘rat-running’ has been virtually eradicated (TfL, 2007).
A report written for the London Assembly in January 2017 London Stalling: Reducing Traffic Congestion in London states that the London congestion charge is no longer achieving any of its outcomes. The report calls upon the Mayor of London to reform the congestion charge and to implement a number of other recommendations including the relaxation of night time delivery bans to encourage more re-timing, encourage more consolidation centres to be implemented around London and a pilot scheme for GLA staff to ban personal deliveries (London Assembly Transport Committee, 2017).</td></tr>
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Caroline Pidgeon MBE AM, Chair of the Transport Committee stated, “What is clear is that the current Congestion Charge is no longer fit for purpose – it is a blunt instrument using old technology that covers a tiny part of London. Fundamentally, vehicles should be charged according to their impact on congestion. Charging a daily flat rate to enter a zone may discourage some people from using part of the road network, but this approach is failing to target vehicles spending longer on the roads, at the most congested times, and travelling in other areas where congestion is high” (London Assembly Transport Committee, 2017).

Stockholm: Whilst not HGV specific, the effects of the congestion charging in Stockholm on vehicle traffic were remarkable, and surprised even the transport planners, who had expected a relatively small effect. In January 2006 traffic dropped 28%, from 450,000 vehicle passages per day to just over 300,000 (City of Stockholm Traffic Administration, 2009). And though it slowly increased to 390,000 in June 2006, it is clear that this was a seasonal effect – traffic always increases in spring and summer – rather than a falling-off effectiveness of the congestion tax; traffic was still down by 21% in June 2006. The trial was terminated at the end of July 2006 but surprisingly, though traffic increased, it remained 5–10% below 2005 values even though there was no congestion tax! (RAC Foundation, 2011). It has concluded that congestion charging works: congestion is dramatically reduced and traffic is not diverted onto other routes. However, it could not be evidenced that this was the effect of congestion charging alone or other interventions implemented at the same time. There is scepticism about the efficacy of charging in reducing congestion, and whether it would simply displace it to other locations and times. The evidence from Stockholm and from the London Congestion Charging Scheme is that it does not. In addition, congestion is non-linear – so a small reduction in traffic will produce a large reduction in congestion – as happens for example during school holidays (RAC Foundation, 2011).

The reasons why the London Congestion Charging has potentially lost its efficacy in relation to congestions may not be to do with the principle of charging but several other factors such as:
(a) The growth in minicab and van traffic;
(b) The transfer of streetspace away from motor vehicles to pedestrians and cyclists
(c) The fact that a simple daily charge, which was very effective in reducing car commuting is ill-suited to vehicles which make multiple journeys during the day and have no incentive to avoid the peak (other than the effect of congestion itself)
(d) It doesn’t necessarily affect freight congestion as they will go into urban areas charge or no charge and a time/mileage based charge may be more effective to manage freight congestion.

TfL data shows that the congestion charge seems to have little impact on HGV traffic. HGVs are disproportionately concentrated in the early part of the day, when they typically comprise 6-7 per cent of traffic entering the zone. This compares to, typically, 3-4 per cent in the afternoon. Between 07:00 and 10:00, some 3,463 HGVs entered the charging zone on an average weekday in 2016. This was 27.9 per cent of the daily total of 12,397 HGVs and 5.7 per cent of total motorised traffic at that time (TfL, 2017).
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<td>Opportunity to Develop Further</td>
<td>There is a strong case to introduce charging in other cities, but there is an argument that this needs to be guided by national policy to avoid a disproportional impact on the freight industry who often work nationally and its effectiveness will depend on the alternatives available to businesses and individuals. For freight, the potential benefit of freer flowing traffic will need to be offset by the charge itself and the number of HGVs themselves may not be reduced.</td>
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Intervention Title	**CONNECTED ROAD VEHICLES AND CORRIDORS**	Intervention Number	E6
Intervention Description	A connected vehicle is a vehicle with technology that enables it to communicate and exchange information wirelessly with other vehicles (V2V), infrastructure (V2I), other devices outside the vehicle and external networks (V2X) with very low latency i.e. in real-time. Connected vehicles and corridors (infrastructure) will have technology that allows connected vehicles to communicate with other connected vehicles and infrastructure via wireless communications to receive and send information. Typically, these wireless technologies are 4G cellular LTE (3.4-3.8 GHz) or ITS G5 (5.9 GHz) based. In the future it is expected that 5G cellular will also provide communication services to and from and between vehicles (SMMT, 2017). *"Unprecedented volumes and new types of data generated by connected and autonomous vehicles and related connected technologies stand to improve safety, of goods and people, and bring direct commercial benefit based on improved consumer experience. environmental outcomes, and accessibility, streamline movement".* (Deloitte LLP, Date unknown) However, given the statement above currently cellular service providers do not provide the requisite coverage, reliability, capacity or latency required for all road locations in the UK. Almost 4,600 miles (2%) of UK roads have no 2G coverage from any network provider, whereas only 43,000 miles (18%) and 119,000 miles (48%) have full 4G and 3G coverage respectively (EU, 2016). There is currently a debate over how the additional coverage, latency, capacity and reliability will be provided e.g. 4G/5G or ITS-G5. The 'Day 1' C-ITS services are those that the industry is focusing on developing first. These are defined by the European Commission as follows (EU, 2016): Hazardous location notifications: • Slow or stationary vehicle(s) & traffic ahead warning; • Road works warning; • Weather conditions; • Emergency brake light; • Emergency vehicle approaching; • Other hazards. Signage applications: • In-vehicle signage; • In-vehicle speed limits; • Signal violation / intersection safety; • Traffic signal priority request by designated vehicles; • Green light optimal speed advisory; • Probe vehicle data; • Shockwave damping (falls under European Telecommunication Standards Institute (ETSI) category 'local hazard warning'). Following on from the 'Day 1' C-ITS services are the next set of C-ITS services defined by the European Commission as the 'Day 1.5' C-ITS services. These include: • Information on fuelling & charging stations for alternative fuel vehicles; • Vulnerable road user protection; • On street parking management & information; • Off street parking information; • Park & ride information;		

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- Connected & cooperative navigation into and out of the city (first and last mile, parking, route advice, coordinated traffic lights);
- Traffic information & smart routing.

The above ‘Day 1’ services are predominantly aimed at providing safety and advisory information for road users whereas the ‘Day 1.5’ service will support HGV platooning and routing of vehicles. The expected benefit of these services in terms of freight congestion is as follows:

- Reduced vehicle headways as a result of freight platooning increasing road capacity,
- Reduced frequency and severity of accidents through advanced warnings, and
- Smoother flows of traffic as through more controlled speeds and signal timing warnings.
- Freight route optimisation both in terms of last mile, urban and inter-urban routes.

Connected vehicles and infrastructure are also expected to be enablers for Connected Autonomous Vehicles (CAV) through vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication. For example, the sharing of high definition map updates in terms of location, features from camera images and lidar point clouds will enhance vehicle localisation. More accurate mapping will enable longer periods of autonomous driving with the associated capacity benefits.

However, there are known issues with connectivity and data security and ownership that need to be resolved. For example, if the coverage, bandwidth reliability and latency issues are not resolved, the advantages of the ubiquitous connected corridors strived for will not be achieved and the benefits associated with the services described above will not be realised. **Error! Bookmark not defined.** Also data sharing and interoperability is seen as key to realising the benefits but to enable this standards need to be implemented and trust needs to be realised through adequate security architectures.

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Quality of Evidence

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Evidence exists on the proposed implementation of connected corridors and its benefits for congestion. However, there is very little evidence on the actual benefits or freight specific benefits in terms of congestion. For example:

“More research is needed to anticipate the long-term effects of automated and connected driving. For instance, it is anticipated that driverless mobility will decrease transport costs, free driver's time, and foster car sharing, thereby improving air quality and urban planning. But lower transport costs and freeing the driver from driving tasks could also lead to more or longer journeys, a bigger increase in total traffic, and subsequently an increase in total emissions and congestion.” (EU, 2016)

The evidence also tends to suggest high penetration rates are required to achieve reduced delay reduction benefits. For example:

“There is great potential for substantial improvements in network performance, particularly in high-speed, high-flow situations. However, there is evidence that at low penetrations, any assertive Connected Autonomous Vehicles (CAV) are limited by the behaviour of other vehicles; that vehicles are not able to make use of their enhanced capability. This leads to suggestion of a tipping point – the proportion of enhanced vehicles required before benefits are seen. This work suggests this may be between 50% and 75% penetration of CAVs. Results for the Strategic Road Network (peak period) indicate improvements in delay of only 7% for a 50% penetration of CAVs,

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<tr><td></td><td></td><td colspan="2">increasing to 17% for 75% penetration and as high as 40% for a fully automated vehicle fleet.” (DfT, 2016)
Whilst the above statement is targeted at Autonomous and Connected Vehicles it highlights that penetration rates need to be high for benefit on traffic congestion to occur.

There is limited evidence available on the expected benefit in terms of reduced frequency and severity of impact of accidents resulting from connected corridors, although the US Department for Transport suggests there is potential to reduce the crash related incidents by 25% in winter conditions. The same report also indicates the following: “Combinations of signal control applications (Intelligent Traffic Signal System, Freight Signal Priority, and Transit Signal Priority and Freight Signal Priority) reduced travel time by up to 27 percent.” (DfT, 2016)</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="2">Evidence suggests a very minor positive impact on the optimisation of freight movement across road networks however standards have not yet been harmonised and it is too early in the test this and deployment of these technologies are only just starting to take place hence realising congestion benefits in the next 10-30 years is unlikely given the rate of technology rollout in the automotive sector and penetration rates required.</td></tr>
<tr><td>TRL</td><td colspan="2">5</td><td>Stakeholder Acceptability | 1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="3">Connected vehicles are expected to be able to reduce freight congestion in a variety of ways. One such way is Lorry Platooning. Lorry platooning was highlighted as an early example of CAV close to deployment. Platooning is where one lorry leads and makes the decisions for those behind that are wirelessly connected to form a road-train.
Connected vehicle solutions can alleviate traffic congestion through intelligent traffic control and management, and use technologies such as collision detection, and cooperative merging to smooth the flow of traffic and make it safer as well.
Connected Vehicle generated data can include information such as traffic signal control, intelligent traffic scheduling, fleet management and also route optimisation, all of which can ease congestion.
There is some evidence that connected corridors will improve safety and hence reduce the frequency and duration of accidents including those caused by freight vehicles. The expected monetary benefits of Connected Autonomous Vehicles (CAV) to the UK are: £51 billion per year to the UK economy by 2030; cleaner mobility and reduced emissions; improved traffic flow and efficiency and reduced fuel consumption. Whilst connected vehicle deployment is in its infancy it be noted that in the UK there are few corridors that can support platooning due to junction spacing. Furthermore, benefits associated with connected vehicles are dependent upon high penetration rates. Finally, this technology is in development and until standards are harmonised and penetration rates increase the benefits are likely to be limited.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="3">The SMMT highlights some of what the research into CAVs has shown; they are expected to contribute to cleaner mobility and increased productivity, since they are capable of platooning and travelling at optimised speeds and headway gaps, which in turn improves traffic flow and efficiency whilst reducing fuel consumption and emissions. An example of this is from a Government commissioned study that found a 12% improvement in delays and a 21% improvement in journey times in peak traffic periods even with low numbers of autonomous vehicles on the roads. (SMMT, 2017)

A parliamentary report titled ‘Connected and Autonomous Vehicles: The future?’ provides some information on what the Government knows about CAVs. The report states that it found that CAVs for the road sector are expected to improve traffic conditions and reduce congestion, and that there was a benefit in network optimisation with CAVS enabling a smoothing out in the way which vehicles drive, this allows vehicles to drive more closely together and thus increase capacity in the highway network. (Parlimentary Report, 2016)

The way in which CAVs collect data can also help to reduce congestion states the report. CAVs can provide authorities with much bigger data sets that would allow them</td></tr>
</table>

	to configure the way urban traffic control works better, and influence the way in which traffic signals are managed and how congestion can be managed. The report also mentions that the impact that CAVs have will depend on the level of autonomy enabled and the level of adoption achieved. The longer-term outlook is easier to predict than the medium term due to there likely still being a mixed fleet of vehicles operating on the road, not just a majority of autonomous vehicles. However even with the above examples evidence is limited and currently European Commission is trailing connected vehicles in several countries to harmonise standards and learn more about the impacts. The intent is that these projects will feed back into the C-roads programme standards harmonisation. Example pilot projects include Eco-AT, NordicWay, Scoop@F and Intercor.
Opportunity to Develop Further	• Incentivise the uptake of the connected vehicle technologies in the road freight industry once the standards have been harmonised. • Utilise the 5G spectrum licencing to enhance coverage across the road network by stipulating coverage requirements. • Stipulate data sharing via a single/small number of UK certified platforms to guard against data sharing market fragmentation.

<table>
<tr><td>Intervention Title</td><td>DATA SHARING FROM TELEMATICS SYSTEMS</td><td>Intervention Number</td><td>E7</td></tr>
<tr><td>Intervention Description</td><td colspan="3">Telematics systems are On-Board Units (OBUs) that are fitted to vehicles to collect and transmit data on the vehicle location and performance, driving behaviour and other sensor activations such as detecting when preventative maintenance is required. They are typically used to track fleet vehicles optimising routing, journey times and fuel economy (FT, 2016) whilst also providing an improved duty of care and safety through better driving and pre-emptive vehicle maintenance. There is also evidence that they reduce speeding fines and insurance premiums in some instances.

On average there are 38% of business within the UK that use telematics systems (Fleetnews, 2016) and by 2025 88% of fleet vehicles are expected to have some form of telematics connectivity (Fleetnews, 2016). There is also a growing increase in the use of these systems by insurance companies to enable young drivers to reduce the costs of insurance whilst improving safety and efficiency of the use of the vehicle. The number of registered drivers in 2017 was 975,000 up from 751,000 in 2016 and 455,000 in 2015 (Biba, 2018).

In terms of freight congestion, the use of telematics systems by fleet operators can aid in the identification of congestion on vehicles delivery routes and potentially re-route if possible. However, the bigger opportunity is in the sharing of this data to support UK intelligent mobility efforts. If this information could be made available on a large scale it would enable production of value added services such as accurate origin and destination datasets of freight movements on the road network in near real-time, supporting the further optimisation of network routing and vehicle load utilisation. It would also benefit road operators to target network improvements based on real rather than estimated network usage patterns which would further benefit on-road freight logistics.

There are issues surrounding data privacy, ownership and portability are inhibiting the adoption and exploitation of in-vehicle telematics solutions. In terms of data privacy there are concerns around the use of historical driving data used in court cases against the defendant. In terms of data ownership there are disagreements on who owns the data generated e.g. automotive organisation, fleet tracking organisations, fleet operators or the driver etc. In relation to this, legislation is also complex on the portability and sharing of this type of data and whilst the 2016 General Data Protection Regulations (GDPR) gave some clarity on individuals being able to ‘port’ data, it has still not resolved the issue for organisations wanting to share this information more generally.

Government policy and regulation could reduce the friction in this area clarifying existing legislation on data sharing and potentially adding further legislation to improve portability of anonymous datasets. Furthermore, regulation could be applied to the insurance industry mandating anonymous information sharing of real-time and historical freight data under certain licence conditions.

There are examples of where this has occurred to the benefit of road users. The regulated bus industry in London provides data to support real-time arrival information at bus stops allowing passengers to determine mode choice for optimal arrival time and cost. This information is depersonalised and shared anonymously in real-time on the London data store (Transport for London open data platform) where it is fed into value added services supporting mobility as a service around London (ITS, 2018).

A final point to note, blockchain distributed data technology is starting to be considered for use in the logistics industry to provide transparent data sharing. This could support the development of anonymised data sharing platforms supporting the use cases discussed above (DHL, 2018).</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="2">There is plenty of evidence on fleet telematics systems however, it is limited in terms of benefits for freight congestion.</td></tr>
</table>

Potential Impact on Freight Congestion	1	Evidence suggests that this could have a minor positive impact on the optimisation of freight vehicles on both the SRN as well as inter-urban and urban areas. Furthermore, is could support more targeted road improvements from more accurate origin destination datasets.	
TRL	9	**Stakeholder Acceptability**	1
Freight Congestion Impacts	There is some evidence that telematics data is used to adjust planned routes in advance of journey commencement (UPS, 2016), however there appears to be little real-time route optimisation undertaken, hence congestion benefits are likely to be limited.		
Evidence of Effectiveness	Limited evidence for effectiveness on the reduction in congestion, however it would appear to be a good enabler of interventions that could directly support freight congestion reduction.		
Opportunity to Develop Further	• Better understanding of freight flows that allow for better planning guidance for Local and National authorities • Provision of clarity of legal position on data ownership and portability		

<table>
<tr><td>Intervention Title</td><td colspan="2">DELIVERY DROIDS/PAVEMENT DEVICES</td><td>Intervention Number</td><td>E8</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Delivery droids (pavement devices) are automated vehicles that work on the ground (either road/pavement depending on size/regulations) with the capability to handle small loads up to around 10kg and deliver them short distances in urban settings from stores or specialised hubs, at the time that the customer requests (Hunt, 2018).</td></tr>
<tr><td>Quality of evidence</td><td>0</td><td colspan="3">There is not much substantial information on the impact delivery droids will have; there are no studies, and there is no information regarding the success of the trials in relation to congestion reduction.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">This technology could potentially have a reasonable impact on reducing the congestion caused by delivery vehicles in urban centres, by eliminating the need completely for delivery vehicles, thus reducing on road freight congestion.</td></tr>
<tr><td>TRL</td><td colspan="2">8</td><td>Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">Most of the aforementioned delivery droids are designed to use pavements, thus clearing the road of delivery vehicles that stop outside every other building for several minutes at a time to deliver parcels and food. The delivery drones negate the need for delivery trucks, especially in urban centres, reducing the congestion caused by said delivery trucks. Furthermore, delivery droids could allow for longer delivery shifts, for example, customers could select for their delivery to be delivered in the middle of the night if they were so inclined, thus reducing daytime congestion.

In addition, retailers and fulfilment companies are keen to use these delivery droids as they will make deliveries less expensive and speed up the last leg of the trip (the last leg is often the most difficult and costly part of delivery), and if the last leg of the trip is sped up, there is less congestion (Apparatus, 2018).

There is some apprehension as to the ability of delivery droids in reducing congestion; the Freight Traffic Control 2050 Project agree that delivery droids have some potential to reduce delivery traffic in London, but that it is still a long-term goal due to the many technological, legal and safety issues involved, and that it would be a long time until regulatory authorities would be prepared to accept wide scale use of the technology in dense urban areas. In addition, a London Councils response suggests that congestion needs to be tackled holistically, through reducing trips, not through shifting the problems off the roads and onto the pavements (Cherrett et al., 2017).

Others have a more positive outlook on the overall impact delivery drones and droids will have on freight congestion; Jean-Paul Rodrigue (professor of global studies and geography at Hofstra University in New York) suggests that within 10 years automated deliveries will aid in the reduction of congestion (Reals, 2017). However he does not comment on the specific impact of droids alone.

It has been claimed that “Delivery droids can help to reduce mis-deliveries, which eliminates the need for delivery drivers to try and deliver the same parcel two (or more times) thus reducing costs and increasing efficiency” (Hildred, 2017). However, evidence of this is limited.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">Delivery droids exhibit various shortcomings and weaknesses say the Freight Traffic Control 2050 Project. They state weaknesses such as problems in pressing buttons to cross roads, knocking on doors and doorbells, climbing stairs, calling lifts etc. have prevented their widespread use for freight transport operations. Furthermore they say that the droids would also interfere with pedestrian flows in busy London locations, and that they are prone to theft and vandalism - which makes the FTC say that droids are more likely to be used for freight operations inside buildings than on streets. A trial using a droid for making deliveries in Greenwich by Starship Technologies is underway but currently faces the operational difficulties outlined above (Cherrett et al., 2017).

On the other hand, Starship Technologies have had trials in many other cities across the world that have been more successful. The firm claims that none of their droids have been stolen or vandalised, and that they have already completed 100,000 miles</td></tr>
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	of delivery journeys (Abbott, 2018). Starship Technologies have deployed around 100 robots across eight cities in Europe and the US, and the firm reckon that this number will increase once more are made and manufacturing costs come down. Marble, a competitor to Starship Technologies, labels itself as *“the last-mile logistics company”*. Last year it trialled in San Francisco using a system with on-board LIDAR sensors to help it navigate around pedestrians and other hazards. Marble’s home city of San Francisco have restricted the areas where delivery robots can go in the city in order to protect pedestrians, however at the same time it is a blow for the development of the technology (BBC, 2017).
Opportunity to Develop Further	• Infrastructure changes would help to support the widespread adoption of this technology e.g. new lane for robots (similar to cycle lane). • Drop off docks where the droids can drop off deliveries without the need for someone to open a door etc, can make deliveries at all times of day. • Use alongside larger autonomous delivery vehicles- larger vehicle (that can travel on roads) brings the smaller droids to a drop off point in the city, then can offload several droids to locations nearby- fully automated delivery service. • Underground delivery tunnels/lanes

<table>
<tr><td>Intervention Title</td><td colspan="2">DELIVERY MANAGEMENT SYSTEMS</td><td>Intervention Number</td><td>E9</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Delivery Management Systems (DMS) is a booking system for deliveries providing logistics with planned vehicle movements and security with information for fast access screening. The Delivery Management System regulates the flow of delivery vehicles to distribution centres and construction sites against the booking schedule for the day.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">Evidence is limited to case studies.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">Very localised improvement in congestion at peak times in key logistics areas.</td></tr>
<tr><td>TRL</td><td colspan="2">9</td><td>Stakeholder Acceptability</td><td>2</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">Benefits the main ingress and egress points into key freight centres or busy delivery points and reduces dwell time on sites.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">DMS can range from a very manual process of delivery slot right through to a more control tower approach. A control tower is “a central hub with the required technology, organization, and processes to capture and use supply chain data to provide enhanced visibility for short and long-term decision making that is aligned with strategic objectives”. (Capgemini Consulting, 2013) At its full extend this is the transparency that big data may provide, however, at the booking system level its about being able to book and track vehicles when within a certain geography.

DMS can be used in a variety of locations: consolidation centres, RDCs, ports and offices. Whilst this concept has been in existence for a long time and variations are used across many industries, the increasing levels of automation are allowing for greater benefits.

Port logistics
Vehicle Booking Systems (VBS) are defined by DfT (DfT, 2008) as “…an online booking system for HGV collections and deliveries of containers. It requires hauliers to select a designated slot for delivery and collection to the port, aiming to spread the load for vehicle calls throughout the working day, minimising congestion.” It should be noted that port operators implement VBS to smooth traffic peaks and reduce congestion at their terminal, with the intention of increasing operational efficiency and levels of customer service. If the VBS results in reduced congestion outside the port then this is incidental. VBSs have been implemented at major container terminals in the UK, including Felixstowe (Hutchison), Liverpool (Peel Ports), Tilbury (Forth Ports), Southampton (DP World), and London Gateway (DP World). In 2015, Peel Ports implemented “Intelligent Autogates” at their Liverpool terminal. The VBS allocates time slots for hauliers and relieves peak time pressures at the terminal. It is reported that on-terminal times for trucks is typically less than 30 minutes for 65% of vehicles and less than 60 minutes for 95% of all haulage transactions kiosk In to kiosk Out (Peel Ports). The VBS at Felixstowe also seeks to achieve faster turnarounds for truck drivers and customers. Bookings are made in one-hour periods with the system checking that the containers are ready for collection (customs cleared) before the booking is confirmed. This minimises driver rejections at the gate and thereby minimises wasted journeys. In order to provide consistency to customers, DP World’s VBSs at London Gateway and Southampton are similar, with VBS peak times being Monday to Friday 04.00 – 07.00 and 12.00 – 18.00. These examples are ports which are privately owned, with VBS being deployed for commercial reasons by the port operator. Whilst each operator will have a very good understanding of the commercial benefits of their VBS to their business, the impact of VBS on the external network is not documented. The potential for VBS to impact on network congestion is acknowledged but not quantified. For example, in the Road Traffic section of the Environmental Statement for ABP’s Port of Southampton Berths 101/102 Works, in the traffic mitigation/ reduction measures section, the Port’s VBS is mentioned as being very effective however this effectiveness is not quantified (David Tucker Associates, 2011)</td></tr>
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Where ports are partially or wholly publicly owned, processes and systems may be implemented with the explicit aim of reducing congestion outside the port.
For example, the Israel Ports Company (IPC), in cooperation with the Ministry of Transport and Road Safety, has developed and managed the “Good Night Initiative” which is designed to encourage off-peak truck traffic transporting full containers to and from the country's ports. The IPC provides a monetary incentive to importers and exporters for each container that they transport at night. The initiative is aimed at better balancing the use of port and road infrastructure by spreading traffic throughout the course of the day. As a consequence, the general public is reported to benefit by reduced traffic congestion during the day on the country's main traffic arteries and at the entrance to port cities, as well as reduced air pollution.

Felixstowe at one time suffered from traffic congestion and so redeveloped its freight moving systems to include an advanced Vehicle Booking System (VBS) for British hauliers. The VBS has been a huge success – nearly 10,000 hauliers are currently signed up to use the system. The VBS is based on two simple principles: cargo tracking and online booking. In the first phase, workers at the port verify that shipping containers are ready to go prior to making them available for pickup. Once these are approved and entered into the system, the haulage companies are then informed so they can book their arrival times. Lorries arrive at the appointed time, load or unload, and quickly move on their way. The improvements at Felixstowe reduced average wait times from three hours to 40 minutes. Furthermore, less congestion also reduced wear and tear on local roads. Both are points that officials in Cork hope to repeat at their own port.

Construction logistics
The implementation of a booking system at the London Construction Consolidation Centre “The advantages of this approach not only reduces the congestion on the roads leading to a site, but also produces safer roads and less noise and pollution.” (Motortransport, 2016)

Office logistics
James McNaughton worked with its suppliers to install an online booking system which they claim has reduced congestion on their site and surrounding area. (TfL, Date unknown)
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<tr>
<td>Opportunity to Develop Further</td>
<td>

Promotion of this with operators via FPQs, DSPs and CLPs
Links with design of offices, shopping spaces to allow for adequate delivery management
Use of AI and data sharing as a means to progress the system, however, this is likely to be market driven and based on incremental change.

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<table>
<tr><td>Intervention Title</td><td colspan="2">EXPRESS RAIL FREIGHT</td><td>Intervention Number</td><td>E10</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Express Rail Freight includes several technologies:
• Operating faster conventional freight trains
• Carry post and parcels on passenger trains or converted passenger trains
• High speed freight trains on high speed lines</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">Various trials have not been turned into significant volume. Few reports forecast volume rather than potential.</td></tr>
<tr><td>Potential Impact on Rail Freight Capacity</td><td>0</td><td colspan="3">Potentially provide new capacity for new flows of freight, but does not provide additional capacity for the key markets which are forecast to grow.</td></tr>
<tr><td>TRL</td><td colspan="2">TRL 7-9</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">While some of these systems offer opportunities for modal shift to rail, they are considered here in terms of their potential to provide more rail capacity for freight. In this context, the main benefit would be to reduce the speed differential between passenger and freight trains, which would provide a higher system capacity.

Carrying post or other freight on passenger trains may return as a service opportunity, but the impact in terms of capacity would be small.

On high speed routes, high speed freight services could be operated alongside high speed passenger services – providing capacity where freight could not otherwise operate during daytime hours.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">Network Rail's Freight Network Study (Network Rail, 2017) carried out a "Benefits Study" into increased speed for intermodal flows on the West Coast Main which examined the route between Milton Keynes and Mossend, near Glasgow. "Increasing the maximum speed of these services from 75mph to 90mph provides journey time improvement only if freight trains can be routed on the fast lines. Low line speeds on the slow lines, particularly around the Warrington Bank Quay, Wigan North Western, Preston and Carlisle areas, prevent freight services from taking advantage of the increased possible speed. Substantial benefits could be gained from running electric freight trains (either Class 92 or TRAXX locomotives) rather than diesel traction, particularly for the section north of Preston, where there are significant gradients. Initial indications suggest there are identified potential benefits in a timetable context."
The NR study also notes

"It must be noted, however, that increasing the maximum line speed for freight services may not always lead to notable benefits where the average speed of a service is still constrained by slow sections elsewhere. For this reason, short-term capability options are focused on increasing the average speed and therefore end-to-end journey times. It is recognised that existing constraints may limit some of these aspirations. For example, running 90mph services on the WCML may lead to increased wear on wagons, air turbulence at stations, increased emissions, and the geographical nature and topography of the line north of Preston could present additional challenges"
French operations of 100mph conventional freight trains in the 1980s and 1990s were discontinued due to high costs. The TGV La Poste operation offering converted TGV trains carrying letters and parcels, lasted longer, but ceased operation in 2008 (Wikipedia, 2018).

There is a limited Royal Mail train service in England using passenger style freight electric multiple units with an operating speed of up to 110mph allowing trains to be operated alongside passenger services.

Eurocarex has been working on proposals to introduce high speed freight trains onto high speed lines across Europe, aimed particularly at competing with air freight. However, commercial operation is yet to start. Such services would have to compete with passenger trains for capacity. At night high speed lines have restricted capacity due to maintenance closures.</td></tr>
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Opportunity to Develop Further	The biggest opportunity would seem to be for faster freight trains, particularly domestic intermodal services, but technical issues need to be solved. High speed freight services on high speed lines are more of a niche opportunity in terms of impact on rail capacity or road congestion.

Intervention Title	**FLEET RECOGNITION SCHEMES**		Intervention Number	E11
Intervention Description	Fleet recognition schemes are tools used by authorities to engage with freight operators to encourage operators to comply with best practice standards which may include techniques to route plan, reduce empty running, driver training, vehicle standards.			
Quality of Evidence	0	There are examples of this as an intervention however, the connection to reducing congestion is implied rather than demonstrated.		
Potential Impact on Freight Congestion	1	Whilst there is little evidence there is an implied positive impact on the number of vehicles on the SRN/urban environments where schemes are adopted.		
TRL	N/A		**Stakeholder Acceptability**	1
Freight Congestion Impacts	In principle areas where recognition schemes are implemented this could have a general positive improvement on congestion, which in turn will help freight congestion.			
Evidence of Effectiveness	There is no evidence of how best practice schemes specifically reduce congestion however, the implication is that reduced empty running is best practice and therefore these schemes encourage efforts to reduce congestion. There are a number of examples, however, the two key ones for freight are Fleet Operator Recognition Scheme (FORS) and ECO Stars Fleet Recognition Scheme (ECO Stars). FORS is a voluntary accreditation scheme for fleet operators which aims to raise the level of quality within fleet operations, and to demonstrate which operators are achieving exemplary levels of best practice in safety, efficiency, and environmental protection. The requirement for FORS is driven by market demands, i.e. placed into contracts and is requirement for working with HS2 and Cross Rail (FORS, 2018). The ECO Stars is a free scheme that aims to help fleet operators improve efficiency, reduce fuel consumption & emissions and make cost savings. It was originally set up to tackle local air quality issues caused by transport, focusing on HGVs, buses, coaches and vans. ECO Stars has grown to a number of Local Authorises and in total, the individual schemes have more than 500 members with 14,000+ vehicles (ECO Stars, 2018). FORS claim: *"Through extensive driver training programmes, FORS operators provide a more efficient service, including reduced journey times through better planning, and fewer hold-ups through breakdown or accidents. This helps you keep traffic flowing better across your local area"* (FORS, 2018). Case studies on the FORS website quote improvements in accidents which in themselves would reduce accident related congestion as well as improvements to MPG. This is the same with ECO Stars. Complaints about recognition schemes, in particular in London is that it adds cost to operators when there are multiple schemes clients request operators to sign up to. There is anecdotal evidence to suggest that this doesn't really change journey types/modes and is more of a tool to secure certain contracts (Challenge Panel Feedback).			
Opportunity to Develop Further	• Provision of a single recognition scheme to encourage uptake of best practice. This should be done as a national scheme, not designed by local or regional Government (Challenge Panel Feedback).			

<table>
<tr><td>Intervention Title</td><td colspan="2">HGV PLATOONING ON THE SRN</td><td>Intervention Number</td><td>E12</td></tr>
<tr><td>Intervention Description</td><td colspan="4">‘Using connectivity, trucks in a platoon or road-train can communicate with each other. Distance, speed and braking can all be controlled. The follower trucks use radar and camera...’ (or WiFi and other technologies) ‘...and receive information from the trucks in front.’ (Volvo, 2018). HGV platooning in this definition, can involve a human driver in the lead vehicle.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">There are examples of trials (UK forthcoming trials and previous EU trails) of this as an intervention however, reliable analysis of its effectiveness on congestion is limited when trialled on a small scale. The focus is on the safety of technology at present.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">Little evidence on impact of platooning on congestion on the UK network pending trials.</td></tr>
<tr><td>TRL</td><td colspan="2">5</td><td>Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">• Allows for potential greater utilisation of highway capacity with ‘linked’ vehicles
• Allows for agglomeration of similar loads into platoons to reduce spread of congestion impacts
• Reduces number of driver decision points (active drivers within the platoon) thus aiding overall flow
• Has potential major benefits at times of low levels of background non-HGV traffic (road as a railway)</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">In 2016, the European Truck Challenge demonstrated the technological feasibility of mono-branded platooning, a UK Government-backed truck platooning trial is in the developmental stages.

Industry support within the UK is mixed, with the Road Haulage Association (RHA) (2017) of the belief that the characteristics of the UK Strategic Road Network (defined by character of road network, length of stretches uninterrupted without junctions) and the routings linking to warehouses and delivery destinations (i.e. short usage of SRN) are not particularly suitable for platooning and therefore a trial on the network is essential (Road Haulage Association, 2017). Meanwhile, Ash et al. released a report on the potential for automated freight corridors identifying a strong economic rationale for Highly Automated Vehicle (HAV) deployment with a number of corridors identified, although ironically the best corridors are those already with the lowest congestion and highest throughput (Ash et al., 2018).

The composition of the UK market in terms of fleet operators also needs to be recognised when it comes to analysing the effectiveness of platooning. The UK consists of lots of small fleet owners and therefore there are commercial barriers to collaboration (TRL, 2017). The large fleet providers have a larger capability in terms of implementation, with the potential to adopt quickly for those biggest routes that compete directly with rail.

The European SARTRE (Safe Road Trains for the Environment) Project reports that controlling the following distance between vehicles helps maintain free-running traffic. The most traffic flow benefits of platooning however come about when traffic is beginning to slow due to congestion. The point at which traffic flow ‘collapses’ is dependent on the required traffic space of each vehicle and the time gap. The smaller the time gap the more the collapse point is shifted towards higher traffic flows and therefore platoons reduces this time gap, enhancing road capacity. Beneficial effects of platooning are also reported when platoons leave traffic jams, as the acceleration is sufficient and controlled, maintaining space between vehicles which leads to faster congestion dissolution (Davila & Nombela, 2010).

In a report by Kotte et al., potential efficiencies to overall traffic flow of platooning are shown, but the need for high penetration and long length platoons is also highlighted (Kotte et al., 2012). Similarly, in 2014, in a study for the Department for Transport,</td></tr>
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	Harwood and Reed showed that for a UK style road, HGV platooning needed 50% of HGVs to be equipped with the technology to gain a 2% increase in capacity. Although it has been deemed possible to measure the effectiveness of platooning, reporting of the impacts of platooning on congestion from trials has been limited. The potential benefits of platooning on traffic flows have been simulated, however at present actual trials are focused on ensuring the technology is safe and works well on the roads. The Heavy Vehicle Platoons on UK Roads Feasibility Study for the Department for Transport in turn states that *"parameters such as …congestion cannot be realistically measured in a trial"*, questioning how reliable reporting of effectiveness of platooning can be (Ricardo, TRL & TTR, 2014). Platooning with Connected and Autonomous Vehicle technologies has the potential to maximise the benefits of platooning but the two technologies are not necessarily linked and singular AV HGVs could potentially deliver similar overall benefits. Particular platooning benefits include reducing the number of driver decision points, allows for greater vehicle movements at off-peak times and optimisation of vehicle performance to mesh with load and delivery time slots. Potential benefits occur with regards to fuel savings (of following vehicles) and drivers' hours savings (but this has yet to be tested within the UK's legislative framework). Overall, the impact of platooning on congestion is currently untested and could be potentially negative in areas of the network where there are closely spaced junctions as the platoon could be a limiting factor to traffic joining and leaving the main carriageway. The ongoing UK research work and trial should provide focused UK specific findings.
Opportunity to Develop Further	• The outcome of the current trials needs to be reviewed in terms of operational performance which then can be developed into larger scale trials to prove the use case at scale in terms of impacts on freight congestion. • If there is shift in how freight industry collaborates more generally then adoption could be accelerated provided that appropriate flows and use cases are developed / proven. • There also needs to be a strategic policy direction to identify which corridors on the strategic road network will provide the most benefits.

<table>
<tr><td>Intervention Title</td><td colspan="2">HGV SPEED LIMITS INCREASE</td><td>Intervention Number</td><td colspan="2">E13</td></tr>
<tr><td>Intervention Description</td><td colspan="5">In April 2015, new national speed limits came into force for heavy goods vehicles (HGVs) over 7.5 tonnes on single carriageway and dual carriageway roads in England and Wales. The new limits are:
• 50 mph (up from 40 mph) on single carriageway roads
• 60 mph (up from 50 mph) on dual carriageway roads
Further increases in line with other vehicles could be seen to have benefits.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="4">Evidence is clear that the current increase in speed limits has had positive impacts (so far) on traffic flows. However, evidence to increase speed limits beyond this is non-existent.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="4"></td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td colspan="2">Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="5">Reduction in accidents and increases traffic flow
• quicker journey times,
• less ‘platooning’ of cars and other vehicles behind HGVs,
• less frustration among drivers behind which may lead to risky and ill-judged overtaking,
• reduced toxic emissions (NOx) from HGVs (although faster-moving cars may generate more CO2 than currently) (AA, 2015).</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="5">Research found that all HGV drivers consulted were aware of the speed limit changes on single carriageways, but not all were aware of the changes on dual carriageways. Conversely, 25% of non-HGV drivers were aware of the changes. There was also a very low level of awareness among residents living adjacent to roads affected by the speed limit changes. HGV drivers also noted the opinion that the ability to drive up to 50 mph on single carriageways had, or will, reduce collisions involving the overtaking of HGVs.
The initial analysis of traffic speeds and flows found that:
• speeds for HGVs over 7.5 tonnes on single carriageway roads had increased between 2014 and 2015 by more than 1 mph, on average, across a range of flow conditions
• the equivalent figure for dual carriageways was an increase of less than 0.5 mph
The initial analysis of safety data between 2005 and 2015 identified that:
• historically, up to 17% of all reported collisions in England and Wales have taken place on single (50 mph and 60 mph speed limit) and dual carriageway (60 mph and 70 mph speed limit) roads - 7.6% of the total collisions on these roads were reported to involve HGVs
• prior to the introduction of the new speed limits there had already been a trend of collisions reducing on these roads, though the rate of reduction had slowed in recent years
• in the period following the introduction of the new speed limits there is preliminary evidence of a reduction in HGV collisions estimated to be between 10% and 36%, however, it is not possible to attribute this directly to the speed limit changes
There is no evidence to suggest that further increases to speed limits would benefit congestion, and indeed there are greater risks to other factors (DfT, 2016).</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="5">There is no evidence to suggest that further increases to speed limits would benefit congestion and this does not appear to be being proposed by industry or any other stakeholders as a viable solution to reducing congestion further and evidence suggests that it would be resisted by safety professionals.</td></tr>
</table>

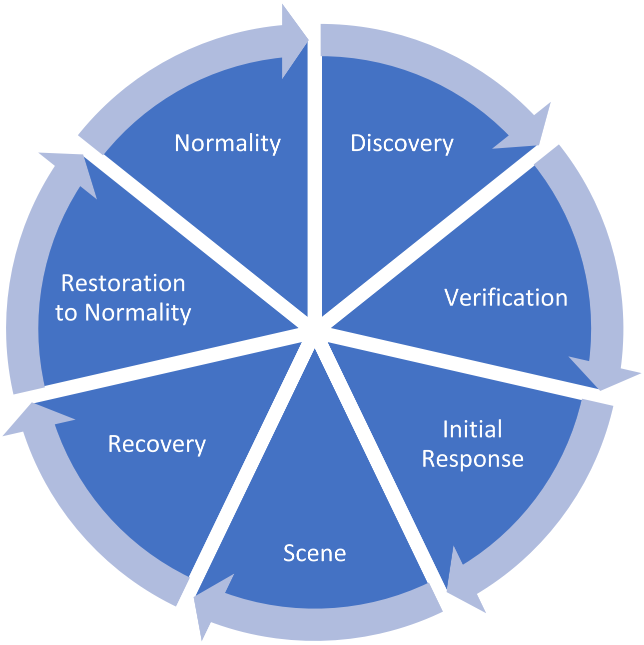
Intervention Title	IMPROVED ROADWORK INFORMATION	Intervention Number	E14
Intervention Description	Poor quality information on planned roadworks restricts the ability to effectively journey plan (route freight vehicles) and journey time reliability: Roadwork data quality issues are primarily caused by: • Poorly written contracts with highway maintainers who are not incentivised to forecast accurately • Lack of common use of standards in recording this type of information (noting that standards are available but inconsistently deployed) • Complex and long business processes – with a lack of joined up thinking between parties in the value chain Roadworks mainly occur at night hence they have a disproportionate impact on freight due to the higher proportion of freight traffic at that time. Typically, this causes unexpected (ad hoc) diversions off the trunk route network or around the local highway network (last mile); increases likelihood of additional driver breaks (also at unplanned locations), and also provides a more stressful journey increasing risk of accidents etc (as well as driver retention). Significant lengths of highway with long term roadworks for major upgrade programmes such as smart motorways, widening etc. does not help with congestion but is likely to be better forecast than shorter duration works. Tools do exist in the marketplace to help aggregate and inform about works such as ELGIN http://roadworks.org. There are also tools to report roadworks such as https://www.mysociety.org. However, this is not primarily a technology problem but rather a process one. Wider challenges within Highways England's traffic management regime frequently impact heavily upon freight users. Suggested improvements on the Highways England side include: **Design** - Develop 'customer-centric' approach in objectives and communications: Highways England/contractor judgement may be over-prioritised, and freight needs under-considered, due to a lack of a clear framework for trading off freight requirements and other objectives – this can be seen in longer stretches of roadworks than might be considered acceptable by road users. - Review guidelines on length, spacing regulations, and acceptable delays: road operators in other jurisdictions have demonstrated the benefits of 'customer-centric' roadworks design in defining acceptable delay times, roadworks length and frequency, etc. - Build robust process around roadworks design to ensure reliance on individuals is minimised: within operations, the reliance on specific individuals with local network knowledge (and associated lack of knowledge management) make effective roadworks design needlessly risky. **Scheduling** - Better engagement with freight operators: the adoption of NOMS should support this from a data accuracy/scheduling visibility perspective, more can be done with increased collaboration and a single roadworks scheduling system giving freight companies full and timely visibility of scheduled roadworks. - More agile and holistic approach to traffic management focused around users' end-to-end journeys and economic impacts of roadworks: Highways England has been slow to acknowledge the disproportionate impact of night-time scheduled works on the freight industry, which increasingly tends to rely on overnight journeys. **Ongoing road management**			

<table>
<tr><td></td><td colspan="3">- More accurate rewards/penalties to ensure contractors are incentivised to finish work quickly and safely: there are minimal disincentives for work overrunning (eg lane rental), whilst an emphasis on ensuring contractors report accurately can lead to disincentives to complete work ahead of schedule.
- Develop formalised roadworks-specific performance tracking KPIs to measure actual vs target performance: Highways England does not currently have a clear process (and required data) with which to monitor roadworks actual performance vs. planned objectives (though it does pick elements of this up through stage gate reviews and audits).
- Use ITS/big data to track traffic management effectiveness through roadworks: there is potential to make greater use of emerging technology and ‘big data’ to track traffic management effectiveness.
Communications
- Improve reliability of communications: issues have been noted with the reliability of communications, with outdated, inaccurate communications being issued, which lead freight operators them to lose trust in the information provided by HE.</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="2">Significant, quality published material</td></tr>
<tr><td>Potential impact on freight congestion</td><td>1</td><td colspan="2">Improvement in Highways England roadwork planning regime which would put a major focus on what works for freight companies (as opposed to current inward-looking focus) and outing this into practice.</td></tr>
<tr><td>TRL</td><td>N/A</td><td>Stakeholder Acceptability</td><td>2</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="3">More effective management of roadworks may alleviate freight congestion by:
- Enhancing the incentive/penalty regime for on-road contractors – leading to fewer roadworks on the network at any given time.
- Improved Highways England understanding of the core issues affecting freight users and a commitment to considering these issues when planning roadworks.
- Improved communication with freight companies enabling freight to proactively plan journeys better and account for the possibility of delays.
- Enhanced monitoring regime to track network performance on roadworks and how this affects freight, facilitating more accurate problem identifications and interventions.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="3">Many of these interventions are new for Highways England and as such there is limited evidence for their efficacy in England; evidence has been taken from comparable countries and highways regimes including:

Design: customer-centric guidelines for design are common overseas; the Rijkswaterstaat in the Netherlands adopts a road user-focused network management regime with outcomes such as “Smart Planning” which prohibits roadworks on diversion and parallel routes.

Scheduling: Transport for London is a leader in scheduling via the use of a single roadworks scheduling system and encouraging contractor collaboration in effective use of roadworks space.

Communications: The Dutch Minder Hinder model has Effective Customer Communication as a core pillar.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="3">• Significant scope to use technology to attune highways operation with freight demand – next step is to ensure management processes are instituted to maximise the potential of this technology. These processes need to be considered on the side of both freight and highways operators.</td></tr>
</table>

Intervention Title	**INCIDENT MANAGEMENT - INFRASTRUCTURE**	**Intervention Number**	**E15**
Intervention Description	Incidents on the Highways England Strategic Road are an unfortunate occurrence and can number up to 350 daily. 85% of these incidents are cleared within 60 minutes however some can take five or more hours to clear (Highways England, 2017). In 2016 incident related delays cost UK Plc an estimated £9billion. (INRIX, 2017) A large proportion of this cost will be attributed to the freight vehicles through missed delivery slots, time sensitive loads and perishable goods. Improved incident management processes focussed on the freight haulage industry could have a significant positive impact to reduce incident related congestion, contribute to a free-flowing network and improve journey time reliability. The wheel below shows the different phases of Traffic Incident Management (TIM) that impacts upon the available capacity (CEDR, 2012). The acceleration of any of these phases starting with Discovery and ending in Normality can aid the return to normal capacity and traffic conditions as quickly as possible.  Interventions that are being developed or implemented to reduce the impact of TIM on the road freight haulage industry include: **Improved strategic information management:** Traffic flow data can be used to update and inform logistic centres or in vehicle devices to advise of congestion on a planned route. These updates must consider 'whole journey' route planning and be cognisant of appropriate formal diversion routes. Early detection of an incident and pre-emptive re-routing of road freight should be considered as a priority over other road users. This ensures that time sensitive or perishable loads are cleared from the area at the earliest opportunity and not further delayed in the local diversion routes. **Timely communication of incidents and related congestion:** Information related to incidents and related congestion should be shared as close to 'real-time' as possible to improve driver awareness and influence logistic planning processes and tools both 'back office' and in-vehicle. Early notification will provide opportunity for loads in transit to be redirected and planned loads to be alternatively routed around the location of the incident if possible. Driver awareness provides the driver opportunity to re-route or plan regulatory stops (tachometer breaks) around the incident location and timings. The National Traffic Information Service (NTIS) provided by Highways England does this on the SRN, however multiple private organisations also provide this information from various Government and non-Government sources.		

<table>
<tr><td></td><td colspan="4">**Improved junction design to accommodate rearward relief:** Rearward relief is the process whereby traffic is turned around from the back of a traffic queue and guided back to the junction prior to the incident. The traffic is then able to leave the motorway from the exit slip road onto the local roads and approved diversion routes. This manoeuvre can be difficult for articulated heavy goods vehicles who require a large turning circle to avoid the potential for jack-knifing. Improved junction design should accommodate the potential for articulated vehicles turning against the usual traffic flow direction.

Dedicated emergency exits to release trapped traffic onto surrounding road network: On sections of motorway with extended distances between junctions dedicated emergency exits onto suitable local road diversion routes would provide swift congestion relief of trapped traffic which would take up to four hours to clear three kilometres of vehicles following the standard procedure for rearward relief.

Use of emergency central reservation turnaround points: Sections of smart motorway and some other standard motorways are fitted with emergency central reservation turnaround points / gates. These provide a safe access point in the concrete central reservation and can be utilised by the emergency services to turn traffic from the affected carriageway onto the opposing carriageway. They are managed and maintained on behalf of Highways England by regional maintenance service providers. Use is authorised by the Traffic Officer Service (TSO) or Police. Although resource intensive to implement they can be used to relieve large volumes of traffic relatively quickly.

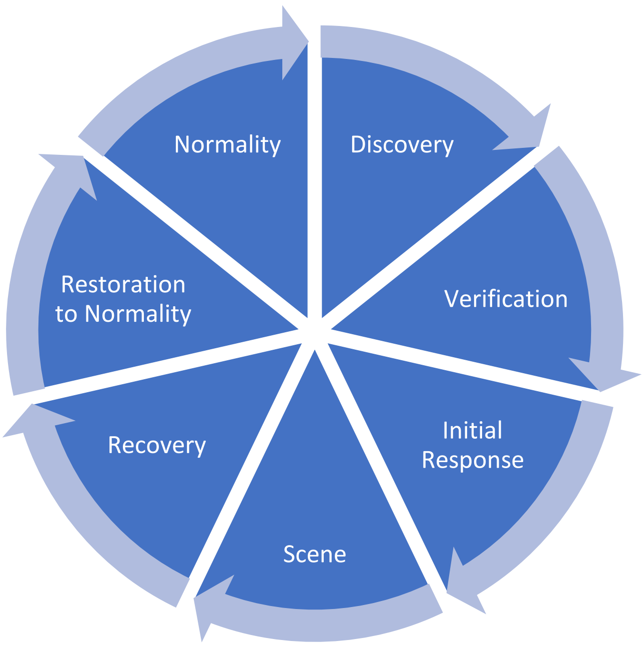
Role of Regional Control Centres
The Traffic Officer Service Regional Control Centres (TOS RCC) provide a focal point for incident management on the TOS patrolled SRN. This role could be expanded to include non-patrolled SRN and Major Roads Network (MRN) where the centric approach provided by the TOS RCC could provide several benefits;
- Collation and dissemination of incident related information, location, carriageway impact, likely duration, approved diversion routes.
- Management of signs, signals and urban traffic management control to prioritise diverted motorway traffic onto local road diversion routes
- Management of signs, signals and liaison with the National Traffic Information Service (NTIS) for strategic sign setting to provide early warning of incidents or congestion ahead.
- Monitoring traffic flows and known congestion / incident ‘hotspots’ and communicating with NTIS to pre-emptively disseminate information of traffic conditions to logistics hubs.
- Monitoring of traffic queues and signage or resource deployment to prevent subsequent incidents involving waiting traffic

Traffic Officer Service
Often the lead agency regarding traffic management at an incident and as such, traffic management procedures at an incident could be optimised to focus on the specific needs of the road freight haulage industry. Safety (welfare) and customer experience are Highways England imperatives and as such should be considered in more detail around the specific needs of this road user group. Focussing removal of road haulage vehicles from trapped traffic as a priority, amending rearward relief and reverse access procedures to accommodate road haulage needs all provide tangible welfare and customer experience benefits to the road freight driver.</td></tr>
<tr><td>**Depth of evidence**</td><td>1</td><td colspan="3"></td></tr>
<tr><td>**Potential impact on freight congestion**</td><td>1</td><td colspan="3">Potential to have significant positive impact if road freight haulage can be prevented from joining existing congestion or quickly removed from / routed around an incident.</td></tr>
<tr><td>**TRL**</td><td colspan="2">N/A</td><td>**Stakeholder Acceptability**</td><td>2</td></tr>
<tr><td>**Freight Congestion Impacts**</td><td colspan="4">Currently, when incidents are being cleared via rearward relief or reverse access, heavy goods vehicles are often the last to be moved and as such they are probably disproportionately impacted.
Infrastructure is not designed with HGV limitations in mind (turnaround points, junction design for rearward relief, cross over points etc) and as such limits options that can be implemented when</td></tr>
</table>

	managing an incident. Improvements in these designs would provide additional congestion relief solutions. Greater management and control of incidents on the non-patrolled SRN and MRN would provide improved communication and dissemination of information via signs and signals and more conventional information sharing via multi-media channels. Traffic Officer presence and management of incidents would ensure incidents are cleared quicker with a reduction on impact on traffic flow.
Evidence of effectiveness	Active incident management on the SRN by Highways England began in 2004 with the introduction of the TSO. Comparative data recording of carriageway impacting incidents for the period of 2004 to 2015 has proved difficult to source and as such a baseline prior to 2004 has not been established. Reliable datasets from 2015 are available and have been used in the illustration / assumptions below: • There were approximately 121,000 carriageway impacting incidents on the strategic road network in 2015 – 2016 with an estimated cost to the UK of £9billion in 2016. • Owing to active TOS incident management intervention, 85% of these incidents were cleared within 60mins. • By 2017, 87% of carriageway impacting incidents were cleared within 60mins. Further improvements could be made on these figures implementing the interventions stated, noting the detail below regarding longer duration incidents – especially those involving HGVs. This data only reflects incidents on the SRN – similar incidents involving HGVs on the Main Road Network (MRN) are not captured and may be longer in duration owing to fewer incident management resources available to assist in restoring to normality. • Fewer than 1% of the total number of incidents that impact the carriageway last over 5 hours, but incidents lasting over 5 hours account for over 16% of the duration that carriageways are impacted, • Sub-5-hour incidents account for 52,000 hours of carriageway impact annually 2015-2016, • Whereas for 5-hour+ incidents the figure is some 10,000 hours, • Of the incidents recorded in 2017 (1495) – 542 involved an HGV, • Of the 542 HGV incidents - 169 incidents took 5-10hrs to resolve and 89 incidents were 10+hrs in duration (Highways England, 2017).
Opportunity to develop further	• Expansion of the TSO onto the currently non-patrolled SRN and MRN would provide incident management expertise and resource to a road network that currently has very basic incident management support. • Expansion in scope of the Highways England Regional Control Centres to cover a wider road network (something akin to the MRN). • Additional diversion routes need to consider HGV parameters of weight, height and length - additional routes could be redesigned to accommodate increased traffic flows and larger vehicle types. • Provision of an increased number of strategically positioned emergency exits and/or central reserve exits to release trapped traffic.

<table>
<tr><td>Intervention Title</td><td>INCIDENT MANAGEMENT – ECALL</td><td>Intervention Number</td><td>E16</td></tr>
<tr><td>Intervention Description</td><td colspan="3">
Incidents on the Highways England Strategic Road are an unfortunate occurrence and can number up to 350 daily. 85% of these incidents are cleared within 60 minutes however some can take five or more hours to clear. In 2016 incident related delays cost UK Plc an estimated £9billion. A large proportion of this cost will be attributed to the freight vehicles through missed delivery slots, time sensitive loads and perishable goods.

Traffic Incident management processes focussed on the freight haulage industry could have a significant positive impact to reduce incident related congestion, contribute to a free-flowing network and improve journey time reliability. The wheel below shows the different phases of Traffic Incident Management (TIM) that impacts upon the available capacity (CEDR, 2012). The acceleration of any of these phases starting with Discovery and ending in Normality can aid the return to normal capacity and traffic conditions as quickly as possible.



eCall (Emergency Call) is an in-vehicle service that will automatically dial 112 in the event of a serious road accident, and wirelessly send airbag deployment and impact sensor information, as well as Galileo coordinates to local emergency agencies. eCall could reduce emergency response times by 40 percent in urban areas and by 50 percent in rural areas (Wikipedia, 2018). eCall supports quicker discovery and verification times as well as the recovery time as it can indicate the types of vehicles involved more quickly. Whilst improving the discovery and verification should also improve the dissemination time of information relating to the incident further reducing impact as road users change their travel behaviour as a result.

eCall devices are mandatory in all new M1 (motor vehicles with at least four wheels designed and constructed for the carriage of passengers) and N1 (vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes) type vehicles sold in the European Union after 1 April 2018.
</td></tr>
<tr><td>Depth of evidence</td><td>0</td><td colspan="2">Limited published material, early rollout phase</td></tr>
<tr><td>Potential impact on freight congestion</td><td>1</td><td colspan="2">Potential to have minor positive impact if incidents impacting road freight haulage can be prevented or the impact timeliness can be reduced.</td></tr>
<tr><td>TRL</td><td>8-9</td><td>Stakeholder Acceptability</td><td>2</td></tr>
</table>

Freight Congestion Impacts	Freight is likely to be a secondary beneficiary of the eCall rollout as incident durations and severity reduce, resulting in lower impacts for road network users including freight. However, eCall has more benefits in terms of safety than congestion as the busier interurban and urban routes used by freight are likely to have quick detection times already.
Evidence of effectiveness	eCall rollout has only just started hence evidence is limited. However, some analysis has been made of the expected benefits with the following report from the association of advancement of automobile medicine indicating an 5 minute average reduction in time from discovery to verification over existing methods. However, it also says these benefits tend to be for rural locations where congestion will be reduced compared to urban and interurban routes (NCBI, 2008).
Opportunity to develop further	eCall is likely to be superseded by connected vehicle technology

<table>
<tr><td>Intervention Title</td><td>LORRY PARKING</td><td>Intervention Number</td><td>E17</td></tr>
<tr><td>Intervention Description</td><td colspan="3">The lack of lorry parking is one of the challenges facing the freight industry: the impact on congestion is the resultant inappropriate parking on roads which in turn causes access issues. The DfT identified “an immediate need” for more than 1,400 new parking spaces in critical areas of the country (DfT, 2018) . In addition, having adequate provision at distribution parks, ports and urban centres can contribute to the congestion on the adjacent roads (SRN or local).</td></tr>
<tr><td>Depth of evidence</td><td>0</td><td colspan="2">There is much evidence of the lack of lorry parking, however, its contribution to congestion is a logistical leap rather than evidenced.</td></tr>
<tr><td>Potential impact on freight congestion</td><td>1</td><td colspan="2">Evidence suggests that this could have an impact at key pinch points e.g. ports and major freight routes. The impact is of lorry parking on congestion is significant but only in the areas where there is a parking issue.</td></tr>
<tr><td>TRL</td><td colspan="3">N/A</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="3">Searching for suitable parking creates unnecessary HGV mileage, as does driving to parking which is not on the most efficient or direct route and can cause delays and cost.

M20 example, highlights the extreme position where parking is insufficient and result in major congestion issues. Other examples are less extreme, but none the less important to maintain free flow of traffic especially at access points at logistics parks, ports and so on.

In key hotspots in the lack of lorry parking impacts congestion through the resulting inappropriate parking which can obstruct the highway, or in extreme cases completely prevent the free flow of all traffic. This is limited to specific locations, in particular access to logistics sites or ports.</td></tr>
<tr><td>Evidence of effectiveness</td><td colspan="3">18,670 vehicles were found to be parked overnight across England. The total capacity of on-site spaces was found to be 15,012, hence leaving a theoretical excess of 3,658 vehicles that could not park in an on-site space. The following regions have parking that exceeds or is close to exceeding capacity: East Midlands, East of England, North East, South East, West Midlands and South West. The number of HGVs counted making overnight stops on a typical mid-week night has risen from 13,708 (2010) to 18,670 (2017). This represents a 36% increase (4,962 vehicles). In comparison, the total capacity of on-site spaces available in lorry parks or motorway service areas (MSAs) has increased by just 14% to 15,012 (AECOM, 2017).

An extreme example of the impact of inadequate lorry parting is the consequences of disruption at the Port of Dover and Eurotunnel in Kent can lead to significant congestion in that county and further afield. In the event of such disruption, Operation Stack is deployed which queues lorries on the M20 until they can access their ferry or train, closing parts of the motorway to other traffic. However, it has been accepted that this is not an ideal contingency solution particularly given the impact it has on the M20, the surrounding roads, and in particular on people and businesses in Kent (Grayling, 2017).

There is little evidence of the impact of the lack of lorry parking as it relates to its impact to congestion, with the exception of M20. There is a logical argument however, of increased mileage as drivers are seeking appropriate parking and therefore contributing to congestion, especially in urban areas. There is anecdotal evidence through industry discussion that lorry parking remains one of the key issues for the industry, effecting congesting (additional miles, obstruction), attractiveness of the industry to work in, compliance to regulation (driver hours). There is evidence on the impact on local residents and nuisance, however this doesn’t extend to published congestion impact caused by inappropriate parking.</td></tr>
<tr><td>Opportunity to develop further</td><td colspan="3">• Development of appropriate guidance for developers and planners on the assessment on the need for lorry parking on both the SRN and local networks.
• Local solutions need to be created and included in local freight plans.</td></tr>
</table>

Intervention Title	**MODAL SHIFT TO INLAND WATERWAYS**	**Intervention Number**	**E18**
Intervention Description	Transport of goods on rivers or canals. This includes inland movement of goods from ports, and movements between wharves on the inland waterway network.		
Quality of Evidence	1	There have been numerous reports and studies into the potential for more use to be made of canals, the Thames, Trent, Scottish inland waterways, and the Manchester Ship Canal,	
Potential impact on freight congestion	0	There does not seem to be potential to transfer significant volumes of goods onto any of the inland waterways at a national scale. Locally, use of inland waterways can have a significant impact on some routes, for example in London.	
TRL	N/A	**Stakeholder Acceptability**	2
Freight Congestion Impacts	Both categories of inland waterway movement are typically for short distances (with movements between the Trent and Aire and Calder being a rare, longer distance, exception. Movement inland from ports is a strong market for water freight, as the port origin is, obviously, accessible for water freight vessels. The limiting factor is likely to be availability of inland wharves / transfer points. Movement of aggregates inland from London ports provides an important alternative to road transport. More recently, the development of Port Salford will provide an inland destination reachable by water from the Port of Liverpool. Pure inland waterways freight suffers from a number of obstacles including lack of waterside origins and destinations for goods, capacity limitations due to draught and air draught (clearance through bridges and tunnels), slow speed, and the impact of locks on speed and vessel dimensions.		
Evidence of Effectiveness	The opportunity to increase the use of wharves on the Thames has been extensively researched (Mayor of London, May 2018). There are significant opportunities to move materials to and from construction sites, notably major infrastructure schemes such as Tideway. However, organic growth of the movement of aggregates and waste is forecast to be more limited. Extensive research has been undertaken on many of the other waterways, including the Trent, Manchester Ship Canal, and London Canal Network. These show only niche opportunities, which may be worth pursuing individually, but in total would not have a significant impact on congestion.		
Opportunity to Develop Further	Developers of waterside locations and infrastructure projects should make full use of inland waterways where feasible.		

<table>
<tr><td>Intervention Title</td><td colspan="2">NIGHT TIME FREIGHT TRAINS</td><td>Intervention Number</td><td colspan="2">E19</td></tr>
<tr><td>Intervention Description</td><td colspan="5">Movement of more rail freight at night. Most rail freight trains already operate at night for some part of their journey.</td></tr>
<tr><td>Quality of Evidence</td><td>1</td><td colspan="4"></td></tr>
<tr><td>Potential Impact on Rail Freight Capacity</td><td>1</td><td colspan="4">Limited – and night time capacity is under threat</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td colspan="2">Stakeholder Acceptability</td><td>2</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="5">Currently 65% (Network Rail, 2017) of freight trains operate at night for part or all of their journey. However, opportunities to path trains at night are becoming constrained by the need to block routes for engineering access, and a trend towards late night or 24 hour operation of some passenger services.

Night time freight can be encouraged by providing high quality diversionary routes to all of the main rail freight corridors that can be used when the main route is blocked.

Not all freight trains can operate at night, not least due to customer requirements and the need to spread terminal operations across the day and night. However, there may be some opportunities to operate new freight services at night, including using passenger stations at night to unload goods for city centre deliveries, and making use of night time capacity on HS1 to and from continental Europe.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="5"></td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="5">Network Rail is addressing some night time restrictions. The Network Study (Network Rail, 2017) identifies several opportunities for more night time operations including rearranging maintenance schedules to allow night-time access to the Chat Moss corridor.

In addition, Network Rail could:

• Continue to develop diversionary routes
• Encourage innovative night time use of passenger routes and stations for express freight.</td></tr>
</table>

Intervention Title	**NIGHT TIME ROAD TRUNKING**		**Intervention Number**	**E20**	
Intervention Description	Where movements are not restricted by time, moving at night on the SRN allows for the movement of goods when the network is less congested.				
Quality of Evidence	0	Night time trunking is custom and practice where possible, and whilst there is little published data about how night time trunking reduces congestion, the advantages are well known.			
Potential Impact on Freight Congestion	1				
TRL	N/A		**Stakeholder Acceptability**		2
Freight Congestion Impacts	Trunking at night allows operators to take advantage of a less congested network providing that receiving depots can accept deliveries 24/7. That said, roadworks are often undertaken at night and can impact the reliability of freight movements at night.				
Evidence of Effectiveness	Night time operations in urban areas are more difficult (albeit can be managed) as discussed in the Removal of HGV Restrictions dashboard, however, it is possible to take advantage of less congested times when using the SRN. This both improves journey times for the operator but also removes a vehicle movement at more congested times. Analysis on the M6 suggests that 42% of HGV traffic travels between 1900 and 0630. Widening the analysis to include more locations on the SRN, including the A34 and the A14, still shows 36% of HGV traffic travelling at night.				
Opportunity to Develop Further	Promotion of this as an intervention via Freight Quality Partnerships				

Intervention Title	**RAIL FREIGHT NODES**		**Intervention Number**	**E21**
Intervention Description	Developed at strategic geographic locations, nodal yards act as freight traffic staging and regulation points at the confluence of adjacent route sections, enabling effective management of freight traffic flows and better exploitation of end-to-end freight path components.			
Quality of Evidence	-1	Theoretically this should provide additional capacity and flexibility. NR is proposing a trial operation to provide evidence of the impact in practice.		
Potential Impact on Rail Freight Capacity	2	This intervention could provide more capacity by allowing freight trains to pause between sections of the network, creating better opportunities for longer distance freight paths.		
TRL	N/A		**Stakeholder Acceptability**	0
Freight Congestion Impacts	High quality freight train paths are required to support the development of freight growth. Historically, freight services have often suffered from paths which required them to wait in loops whilst faster trains passed them, increasing the overall journey time, impairing the operational efficiency for operators and delaying end customers. The creation of nodal yards can create the capability for freight to operate in paths that are more appropriate and deliver benefits such as improved timetable capacity and network performance (Network Rail, 2017). In addition to timetabling benefits, the Nodes could be used to join and split trains into very long trains along selected corridors, providing further capacity benefits.			
Evidence of Effectiveness	This would be a new concept for the UK, and should not be confused with earlier generations of marshalling yards which added time and cost to rail freight. Monitoring trial implementations needs to ensure that capacity benefits are not outweighed by journey time and cost disbenefits.			
Opportunity to Develop Further	Trial operation should be supported and closely monitored.			

<table>
<tr><td>Intervention Title</td><td colspan="2">REDUCTION OF HGV RESTRICTIONS</td><td>Intervention Number</td><td>E22</td></tr>
<tr><td>Intervention Description</td><td colspan="4">The reduction of HGV restrictions to encourage night time road use (dealt with separately), incentivise full vehicles, and help operators improve efficiency (reduced wasted mileage). Opportunities also exist to encourage better road utilisation e.g. use of bus lanes. HGV restrictions exist for several reasons:
Time/noise restrictions due to residential areas – these can be planning restrictions, voluntary restrictions, planning or noise abatement notices.
Weight and width restrictions – sometimes to protect infrastructure, sometimes to deter larger vehicles from residential or other unsuitable streets eg Lorry Control Schemes
Air quality issues – low emission zones
Customer restrictions – caused by operating times, stock requirements, labour restrictions
Road space restrictions eg bus lanes, kerb space
Speed restrictions
Removing these restrictions could provide incentives to encourage a reduction in empty running and could be used to encourage companies to collaborate. This could include priority access given to high utilisation vehicles or vehicles delivering to or from consolidation centres or rail terminals.</td></tr>
<tr><td>Quality of Evidence</td><td>Developing</td><td colspan="3">Evidence on the impact on congestion is patchy: there are key studies which have effectively demonstrated the impact of the reduction of some restrictions (e.g. delivery times) but less so for the removal of other restrictions e.g. lorry bans. The impact of restrictions on van usage is also implied rather than evidenced.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>2</td><td colspan="3">Evidence suggests that this could have a major impact on the number of vehicles in peak hours in the specific urban area in which it is implemented. The removal of restrictions may have an impact on reducing van usage. Vans may well be used as an alternative where HGVs can’t be used either because of noise, air quality or physical size/weight constraints.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">In specific areas where restrictions are implemented could have a general positive improvement on congestion, which in turn will help freight congestion. This is particularly the case where deliveries are taken out of peak times thereby reducing congestion for time critical deliveries and vehicle movements. More than 90% of London's freight is transported by road. In the morning peak (07:00-10:00) deliveries and servicing vehicles account for about one-third of all traffic. Avoiding these times can benefit businesses and the local area. This position is reflected in other urban centres as well as logistics centres such as ports or concentrations of distribution centres, rail freight interchanges – anywhere where time restrictions are imposed. Accelerating delivery reception processes at factories, warehouses and shops can reduce these times, increasing the number of drops or collections per delivery and thereby cutting the number of trips. It has been noted that removing access restrictions on permissible delivery times would make it possible to reduce GHG emissions by up to 7% (P Greening, 2015). Fewer restrictions would make delivering easier to plan. Vehicles would have more flexibility on time of day and could plan more direct routes. A particular issue is differing restrictions in neighbouring areas, making efficient planning very difficult (TRL, 2017).</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">Time/noise restrictions: TfL has had a policy of working with business and local authorities to review the opportunity to retime deliveries –TfL’s retiming deliveries programme has helped more than 500 London businesses retime their deliveries outside peak hours.

Legal limits on driving time determine the maximum number of destinations that can be visited on a single delivery trip. Distances and congestion also play a significant role in limiting the number of deliveries and collections than can be made on a trip, and hence the vehicle loading. The centre for Sustainable Road Freight notes that there is limited available literature in this field.</td></tr>
</table>

	Some reports highlight that making deliveries outside peak periods avoids congestion, thereby reducing travel time by up to 16% (Greening, 2015). This infers that fewer load plans will be time constrained, resulting in higher load factors and fewer journeys, in turn resulting in a 3% reduction in km travelled. Further reductions in km travelled are possible if relaxed time constraints permit the extension of a journey plan to incorporate more destinations. This is supported by TfLs Out of Hours trials which showed that a 3.2% saving (TRL, 2017) in fuel can be made because of moving just one delivery from daytime to out of hours and the DfT/FTA Quiet Deliveries Demonstration Scheme showed one retailer experienced a 5.7% saving in fuel as a result of night-time deliveries vs daytime. The extent to which out of hours deliveries could be utilised is unknown, however, as a hypothetical example a large retailer who delivers 90% of deliveries to its 1200 stores during the day and achieves a 4.5% improvement by replacing one of these deliveries into an out of hours timeslot could result in a reduction of 25 million (25,155,749) litres of fuel and 647 tonnes (647,174kg) CO2 in a year (TRL, 2017). More recently TfL's Area Wide Retiming Study demonstrated that moving deliveries to outside of peak times, in this example, allowed 14 HGVs to be taken off the road, together with 25 retimed outside of peak times each week. This implies that the vehicles are now fuller and able to operate as part of a milk run rather than dedicated half full vehicles (WSP, 2017). Air quality impacts may have a growing impact on freight deliveries because if the impact. Some cities such as Lincoln have imposed blanket restrictions where deliveries can be made between 10pm and 4am can have deliveries but not outside of that (Challenge Panel Feedback, 2018). **Customer restrictions:** opportunities for rescheduling freight journeys may prove more limited than expected. There has already been a two-and-a-half-fold increase over the last 20 years in the proportion of HGV kms run between 8pm and 6am. However, still more opportunity (Black et al, 2003). There is a view that where the whole supply chain benefits from the removal of time restrictions, changes will already have been undertaken. That said, anecdotal evidence suggests this may be the case for larger integrated supply chains, but less so where transport costs are not truly reflected within the supply chain cost, and therefore customers may demand restricted delivers to suit them rather than the transport operation. **Weight and width restrictions:** the removal of lorry bans has an implied benefit. Anecdotal evidence suggests that lorry bans add mileage to deliveries into the affected areas and as such contributes to the wider HGV mileage issues but less so congestion as the bans usually impact out of hours when congestion is less. Lorry bans have the potential impact of encouraging vans to be used instead of HGVs in controlled periods. Evidence for this was anecdotal – although there has been an increase in van use, it is unclear if this is specifically for use of freight or at night time. The London Lorry Control Scheme Review highlighted that feedback suggested that that a small majority of vehicle operators had not been discouraged from delivering during the hours of the scheme. However, a significant minority of 49% indicated that they were discouraged (London Councils, 2017) – this suggests that the London Lorry Control Scheme has potentially pushed more vehicles in peak congested times. A further concern was raised in the review was that the scheme creates 'bottlenecks' on excluded road network (ERN) (London Councils, 2017), and therefore simply moves congestion to a different area. Together, extending delivery times/relaxation of JIT pressures and rescheduling deliveries to inter-peak periods and evening / night, represent the greatest potential for reducing CO_2 savings according to Greening's modelling (P Greening, 2015). The impact of relaxing time constraints is difficult to predict as the benefit amplifies the effect of other logistics improvement measures which have already been implemented. However, it was assumed that relaxing time constraints would reduce the kms driven by 3% (P Greening, 2015).

	Road space restrictions: currently UK urban infrastructure generally only prioritises the buses, cyclist and taxis and in some cases motorcycles or multiple occurancy. through bus lanes. The FTA believes these should be adjusted to take a more nuanced view of what an efficient use of road space is. For example, it could become a promoted policy to have lanes that are 'bus only' at rush hour but also open in addition to commercial traffic outside those hours (TRL, 2018) (TRL, 2017). Some believe that this would affect the reliability of bus travel in urban areas encouraging people to adopt other methods of transport and increasing congestion (Challenge Panel Feedback, 2018). Competition for kerb space is increasing in many cities, competing with bus lanes, cycle lanes and parking. The impact of this on congestion is evidenced through the growth of alternative, dynamic solutions to kerb space management. *"Kerb space is a massive but finite piece of real estate that is badly managed – if it is managed at all. The chaos creates congestion, leading to pollution and air-quality issues, reduced traffic speeds and frustration"*. (Telegraph, 2017) Barcelona undertook a trial that allowed for multiple use of lanes. depending on the time of day these lanes served as public parking spaces, load zones or priority bus lanes and this was displayed on a screen. The trial suggested that improvements were made to vehicle flow, however it did suffer from enforcement problems (SINTEF, 2012). A report for TfL in 2017 recommended: explore potential for freight-only lanes or prioritisation of freight through advance vehicle detection to reduce journey times on key freight corridors, aligned with distribution hub/consolidation centre locations which may allow for better use of limited road space. (TfL, 2017) **Speed restrictions:** the changing of the national speed limit on single carriageway road for HGVs was proposed to allow the UK's roads to be used better and more effectively, reducing the speed difference between different types of traffic (despite nearly 75% of HGV drivers breaking it already). It was claimed that the changes would 'reduce delays and congestions, particularly on busy single carriageway A roads' (DfT, 2014).The final report is expected in 2020 but in 2016 it was reported that speeds for HGVs (over 7.5 tonnes) on single carriageways roads and dual carriageways had increased by more than 1mph and less than 0.5mph respectively (DfT, 2016)
Opportunity to Develop Further	• Better guidance for Local Authorities • Better design for freight/deliveries • Re-instigation of Freight Quality Partnerships (FQPs) to get businesses, manufactures and Local Authorities working together • Work needs to be developed in specific incentives that would a) encourage operators and b) instil the right behaviours (ie take vehicles off the road). • Review of road space management and potential solutions (such as dynamic loading bays)

INCREASE NETWORK CAPACITY

After optimisation of the first four steps, increased capacity can be achieved in a variety of ways which, ultimately, could require new roads or railways.

Intervention Title	BALANCE BETWEEN PASSENGER AND FREIGHT RAIL	Intervention Number	C1
Intervention Description	Currently the rail passenger franchising process takes little or no account of future freight needs when planning timetable changes. On non-core passenger routes there is a case that the value of potential freight demand should be balanced against the value of additional passenger paths.		
Quality of evidence	0	There is only one high quality report that has considered this issue.	
Potential Impact on Rail Freight Capacity	1	Some benefit on cross country routes and branch lines.	
TRL	N/A	**Stakeholder Acceptability**	-1
Rail Freight Capacity	An often-cited example is the Felixstowe Branch, where 775m long container trains compete for limited capacity with two car passenger trains. Removing selected, low demand passenger services could provide more freight capacity or remove the need for expensive infrastructure enhancements. A key role for the Department for Transport is to manage the passenger rail business and let franchises. Recent changes to the franchising process require passenger franchise bidders to take into account freight impacts when planning new passenger services.		
Evidence of Effectiveness	This issue was considered in a report for the ORR (SKM Colin Buchanan, 2012) which concluded: *"The other change we tested was reallocating paths from passenger to freight in the off-peak. In the examples we tested there was a clear economic benefit from this re-allocation of capacity although we did not test whether other passenger services would be impacted by the additional freight paths outside the corridor we studied."* One example considered by this study was to remove one passenger service between Felixstowe and Ipswich at about mid-day. The Felixstowe line offers a broadly hourly off-peak passenger service but is also in high demand for container train services. *"Using MOIRA, we estimate that the revenue impact of removing this one service would be a loss of £54k per year. The economic disbenefits associated with increasing passenger journey times (forcing some passengers to wait longer for a train) would be -£130k per year. As off-peak services are provided using spare rolling stock and train crew, we have not assumed there would be a cost saving from withdrawing this service".* As shown above, a container freight path on this route could deliver economic benefits of £1.5m per year if it can operate at 90% utilisation. Even if the path was 50% utilised, the economic benefits would be worth around £0.8m per year. This is significantly more than the revenue and GJT disbenefits associated with the removal of the off-peak passenger service, although we have not assessed any disbenefits associated with passenger services outside of our case study area. This suggests that, for this case study, it is more efficient for society to operate freight services than off-peak passenger services if demand for freight reached a level where there were no more freight paths available. However, the value of a passenger train path is not only the number of passengers carried on that train, but the perception that there is a regular timetable which encourages more passengers onto the route as a whole, generally at minimal cost to the passenger operator.		
Opportunity to Develop Further	A first step could be to increase protection of selected strategic freight paths from enhanced passenger services.		

Intervention Title	**DIGITAL RAILWAY**	**Intervention Number**	**C2**
Intervention Description	Digital Railway is the proposal for the UK to adopt modern digital signalling and train control within the next 25 years and create credible options to upgrade the railway to next generation technology as it becomes available. Examples of these technologies include (Network Rail, April 2018): • European Train Control System (ETCS), which allows trains to run closer together and travel at their optimal speeds and provides enhanced train protection • Traffic Management (TM) (linking with other systems such as DARWIN and Crew & Stock), which maximises the throughput that infrastructure can support, improves service recovery and enhances performance • Connected Driver Advisory System (C-DAS), which provides decision support to drivers in the cab to improve timetable adherence and therefore overall performance • Supervised Automatic Train Operation (ATO), which provides the ability to control trains to a finer resolution in order to run to the maximum capability of the infrastructure in a more consistent way • Smart infrastructure, with remote condition monitoring technologies, which will improve performance, reduce disruption and improve safety • Rolling stock system performance, together with decision support tools, providing predictive faulting, performance and reliability improvements and smarter recovery from perturbations • Telecommunications, providing the backbone to transfer data and information between systems, to operational staff and customers Data, Digital Railway is a data-configurable railway, and therefore a high level of data confidence and integrity is essential, supported with the appropriate cyber security and business continuity processes.		
Quality of evidence	0	There is little evidence internationally of the capacity benefits of digital railway signalling and operations techniques on a mixed traffic railway.	
Potential Impact on Rail Freight Capacity	1	While the intervention may reduce headways on busy sections of track, this is not the main constraint to rail freight capacity.	
TRL	TRL9	**Stakeholder Acceptability**	2
Rail Freight Capacity	Digital Railway will provide a number of benefits for rail freight such as greater operational flexibility. Digital signalling and operations control is proven to provide more capacity on lines where trains need to be operated with shorter headways (closer together). DR is regarded as essential for very high capacity passenger metro systems. For freight it DR could provide more capacity on sections where conventional signalling cannot provide enough paths, but most freight constraints are actually at junctions or other pinch points.		
Evidence of Effectiveness	Use of new technology is expected to enable shorter freight journey times, greater capacity for freight operations, more flexibility to respond to short-term needs, and higher speeds thus reducing delivery times. The access requirements of FOC fluctuate, necessitating short term planning and re- planning. This can be difficult to arrange alongside passenger services, but it is the sort of challenge that digital technology could help to overcome. The single greatest obstacle to these goals is the *"go anywhere"* nature of freight operations and the consequential need to fit the majority of freight locomotives as soon as ETCS roll out on the infrastructure commences. The concept of *"targeted implementation"* of ETCS, could prove particularly problematical for freight operators except where clear freight corridors or captured fleets can be managed. There are a number of very successful applications of Digital Technology which are expanding the use of rail freight. A very successful international example of new technology (specifically the European Train Control System (ETCS) Level 2), serving freight opportunities is the Etihad Rail 264km stage 1 connecting gas fields in southern Abu Dhabi with the port of Ruwais as part of the Gulf Cooperation Council GCC railway programme covering the 7 gulf states. Further extensions which will bring the overall length to over 1000km are already planned or in the pipeline.		

	European initiatives and a drive to increase rail freight across Europe is an important factor. The European Rail Freight Corridor regulation 913/2010 is committed to the alignment of rail freight corridors with ERTMS corridors. Examples of European Rail Freight developments are: • Infrabel the Belgian Train Operator is implementing Digital Technology on the so called European Corridor C connecting port of Antwerp to the European mainland. • DB Cargo has launched an international project to equip 1200 of its locomotives with ETCS by 2026 with aid grants from the European Union. The vehicles to be fitted will operate on the core network corridors across Germany Belgium and France and in the Netherlands. Further grants from the EU will support fitment of ETCS to freight locomotives in Sweden and Italy from 2018 to 2023. • Similar alignment plans in the UK to ensure that freight corridors are aligned optimally with the deployment of ETCS and other digital technology would enhance the implementation if rail freight and be a platform to deliver reduced congestion and the subsequent negative environmental impact of road freight transportation. DR has been proven to be effective on metro systems and is working well on Thameslink. There is no published evidence of capacity benefits for freight on mixed traffic railways. Despite all the promise of a wide range of capacity benefits to be delivered by the Digital Railway, there is currently no evidence available to demonstrate the scale of freight capacity improvement, if any. There is strong evidence that digital signalling can allow passenger services to operate closer together, particularly where the trains concerned all have the same operating characteristics. Modern metro systems could not offer the high frequencies that they do with digital signalling and automatic train control. However, on mixed traffic railways with numerous junctions and conflicts, there is currently no evidence of the extent of capacity benefits, particularly for freight. Running trains more closely together may deliver additional paths on busy sections of line, or longer gaps between trains on other lines, but the ability of freight services to utilise the additional capacity needs to be tested.
Opportunity to Develop Further	More evidence is required on routes where track path capacity is the major freight constraint, notably the West Coast Mainline.

<table>
<tr><td>Intervention Title</td><td colspan="2">EXPRESSWAYS</td><td>Intervention Number</td><td colspan="2">C3</td></tr>
<tr><td>Intervention Description</td><td colspan="5">All-Purpose Trunk Roads (APTR) upgraded to the Expressways standard consist of many common characteristics including: dual carriageway; grade separated junctions; a minimum spacing of junctions; restrictions on slow moving vehicles; rigid central barriers; incident detection and queue protection through variable mandatory speed limits; emergency areas; formal rest areas (not laybys) and Traffic Officer Service patrols.

The intent is to bring a large number of Major A-roads up to standards similar to Motorways through the provision of grade separation, improved safety barrier and Smart Motorway technologies for traffic monitoring, enforcement and incident management etc. The intent is to make these routes more favourable (particularly to freight) and spread the demand across the network reducing the dependency on the Motorways network.

The Expressways standard is currently in development and whilst some UK roads most notably the A14 have been upgraded with the Expressways standard in mind, there is no current evidence base for the reduction in congestion.</td></tr>
<tr><td>Quality of Evidence</td><td>-1</td><td colspan="4">This proposed intervention to manage congestion and has been implemented extensively across the UK through Smart Motorways. It is expected that Expressways benefits will be at most similar to Smart Motorways, however with less capacity improvement there is some debate as to the overall benefits likely to be achieved post scheme implementation.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="4">The impact on congestion is minor (unless additional capacity is provided via hard shoulder use) and although this is not specific to freight it does benefit freight road users. Further beneficial impacts on freight could be realised if more focus was given to freight users in terms of dedicated use of capacity at certain times and locations.</td></tr>
<tr><td>TRL</td><td colspan="2">9</td><td colspan="2">Stakeholder Acceptability</td><td>0</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="5">The impact on congestion is significant where implemented by increasing capacity and ensure the free movement of vehicles. This impacts freight in the same way as all traffic but could have a great impact if there were freight dedicated lanes for example. Typically, where smart motorways have been rolled out there has been increased use of freight, however it is not clear whether this is because of freight user choice as a result of perceived and real reductions in congestion and improvements in journey time reliability or whether additional local and national freight demand is driving the increase.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="5">Limited evidence as no implementations have been analysed to date, however it is expected to be similar or less than the benefits of Smart Motorways.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="5">Provision of freight specific capacity.</td></tr>
</table>

Intervention Title	**FUTURE FREIGHT TRAIN**		**Intervention Number**	**C4**	
Intervention Description	The intervention is heavily based on the Spectrum proposal for a future freight train. It is provided as an example of future technological and operational changes to wagons and trains that could result in freight making better use of rail capacity.				
Quality of Evidence	0				
Potential Impact on Rail Freight Capacity	1	Potential beneficial impact			
TRL	3			**Stakeholder Acceptability**	2
Rail Freight Capacity Impacts	A detailed design concept for a high-performance freight train to transport low density high value goods by rail freight has been developed. The design concept is lightweight, has performance characteristics to facilitate mixed running with passenger services, accommodates a number of loading units (ISO containers, swap bodies, Reefers and Micro swap bodies but no semi-trailers) and has an electrical power convertor to accommodate reefers. Is compatible with InnovaTrain horizontal Transhipment System- no need for a dedicated terminal (only a road siding). Design also compatible for application with other transhipment techniques such as MetroCargo, reach stackers and portal cranes. • A service which could achieve up to 160km/h could provide additional capacity as it would facilitate mixed running between passenger and freight services. • High speed freight service (>160km/h) has the potential to allow freight operation on high speed routes leading to more efficient use of capacity. • A shorter train set of less than 300m with running gear and suspension optimised for high speed (160km/h) and calliper disc braking- has the potential to offer additional capacity through improved acceleration and deceleration patterns. • Lightweight wagon design with lightweight materials (Novel High Strength Steels) and geometrical optimisation (pre-fabricated Z section for the main load carrying beams). The reduction in overall weight helps in increasing (and achieving) the target maximum speed to 160km/h for the same traction power.				
Evidence of Effectiveness	Evidence of high speed rail freight services exists (high speed is considered 160km/h for freight): As noted in the intervention 'faster freight trains', examples of high speed freight services in France have ceased operations. However high-speed freight services have been operated by DB AG and Deutsche Post since 2000, operating at 160km/h transporting express parcels. Outside of Europe, China began transportation of express parcels by high speed freight in 2012. Two approaches were employed, freight transport via the inspection train (in advance of the first service of the day) and by passenger EMU transporting parcels in the luggage storage. In 2016 less than 5% of express parcels were transported by rail indicating the large market potential (Gausemeier, etc., 2001; Gong, 2011; Lin and Yu, 2012). Innovatrain Container Mover is operational and has been employed by customers including Swiss COOP and Volkswagen.				
Opportunity to Develop Further	This project is continuing, with the support of the EU. While technical acceptance is clearly important, future studies should identify potential users and the scale of possible future use.				

<table>
<tr><td>Intervention Title</td><td>HIGH CAPACITY NATIONAL FREIGHT CORRIDOR</td><td>Intervention Number</td><td>C5</td></tr>
<tr><td>Intervention Description</td><td colspan="3">Development of a new rail freight route, potentially linking Kent to Scotland. The route would be built to the “European” GB+ gauge, and trains could carry road trailers on standard type wagons.</td></tr>
<tr><td>Quality of Evidence</td><td>-1</td><td colspan="2">Despite several feasibility studies in the past, detailed demand data has not been published.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>2</td><td colspan="2"></td></tr>
<tr><td>TRL</td><td>N/A</td><td>Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="3">A new freight route could provide a “motorway bypass” for international goods traffic from Dover / Folkestone around the M20/M25/M1, for London to the Midlands / NW / Scotland around the M1/M6, and for the Midlands and NW to Scotland.

A very high level assessment for this report estimated that such a system could remove 720 lorries per hour in each direction from congested sections of motorway.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="3">Several proposals have been made for such a corridor. The Great Central Railway scheme provided some evidence of potential demand, but this was very high level and subject to key assumptions.

To be successful, a “motorway bypass” operation would almost certainly require either a positive or negative incentive, such as lorry road user charging.

However, the huge capital cost and significant environmental concerns would make the development of such a corridor a long term and expensive prospect.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="3">Potential demand and costs should be reviewed to establish whether there is any prospect of developing such a scheme.</td></tr>
</table>

<table>
<tr><td>Intervention Title</td><td colspan="2">INFRASTRUCTURE INVESTMENT - ROAD WIDENING IMPROVEMENTS</td><td>Intervention Number</td><td>C6</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Widening of roads is typically used to increase additional lane capacity but can also provide safety benefits. Historically it was a common intervention that was one of the mainstays of government policy for many decades, following a ‘predict and provide’ approach. Since the 1990s widescale use of this approach has been discredited, as the provision of additional capacity typically makes those routes more favourable and hence very quickly results in the additional capacity being filled up. However targeted widening interventions are still undertaken although they are typically used in combination with other measures to control the access to the additional capacity. For example, improving road topology or widening of ring roads from one to two lanes at junctions through provision of filter lanes or the early implementation of Smart Motorways hard shoulder running which only opened the hard shoulder when capacity was required.</td></tr>
<tr><td>Quality of Evidence</td><td>2</td><td colspan="3">There is significant evidence of road widening journey time benefits in terms of congestion management and this is reflected in the DfT webTAG guidance targeting journey time reliability benefits from additional flow provided by capacity enhancing schemes.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>0</td><td colspan="3">In the short term the benefit for freight congestion can be significant, however very quickly the benefits can be eroded as the route becomes more favourable, hence implementation in isolation without considering other interventions across all modes is likely to lead to an increase in congestion in the long term. Furthermore, increasing capacity in one location can result in significant bottlenecks downstream.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>-2</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">Widening of roads can make them favourable to freight users and hence can result in the change of freight routes.

Typically widening tends to be specific to a location or a few junctions on a road and not wide ranging over the full length of a road.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">In the short-term widening can be effective at improving journey time reliability, however it can very quickly result in a more congested network through induced demand i.e. making a route or mode more favourable and hence returning the route to congested state which is at a similar or worse level to that which it was prior to the intervention. An assessment of nine road schemes implemented between 2002 and 2010 indicated that growth was typically in excess of background growth rates by about 5-10%-points over time periods of 3 – 8 years. (Slowman, Hopkinson, Taylor, 2017)</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="4">It is unlikely that there are significant opportunities to develop road widening. However, in the small number of cases where widening is the appropriate solution consideration could be given to restricting use of the additional capacity to freight users due to the significant costs, environmental and social impacts associated with this intervention.</td></tr>
</table>

<table>
<tr><td>Intervention Title</td><td colspan="2">NEW STRATEGIC HIGHWAYS AND LINK ROADS</td><td>Intervention Number</td><td>C7</td></tr>
<tr><td>Intervention Description</td><td colspan="4">The traditional method of dealing with increasing demand and promoting economic growth involves the construction of roads that:
- link the existing and emerging centres of population;
- facilitate access to major ports, airports and rail terminals;
- enable access to peripheral regions; and
- provide key cross-border routes to Scotland and Wales

A current example of a new strategic highway which is under development is the Oxford-Cambridge Expressway. This is part of a broader programme to improve connectivity and travel times between the economic centres in the Oxford-Milton Keynes-Cambridge arc and to open up additional land for growth.</td></tr>
<tr><td>Quality of evidence</td><td>1</td><td colspan="3">Evidence of general economic benefits of improved journey time is available – not specific to the freight sector.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">Provides new direct routes for freight traffic, reducing risk of time spent in congestion.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>-2</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">New strategic highways would improve journey times between the key freight centres and would likely reduce congestion on the existing routes which traffic is using. The deployment of new highways can also result in opportunities for logistics and distribution organisations to relocate to a location which better fits their requirements, optimising their networks</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">LSE’s Spatial Economics Research Centre’s (SERC) research (R. Sanchis-Guarner et al 2010, 2012) reviewed 31 major new road construction schemes built between 1998 and 2007. The research suggests that looking at a range of impacts, including congestion relief, new roads can produce economic benefits – at least locally.

The What Works Centre for Local Economic Growth (Centre for Cities, Unknown) reviewed 2,300 transport projects to understand economic impacts and found that of these only 17 had sufficiently robust methods (noting that these schemes will have included more than just new strategic highways). For those schemes they found that “Congestion did not always decrease as a result of new roads, and traffic growth on new roads was sometimes higher than forecast. This is because of induced traffic on minor roads, which sometimes increased demand for newer roads.” The report further concludes that the data available on assessing the outcomes for many schemes is poor and schemes should develop more adequate evaluations for post-implementation assessment.

The English road network is at a relatively mature state with limited opportunities for further development unless driven by a need to support new transport terminals (ports, airports, rail) or emerging economic areas.</td></tr>
<tr><td>Opportunity to Develop Further</td><td colspan="4">Review of planned or potential new highway schemes which could benefit road freight specifically.</td></tr>
</table>

Intervention Title	**RAIL FREIGHT STRATEGIC CAPACITY PLANNING**			**Intervention Number**	**C8**
Intervention Description	This is a relatively new process by which Network Rail places paths in the timetable which are intended to be used to accommodate forecast freight growth.				
Quality of Evidence	0	Feedback from train operators and customers. No published formal review.			
Potential Impact on Rail Freight Capacity	2	If comprehensively implemented, and if paths could be protected, this would provide assurance to businesses investing in rail freight or considering new freight services that capacity would be available in the medium to long term.			
TRL	N/A		**Stakeholder Acceptability**	-1	
Rail Freight Capacity Impacts	Network Rail has established a process to identify Strategic Capacity and, in particular, to identify paths which are intended to be held as available for growth. Strategic Capacity is capacity for which there is no immediate requirement but is likely to be needed by train operators in order to meet short-term requirements or longer-term future aspirations. This capacity is identified in the form of Strategic Paths which are listed in the Strategic Capacity Statement. When compiling the Working Timetable, Network Rail aims to include the Strategic Paths alongside the train slots requested by all train operators. Those included in the timetable are referred to as Strategic Train Slots.				
Evidence of Effectiveness	Network Rail's April 2017 Strategic Capacity Statement identifies dozens of Strategic Capacity freight paths for the 2018 timetable (Network Rail, 2017). However, the regulated environment under which Network Rail operates means that protection for these paths is weak. If a passenger or freight operator bids for a path which blocks or uses a strategic freight path, the regulatory environment dictates that the bid cannot be refused. Network Rail is working with the rail freight industry and the DfT to seek better protection for strategic freight capacity, particularly where route upgrades have been provided specifically to provide more freight capacity.				
Opportunity to Develop Further	Nonetheless, in the medium term the strategic freight paths are very useful for freight operators looking for capacity for new services.				

<table>
<tr><td>Intervention Title</td><td colspan="2">RAIL FREIGHT TIMETABLE OPTIMISATION</td><td>Intervention Number</td><td>C9</td></tr>
<tr><td>Intervention Description</td><td colspan="4">This dashboard brings together a range of interventions that Network Rail can and does use to improve the efficiency of freight trains and provide additional capacity for freight and passenger services.</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">There is strong evidence that Network Rail has released capacity by deleting unused paths, and some evidence that timetabling of freight trains is inefficient, but little published evidence of the capacity benefits of addressing these issues.</td></tr>
<tr><td>Potential Impact on Rail Freight Capacity</td><td>2</td><td colspan="3">Ultimately, reducing unnecessary allowances in freight timetables could make it easier to find paths for freight trains.</td></tr>
<tr><td>TRL</td><td colspan="2">N/A</td><td>Stakeholder Acceptability</td><td>2</td></tr>
<tr><td>Rail Freight Capacity</td><td colspan="4">Interventions and their impact on capacity include:
Removing unused or underused freight paths from the timetable. This has already been extensively addressed by NR. May release “hidden” capacity for longer journeys.
Reviewing allowances made in timetabling systems for freight trains to accelerate or brake. There is anecdotal evidence that braking curves, in particular, are over pessimistic leading to unneeded additional minutes in timetables.</td></tr>
<tr><td>Evidence of effectiveness</td><td colspan="4">Network Rail has already cleared several thousand freight paths from the timetable. While many of these relate to coal services which have declined dramatically, and are frequently not on routes used by other services, other cleared paths have made it easier for train planners to identify good quality paths for new rail freight services.

There is less evidence about the scale of time efficiencies to be made by improving allowances for freight trains.</td></tr>
<tr><td>Opportunity to develop further</td><td colspan="4">The process of cleaning the timetable is continuing.
The Digital Railway may provide an opportunity to improve knowledge of and application of freight train performance data. High quality information will be needed for every type of locomotive and combination of wagons.</td></tr>
</table>

Intervention Title	RAIL INFRASTRUCTURE INVESTMENT TO INCREASE FREIGHT CAPACITY		Intervention Number	C10
Intervention Description	To continue and support the Network Rail activity of identifying freight capacity constraints and, where necessary, investing to provide additional capacity. Cost estimated at £2 billion by Network Rail over 10 to 15 years. In addition, a range of incremental investments, such as providing grade separation at key locations or removing speed constraints, would provide more capacity for both passenger and freight trains and reduce the timetable impact of freight trains			
Quality of Evidence	1	Network Rail has commissioned a high-level assessment of the impact of addressing key capacity constraints.		
Potential Impact on Rail Capacity	2	The extent of investment in pinch points will determine the future potential for modal shift to rail and any significant growth in rail freight.		
TRL	N/A		**Stakeholder Acceptability**	1
Rail Freight Capacity Benefits	Capacity constraints will constrain growth along some key corridors. Investing in capacity projects identified by Network Rail will eliminate most of these constraints and release rail to achieve its full non- constrained volume. Incremental investment in grade separation and eliminating pinch points would provide capacity for more freight and passenger services.			
Evidence of Effectiveness	Network Rail has commissioned a high-level assessment of the impact of addressing key capacity constraints. This analyses demand in 2023 with ongoing work to extend this to 2033 and 2043. The benefit of investment at selected locations such as grade separation is generally dealt with on a case by case basis, and the various Network Rail strategies and plans have identified many of the suitable locations and developed high level business cases to support investment which will be developed through the normal planning process.			
Opportunity to Develop Further	More analysis required. Investment needs to be managed with a focus on the core freight routes serving intermodal and aggregates markets as identified in the NR Freight Network Study and prioritised according to when the capacity will be needed.			

Intervention Title	ROAD FREIGHT PINCH POINTS		Intervention Number	C11
Intervention Description	There are various locations on the UK road network where obstacles exist that delay freight and other road users. The following are examples of types of 'pinch point' schemes that can improve capacity: • Lane gain for HGV where gradients exist • Grade separation of junctions to improve through flow • Junction improvements to provide additional capacity and smoother flow where vehicles joining and leaving of the network. • Ramp Metering (signal controlled on-slips) to smooth the flow of vehicles joining the network.			
Quality of Evidence	0	This is a well-used intervention to manage congestion and has been implemented extensively across the UK with some examples of specific post scheme improvements. *"Obstacles on the local transport network that restrict growth by limiting the movement of goods, employees and customers."* (Gov.uk/DfT Press release: Cash boost to tackle local pinch points, January 2013)		
Potential Impact on Freight Congestion	1	The impact on congestion is significant in the local area and can make some routes more favourable to freight users		
TRL	9		Stakeholder Acceptability	-1
Freight Congestion Impacts	The impact on congestion is significant but typically localised. However there have been schemes to remove pinch points across significant portions of routes, for example the A1 has a programme of grade separation and junction improvements (DfT, 2017).			
Evidence of Effectiveness	The A1 Peterborough to Blyth grade separation led to an increase in HGV usage to 22% an increase in flow of 18-26%, improvement in journey times and a 26% reduction in collision rate.			
Opportunity to Develop Further	Extend to other areas of the secondary network in the UK.			

<table>
<tr><td>Intervention Title</td><td colspan="2">SMART MOTORWAYS</td><td>Intervention Number</td><td>C12</td></tr>
<tr><td>Intervention Description</td><td colspan="4">Smart Motorways are located on junction to junction sections of Motorway and use Variable Message Signs and signals alongside enhanced traffic monitoring and enforcement technology to safely allow drivers to drive on the hard shoulder improving capacity, reducing severity and frequency of incidents whilst also improving the reliability of journey times. The rollout of Smart Motorways is focused on the busiest areas of the strategic road network. There are currently three different variants of smart motorway currently in the UK, these include: controlled motorways, dynamic hard shoulder running schemes (HSR), all lane running schemes (ALR) (RAC, 2018).</td></tr>
<tr><td>Quality of Evidence</td><td>0</td><td colspan="3">This is a well-used intervention to manage congestion and has been implemented extensively across the UK with some examples of specific post scheme improvements.</td></tr>
<tr><td>Potential Impact on Freight Congestion</td><td>1</td><td colspan="3">The impact on congestion is significant and although this is not freight specific it does benefit freight road users. Further beneficial impacts on freight could be realised if more focus was given to freight users in terms of dedicated use of capacity at certain times and locations.</td></tr>
<tr><td>TRL</td><td colspan="2">9</td><td>Stakeholder Acceptability</td><td>-1</td></tr>
<tr><td>Freight Congestion Impacts</td><td colspan="4">The impact on congestion is significant where implemented by increasing capacity and ensure the free movement of vehicles. This impacts freight in the same way as all traffic but could have a great impact if there were freight dedicated lanes for example. Typically, where smart motorways have been rolled out there has been increased use of freight, however it is not clear whether this is because of freight user choice as a result of perceived and real reductions in congestion and improvements in journey time reliability or whether additional local and national freight demand is driving the increase.</td></tr>
<tr><td>Evidence of Effectiveness</td><td colspan="4">The first smart motorway scheme (known then as a managed motorway) opened to traffic on the M42 motorway in 2006. Analysis of data gathered since opening has found that:
journey reliability improved by 22 per cent
personal injury accidents reduced by more than half
where accidents did occur, severity was much lower overall with zero fatalities and fewer seriously injured (Highways England, 2018)
Further smart motorways have subsequently been rolled out and the design has been continually improved (HSR to ALR) to reduce maintenance effort, permanently increase capacity and reduce operating costs.

For example, the M25 J5-7 ALR scheme provided the following year two results (Highways England, 2017):
Flow increase of 10% J5-6 with 17% achieved clockwise and 7% anti-clockwise due to additional lane.
Journey time returned to pre-scheme levels with a 1% increase clockwise and 2% decrease anti-clockwise. Note this would have been worse if smart motorways not built.
A slight improvement in journey time reliability in both directions
A statistically significant improvement in the reduction in frequency or severity of incidents with 27% reduction in frequency and 39% reduction in Fatal Weighted Injuries (FWI).
The M25 J23-27 ALR scheme provided the following year two results (Highways England, 2017):
Flow increase of 10% J23-26 with 17% achieved J24-25 Clockwise due to additional lane
3% decrease in journey time clockwise with a 0.5% increase anti-clockwise
A slight increase in journey time reliability
No statistically significant improvement in the reduction in frequency or severity of incidents.</td></tr>
</table>

	Highways England analysis shows that for the M25 J5-7 all lane running in year two, there was significant improvement in flow increase with extra lane and capacity for more growth and that there was a slight improvement in journey time reliability. Average journey times returned to close to pre- scheme levels, however it was noted that if the scheme hadn't been in place this would have been worse (Highways England, 2017). For the J23-27 all lane running on M25, there was a reported 10% flow increase achieved with capacity for more growth, average journey times have again returned to pre- scheme times, but would have been worse without the scheme and there has been a slight improvement in journey time reliability for the corridor (Highways England, 2017). Based on the evaluation of the two ALR sections discussed above on the M25, Smart motorways appear to have reduced average journey times by between 2% and 9% (Observatory, 2016). Looking internationally, evidence shows that in Munich, Germany there was a 10% increase in rush hour capacity and in the Netherlands there is a 7-22% increase in rush hour capacity and 7% increase in flow resulting from smart motorways (Ausroads, 2016). The Vic West Gate Bridge in Australia showed a 22% increase in 1 hour flow throughout. In the US there have been some early adopters, including Washington State, Northern Virginia, Wyoming (US Department of Transportation, 2017) however the impact on congestion could not be found. In summary looking in the UK and internationally the following range of results exist: • Capacity increases of 5-22% • Throughput increases of 1-20% • Reliability improvement of 4-60% • Accident reductions, highly variable but for certain time periods 10-50% has been observed. • Speed and Journey Time savings and improvements in reliability are highly variable, although there have been some incidents of controlling speeds to improve overall travel times. As shown above the results are highly variable between locations. It is not clear exactly why this is, however factors are likely to include the operation of the scheme including algorithm configuration, road layout differences (closer junctions result in more traffic weaving reducing benefits) and different driver behaviour and demand patterns. A Smart Motorway can reduce the incidence of traffic flow breakdowns through coordinated ramp metering and lane use management. The potential throughput increases by Smart Motorways were identified as: • All lane running – 22.8% • Integrated Corridor Management – 25.5% • LUMS/VSL with supporting traveller information – 4.8% • Ramp metering – 21.3% • User information – 0.1% • Overall managed motorway – 18.9% (15.7%) (Australasian Transport Research Forum, 2017) The impact on congestion is identified in brackets.
Opportunity to Develop Further	Provision of a freight specific capacity.

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