NATIONAL INFRASTRUCTURE COMMISSION: FUTURE OF FREIGHT DEMAND

Final Report

MDS Transmodal

January 2019

Ref: 218038R Final Reportv4

FUTURE OF FREIGHT

Evidence Base

This report by MDS Transmodal 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

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EXECUTIVE SUMMARY

Section 1 Introduction

The National Infrastructure Commission (NIC) commissioned MDS Transmodal (MDST), in association with Cambridge Econometrics (CE) and Bearing Point, to provide an evidence-based analysis for the future of freight transport demand up to 2050. Given the inherent uncertainty involved in this exercise, it has been undertaken by developing scenarios which seek to incorporate a range of views on how demand for freight transport might develop in the very long term.

The approach to the study involved desk research and data analysis to develop a view of the key drivers of change in freight demand, both in aggregate and in terms of sourcing and mode of transport. Qualitative scenarios were developed and were then quantified by developing input assumptions for each scenario using a macro-economic model of the global and UK economy called E3ME to forecast aggregate demand and a freight demand simulation model - the GB Freight Model- to model the transport impacts.

Section 2 Key drivers of freight demand

The analysis of long-term trends suggests there has been a gradual de-coupling of aggregate freight moved/lifted and GDP from the early 1980s onwards due to the decline of heavy industry and manufacturing and the shift to a more service-based economy.

There has been overall growth in road freight modal share at the expense of rail freight since the inter-war period, although privatisation of the rail freight industry in the early- to mid-1990s arrested this decline. A recent and structural decline in the movement of imported coal by rail (driven by regulation and policy) has masked growth in the construction and intermodal sectors of the rail freight industry; if coal is ignored, rail market share has grown.

There has been a long-term trend since the 1950s for LGV road traffic to grow faster than HGV traffic, although only about one-third of LGV traffic is related to the movement of freight with the other LGV movements being related to the service sector and private use. The growth in LGV traffic since the 1980s has therefore mainly been due to the switch to a more service-based economy, to self-employment and, more recently, to growth in e-commerce which has substituted LGV movements for passenger car trips.

The relatively rapid growth in sourcing of goods from the EU and the rest of the world, substituting for domestic production, shows how deregulation, market liberalisation and the process of globalisation have led to greater integration of the UK economy with the EU and the rest of the world. With manufactured goods being transported by sea and air from the Far East, supply chains are probably reaching their maximum length. With domestic production declining, lower volumes of raw materials and intermediate manufactured goods are transported to supply domestic factories. The result is that freight transport services have increasingly been moving lighter consumer goods over longer distances.

Allied with an energy policy which is incentivising decarbonisation of the economy, these structural changes in the UK economy has led to a decline in the volume of bulk traffic through ports in the last ten years. Roro and lolo traffic in the other hand has reached record levels in 2016-17 and generally been in line with, or grown faster than, GDP growth. The growth trend in air freight volumes is now also exceeding GDP.

In conclusion, our analysis of the history of freight transport since World War 1, analysis of statistical trends and the existing position in the freight market suggests that the key drivers of freight demand are:

- The state and structure of the economy, which leads to changes in the volume and mix of freight flows generated by different industrial sectors and affects the location of production and consumption. A key issue up to 2050 is the extent to which the UK might experience a renaissance in manufacturing, if only of high value manufactured products.
- Consumer behaviour, particularly in the retail sector which requires a market-led response from the private sector. While the retail sector has always been highly responsive to consumer trends, the importance of these trends has accelerated in the last decade as the internet has allowed consumers to purchase a wider range of products at any time of day and have them delivered to their home or place of work.
- Technological change, leading to changes in the relative cost effectiveness of the different types of ‘vehicles’ used to transport freight and therefore changes in modal share. For instance, the greater introduction of electric vehicles and the further deployment of connected and autonomous vehicles may have a significant impact on the relative cost of the different modes up to 2050.
- Public policy and regulation: changes in regulations, policies, taxation and land use planning in response to, for example, the need to reduce carbon emissions. Such changes in the political economy of freight transport affect the economics of the different modes of transport.

The switch towards a service-based economy since the 1970s was hastened by industrial policies in the 1980s, which gradually led to fewer concentrated flows of bulk commodities between mines and power stations and between ports and manufacturing plants, but greater flows of consumer goods either manufactured domestically in many different diffuse locations or imported via a number of different ports. This switch in the economic geography of freight flows favoured the flexibility provided by road haulage and reduced the flows available for bulk trainload and coastwise shipload volumes.

The main impact of technological and logistical change since World War 1 has been to allow the production and consumption of goods to move further apart. The canals allowed the initial process of industrialisation in the 19th Century and the railways drove the growth of industrial output during the late 19th and early 20th Centuries. Road haulage services, along with roro and container shipping services, have allowed the development of just-in-time supply chains and lean manufacturing in the late 20th and early 21st Century where, for example, automotive parts can be imported from the rest of the EU or the rest of the world for assembly in a car plant in the UK. The on-going process of the globalisation of industrial production beyond the major industrialised economies in the EU, North America and Japan has been driven by lowering trade barriers and cost-effective container shipping services so that consumer goods can now be manufactured in China or Vietnam and then shipped by container to the UK. We may now have reached the point where the distance between global production and global consumption cannot be extended but the cost of transport may be no more than 2% of the value of goods moved; a twenty foot equivalent (TEU) of containerised goods with a mean value of $40-50,000 can be transported from the Far East to North West Europe for $1,000.

Section 3 Scenario development

Having determined the key drivers for freight demand in section 2, four qualitative scenarios were developed in consultation with the NIC and some stakeholder representatives. One of these scenarios was a ‘Business as Usual’ (counterfactual) scenario against which three future scenarios that involve significant change could be measured. The three scenarios, which involve significant change from the existing position, were designed to reflect the range of potential changes in technology, policy, consumer behaviour and the impact of different macro-economic scenarios up to 2050. The four scenarios are summarised on the following page.

Summary of qualitative scenarios for 2050

	Description	Economics	New technology	Consumer behaviour	Policy
'Business as Usual'	'What will happen anyway without significant change?'	Business as Usual	Electric LGVs	E-commerce domination: 35% of food retail & 65% of general merchandise.	Ban on sale of diesel/petrol LGVs & taxation via VED. No ban on diesel HGVs; taxation of HGVs unchanged (VED/HGV Levy plus Fuel Duty)
'Carbon Reduction Scenario'	'What will happen if commercially viable technological solutions are found to provide zero emission HGVs/trains and society seeks to reduce carbon emissions as much as possible?'	EU Trade Focus	Electric LGVs & HGVs Hybrid electric locomotives Automated HGVs, LGVs & trains	E-commerce consolidation: only 20% of food retail & 45% of general merchandise due to consumer response to increased delivery charges.	Ban on sale of diesel/petrol LGVs & HGVs. Taxation through distance-based road pricing. Changes to planning system leads to more warehouses being located on rail and water-connected distribution parks. Longer HGVs and trains.
Carbon Survival Scenario	'What will happen if no commercially viable technological solutions are found to provide zero emission HGVs and trains? '	EU Trade Focus	Electric LGVs Automated HGVs, LGVs & trains	E-commerce domination: 35% of food retail & 65% of general merchandise.	As for 'Carbon Reduction' but no ban on diesel HGVs and diesel locomotives.
Manufacturing Renaissance Scenario	'What will happen if the UK becomes more successful as an advanced manufacturing economy, leading to additional high value exports of goods and the UK trades more extensively with deep sea countries?'	Global Trade Focus, with more manufacturing output & more trade with deep sea countries, leading to manufacturing capacity being located at ports.	Electric LGVs & HGVs Hybrid electric locomotives Automated HGVs, LGVs & trains	E-commerce domination: 35% of food retail & 65% of general merchandise.	Ban on sale of diesel/petrol LGVs & HGVs. Taxation through distance-based road pricing. Changes to planning system leads to more warehouses being located on rail and water-connected distribution parks. Longer HGVs and trains.

Section 4 The modelled scenarios

Introduction

Aggregate demand in each of the four scenarios is based on assuming a relationship between forecast growth in GVA by industry sector from the E3ME macro-economic model and growth in freight tonnes. Freight tonnes by industry sector were assumed to increase at a slower rate than any forecast increase in GVA, based on the evidence over the last 20 years, which suggests there may be a continuing gradual increase in the proportion of each industry sector's GVA which will be related to the provision of services rather than generating additional freight tonnes. GVA by sector has grown by around 0.5% per annum more than tonnages generated, reflecting a switch away from manufacturing to a more service-based economy which tends to consume lighter and more voluminous finished goods.

The aggregate freight demand was then provided as an input to the GB Freight Model (GBFM), which is a multimodal freight transport demand simulation model that has been used by the Department for Transport for modelling and forecasting freight transport within the National Transport Model. The model includes a calibrated base case for 2015 which 'explains' the movement of freight by inland mode and port of entry and exit using generalised costs. GBFM therefore includes validated freight cost models for each mode of transport and provides outputs in terms of tonnes and tonne kilometres by mode.

Aggregate freight demand

Modelled aggregate demand for 'heavy' freight in HGVs or by rail in tonnes lifted is shown below. Total heavy freight is forecast in the BAU 2050 scenario to increase by 1.1% per annum to reach 2.86 billion tonnes of freight lifted in 2050; annual average growth rates for the other three scenarios are lower, ranging from 0.7% to 0.9% compound average growth rate, and reflect the lower levels of forecast economic growth in these scenarios. These growth rates compare with a long-term historic growth in tonnes lifted by road of 1.0% per annum for the period 1953-2015.

Modelled aggregate demand for 'heavy' freight transport

Billion tonnes lifted

	2015	Business as Usual (BAU) 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing Renaissance 2050
Freight tonnes lifted	1.97	2.86	2.60	2.62	2.49
Total growth 2015-50	-	45.3%	32.2%	33.4%	26.5%
Compound average growth rate 2015-50	-	1.1%	0.8%	0.9%	0.7%

Source: MDS Transmodal GB Freight Model

The table below provides the modelled results for trips by LGVs transporting ‘light’ freight, as opposed to those involved in the provision of services or being used solely as a means of passenger transport.

Modelled demand for freight transport in LGVs in trips

	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing & Global Trade Renaissance 2050
Freight transported in LGVs (billion trips)	2.76	9.24	5.44	8.92	8.74
Growth 2015-50		235%	97%	223%	217%
Compound average growth rate 2015-50		3.6%	2.0%	3.5%	3.4%

Source: MDS Transmodal GB Freight Model

Total light freight in terms of trips is forecast in the BAU 2050 scenario to increase by 3.6% per annum to reach 9.24 billion trips in 2050; annual average growth rates for the Carbon Survival and Manufacturing Renaissance scenarios are lower at 3.5% and 3.4%, reflecting the lower levels of forecast economic growth in these scenarios. The growth rate for the 2050 Carbon Reduction scenario is lower at 2.0%, which reflects a lower penetration of the retail market by e-commerce as consumers are assumed to be paying for the full cost of the e-commerce deliveries and choose to maintain a higher proportion of their retail expenditure in ‘bricks and mortar’ shops.

The table below provides the modelled results for LGVs transporting freight in terms of vehicle kilometres. The freight moved in LGVs increases in the 2050 Business as Usual, Carbon Survival and Manufacturing Renaissance Scenarios at an average annual rate of up to 3.5% compared to the 2015 base case, mainly due to the assumed increasing penetration of the retail market by e-commerce. However, in the Carbon Reduction Scenario this growth is restricted to only 1.9% per annum for the reasons explained above. There are no official statistics on the long-term historic growth rate for LGVs carrying freight, but the growth rate for total LGV vehicle kilometres between 1950 and 2016 was 3.5% per annum, while the annual growth rate for the period 2009-16 alone was 2.7%. The growth rate in non-freight LGV traffic may be associated with growth in self-employment over the last 40 years. The forecast growth rates up to 2050, which are the result of forecast greater penetration of the retail market by e-commerce, are therefore in line with historic trends.

Modelled demand for freight transport in LGVs in vehicle kilometres

	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing & Global Trade Renaissance 2050
Freight transported in LGVs (billion km)	25.6	81.6	48.3	78.6	69.5
Growth 2015-50		219%	89%	207%	172%
Compound average growth rate 2015-50		3.5%	1.9%	3.4%	3.0%
Average length of trip (km)	9.3	8.8	8.9	8.8	8.0

Source: MDS Transmodal GB Freight Model

Road and rail modal split for inland freight transport in Great Britain

The modelled modal split for ‘heavy’ road freight (transported in HGVs) and rail freight in terms of tonnes moved (the most appropriate measure of modal split) is shown below.

Modelled ‘heavy’ road & rail freight transport in tonne kilometres

		2015	Business as Usual 2050*	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing Renaissance 2050
ROAD	Road tkm by HGVs (billion)	164	223	180	179	168
	Growth in road tkm by HGVs 2015-50	-	36.4%	9.8%	9.3%	2.5%
	Compound average growth rate for road tkm by HGVs 2015-50	-	0.9%	0.3%	0.3%	0.1%
	Average length of road haul by HGVs (km)	87	81	72	71	71
RAIL	Rail tkm (billion)	15	21	19	23	27
	Growth in rail tkm 2015-50	-	35.6%	23.0%	54.4%	79.1%
	Compound average growth rate 2015-50	-	0.9%	0.6%	1.3%	1.7%
	Average length of rail haul (km)	167	191	183	197	212
	Rail modal split in tkm	8.5%	8.4%	9.4%	11.6%	13.9%

Source: MDS Transmodal GB Freight Model

* Excludes additional clustering of warehousing on rail- and water-connected distribution parks

Note: Rail traffics not including Network Rail engineering, other, nuclear, empty returns of waste containers and, for intermodal, the weight of containers.

The rail modal split in terms of tonne kilometres falls from 8.5% in 2015 to 8.4% in the BAU 2050 Scenario – which does not include the additional clustering of warehousing on rail- and water-connected distribution parks - and mainly reflects an increase in the number of HGVs required for the ‘bulk’ transport of more voluminous e-commerce parcels between regional distribution centres and local sorting offices rather than more consolidated loads from distribution centres to retail outlets as at present.

The increased modal split for rail of between 9.4% and 13.9% in the other 2050 scenarios is the result of, in addition to the bulk transport of e-commerce described above, a combination of other factors:

- The assumed availability of autonomous HGVs which significantly reduces fixed labour costs and therefore improves the cost effectiveness of road haulage in competition with rail;
- The assumed availability of electric HGVs, which reduces the variable costs of road haulage in the Carbon Reduction and Manufacturing Renaissance scenarios and therefore improves the cost effectiveness of road haulage in competition with rail; this impact is reduced through the introduction of road pricing which increases the .
- The greater clustering of distribution centres on rail- and water-connected distribution parks which improves the cost effectiveness of intermodal rail freight transport chains by ensuring that a final road collection or delivery leg is not required at, at least, one end of the intermodal transport chain.
- The greater concentration of freight origins and destinations in the 2050 Manufacturing Renaissance scenario at deep sea ports (receiving higher volumes of deep sea trade and also generating manufactured goods within their port estates) with their associated rail connections, therefore providing a critical mass of cargo for intermodal rail freight services.

The most significant factor in improving the modal split for rail is likely to be the clustering of distribution centres at locations that are connected to the rail network, which incentivises a switch of heavy freight traffic from road to rail. This clustering effect helps rail to increase its modal split in terms of freight moved despite the reduction in the costs of road haulage as a result of the assumed introduction of autonomous HGVs by 2050. In addition, in the 2050 Manufacturing Renaissance scenario the major deep sea (and rail-connected) ports are handling greater volumes of trade and manufactured goods which are suitable traffics for inland distribution by rail.

Apart from the BAU Scenario, the 2050 scenarios all assume significant technological advances by 2050 involving the successful implementation of autonomous HGVs on a large-scale, which would require not just technological solutions but also a suitable legal framework and public acceptance; this leads to a significant modal switch away from rail to road for the transport of ‘heavy’ freight. Another scenario, which does not assume such technological changes by 2050 and is essentially the Business as Usual scenario with additional clustering of warehouses on rail-connected distribution parks has been run by MDS Transmodal using GBFM for TfN and Network Rail. This resulted in rail securing about 160 million tonnes of traffic or about 15% modal split in terms of tonne kilometres in 2050 and provides some additional sensitivity testing of a scenario where such significant technological change is not achieved.

Section 5 Conclusions

Aggregate growth in freight demand is unlikely to be sensitive to foreseeable changes in the cost of freight transport up to 2050 because the value of goods being transported is so much higher than the cost of door-to-door freight transport. The amount of freight transport required in 2050 will therefore be determined mainly by the growth and future structure of the UK economy and its future trading relationships. As the UK has gradually developed since the 1980s into an essentially service-based economy, future growth in freight is likely to be at a lower rate than growth in overall GVA and closer to forecast growth in population as it reflects levels of consumption.

The structure of this service-based economy is such that the UK is likely to continue to have a propensity to import consumer goods rather than produce them within the domestic economy and so international gateways will retain their key role in the UK's freight transport system. Having said that, high value manufacturing is likely to retain a role in the economy and, in some scenarios, could increase its role; such manufacturing may not increase the volume of HGVs, trains or containers moving to and from ports as the traffic will provide backloads for otherwise empty units.

Future significant growth in e-commerce is likely because of its convenience for consumers and this would lead to a significant increase in traffic making deliveries in urban areas instead of generating passenger trips to retail outlets. The extent of this growth is likely to be determined partly by consumer requirements and habits and where people live, but also by the extent to which the full cost of deliveries is incorporated transparently into the pricing of e-commerce purchases.

The UK's future trading relationship with the EU and the rest of the world is likely to have a major impact on international gateways, with a possible re-focusing of trade to the rest of the world and away from the EU likely to lead to a greater market share of high value unitload traffic being handled through deep sea container ports and major international airports rather than through short sea ferry ports.

Whatever the nature of the UK's trading relationships in 2050, international gateways (major ports, the Channel Tunnel and major international airports such as London Heathrow) are likely to retain their importance in the freight transport system, both for the handling of imports and exports of high value manufactured goods and foodstuffs, parts for assembly lines and materials for activities such as construction. The handling of energy products at major ports, on the other hand, will have ended as the UK economy decarbonises and North Sea oil production ceases.

Road and rail freight services are likely to retain their major role for the domestic distribution of 'heavy' freight and for the inland distribution of goods to and from international gateways. Inland waterway transport and coastal shipping would also play a role in some transport chains, particularly where relatively large consignments of non-time sensitive goods are being transported. The successful and widespread implementation of autonomous vehicles in the road haulage sector by

2050 could radically improve the economics of road haulage in competition with other modes because it could, in theory, remove a significant proportion of the mode's fixed costs. This would, in the absence of any other changes, lead to a switch of traffic away from rail and other inland modes because the introduction of autonomy for other modes has a much less significant impact on the cost of moving a tonne of cargo. This is because road haulage is otherwise highly labour intensive.

The assumed widespread introduction of electric LGVs and HGVs by 2050 would cut dramatically the emissions from road freight transport as long as the required electricity can be generated from renewable sources. It would also have the effect of reducing the variable costs per kilometre due to the assumed lower cost of energy and lower maintenance costs, unless a system of road pricing was introduced by the Government both to manage road congestion and also to maintain tax revenue following the loss of Fuel Duty currently levied on diesel.

The land use planning system is likely to have a key role to play in facilitating the greater use of rail, inland waterways and shipping up to 2050 and encourage the greater use of non-road modes to relieve pressure on the strategic road network. The planning system would need to encourage the clustering of distribution centres on sites which are rail and/or water-connected, so there would be no additional fixed cost of road haulage required to distribute the freight between the rail and/or water-connected terminal and off-site distribution centres. In the event that autonomous HGVs do not emerge as a practical technological solution by 2050, but the planning system leads to greater clustering of distribution centres on rail-connected distribution parks, there would be a substantial net switch of traffic from road to rail.

Urban freight movements are likely to increase up to 2050 as a result of an assumed increased penetration of the retail market by e-commerce. These additional freight movements, mainly in LGVs, would replace some existing passenger trips to retail outlets and would be completed using electric vehicles and so minimise emissions; nevertheless, there may be political pressure to re-organise urban logistics chains to reduce the potential congestion impacts of these movements. The clustering of distribution centres on rail- and water-connected sites on the edge of major conurbations may provide an opportunity for greater use of non-road modes for trunk hauls of e-commerce goods and consolidation of loads in electric LGVs for final deliveries in the urban areas.

The freight transport system may not be so radically different from that in 2018 in that the same modes are likely to be required for the transport of the vast majority of freight tonne kilometres – with 'alternative' modes such as drones securing a limited market share in niche markets. The major changes may be in the reduction in emissions and the reduction in costs in real terms as a result of the introduction of electric and more autonomous vehicles. New logistics models may have been successfully implemented to reduce the impact of greater demand for e-commerce deliveries in urban areas.

1 INTRODUCTION

1.1 Study objective and scope

The National Infrastructure Commission (NIC) commissioned MDS Transmodal (MDST), in association with Cambridge Econometrics (CE) and Bearing Point, to provide an evidence-based analysis for the future of freight transport demand up to 2050. Given the inherent uncertainty involved in this exercise, it has been undertaken by developing scenarios which seek to incorporate a range of views on how demand for freight transport might develop in the very long term.

A 'freight transport system' can be defined for the UK which consists of a network of users of freight transport (principally shippers and receivers of cargo), freight transport and logistics service providers and the infrastructure which these services use[i]. As this study was focused on demand for freight rather than the infrastructure it uses, it is mainly interested in:

- The total demand for freight by shippers and receivers in terms of tonnes of goods moved by broad commodity;
- The sourcing of the goods, whether domestic or international;
- The 'vehicles' (trucks, trains, ships etc.) that are used by the freight transport and logistics service providers to move the goods and the mode of transport.

Freight demand has been measured in terms of both freight lifted (tonnes and units) and freight moved (tonne kilometres) by the different modes of transport and, wherever possible, by broad commodity type.

The geographic focus has been on the UK, including demand for freight transport services that link the UK with the Republic of Ireland, the continental mainland and the rest of the world given the open nature of the UK's economy. The analysis provides some regional breakdown for the NUTS1 statistical regions (i.e. Scotland, Wales and Northern Ireland and the English administrative regions). Case studies on the future of urban logistics have been completed for:

- Manchester and Glasgow (as examples of conurbations);
- Southampton (as an example of a port city);
- Bath (as an example of a heritage city), within the wider local authority area (Bath and North East Somerset).

All existing and potential future modes of transport have been included within the scope of the study. The main focus has been on the surface modes of road, rail and shipping but the study also considers, if only in outline, aviation, inland waterways, pipeline and, particularly for urban logistics, 'alternative modes' such as drones and cycling.

1.2 Overall approach

The approach to the study involved desk research and data analysis to develop a view of the key drivers of change in freight demand, both in aggregate and in terms of sourcing and mode of transport. Qualitative scenarios were then developed in consultation with the NIC at a workshop in August 2018 and with representatives of stakeholders at a further workshop in September 2018. The qualitative scenarios were then quantified by developing input assumptions for each scenario using a macro-economic model of the global and UK economy called E3ME to forecast aggregate demand and a freight demand simulation model - the GB Freight Model - to model the transport impacts.

The stages of the study are set out in Figure 1.

Figure 1: Stages of the Future of Freight Demand Study

Historic trend analysis

Current freight demand

Key factors affecting demand

Draft scenario development

Client & stakeholder workshops

Final scenario development & modelling

2 KEY DRIVERS OF FREIGHT DEMAND

2.1 Introduction

Freight transport is needed because goods available at one geographical location are required at another location for processing, sorting or consumption. Freight transport is therefore an example of a derived demand as the transport is not required in itself, but only as a means to satisfy another demand. As a derived demand, the demand for freight transport does not come directly from consumer needs or wants but from private sector companies such as retailers, manufacturers and processors. However such organisations are ultimately responding to consumer demand for goods and dealing with return flows such as unwanted or faulty goods and waste materials such as packaging for recycling or disposal.

Freight transport and logistics services are delivered almost exclusively by private sector companies which invest heavily in fixed infrastructure, such as port facilities, rail terminals, distribution centres, and mobile equipment such as trucks, vans, fork lift trucks, ships and railway locomotives and wagons. The private sector needs, however, to use publicly owned road and rail infrastructure and is subject to the taxation and regulatory regimes that the public sector puts in place.

As the freight transport industry is highly competitive - facilitated by relative ease of entry into the market for freight transport and logistics operators - any interventions by the public sector will lead to a response from the private sector operators and any resulting changes in costs will be passed on, in the medium to long-term, to the industry's customers and, ultimately, to the wider economy.

Much of this section of the report considers historic trends in freight transport demand using, as far as possible, official statistics which measure freight transport in a number of ways. Freight transport is usually measured in terms of freight tonnes lifted or freight tonnes moved. Freight tonnes moved can be expressed in tonne kilometres (tkm) or, for road freight, vehicle kilometres (vkm). Tonne kilometres is generally regarded as the most relevant measure for defining modal share and a combination of tonne kilometres and tonnes lifted allows the average length of haul to be derived.

Tonne Kilometres (tkm) = Tonnes Lifted x Length of Haul in Kilometres

Vehicle Kilometres (vkm) = Tonne Kilometres / Average Load in Tonnes

Tonne Kilometres / Tonnes Lifted = Average Length of Haul in Kilometres

The key drivers of freight demand have been analysed through:

- A review of the history of freight transport since World War 1 based on secondary sources. This review sought to focus particularly on the period between 1918 and the early 1950s for which there is no official freight transport data available on a consistent basis, but also covered some more contemporary history related to the global container shipping industry.

- Analysis of official freight transport statistics from the early 1950s. A statistical 'picture' of the existing position of the freight transport market using mainly official statistical sources.

2.2 Overall trends in freight transport since 1918

There are no official statistics available on aggregate freight transport demand or by mode on a consistent basis until the early 1950s, but some general observations can be made on the subject before that time based on a review of secondary sources.

The horse and cart was still an important mode of transport in 1918 for short haul movements and for final collection and delivery to and from rail heads with rail freight and coastal shipping dominating long-haul movements. In London, for example, the number of horses involved in goods transport peaked at 33,000 in 1909, but had halved by 1923 and disappeared by the mid-1950s as improvements in HGV technology gradually reduced its unit costs and increased the flexibility of its use.

Overall the history of freight transport from 1918 until rail privatisation in the mid-1990s is essentially the story of the rise in the relative importance of road haulage in competition with, firstly, the horse and cart and then the railways and coastal shipping. This was a result of four main factors: firstly the inherent flexibility of road haulage, which allowed trucks to transport goods directly between almost any origin and destination; secondly its individualistic and entrepreneurial culture, given that it was a nationalised industry only from 1948 until 1956 with the process of denationalisation starting from 1951; thirdly, changes in the political economy of freight transport since 1918 (usually lagging behind technological developments which made road haulage relatively safe for the transport of increasing payloads) which tended to reduce the cost per tonne moved compared to other modes.

These changes in the policy and regulatory framework include:

- The increase in the maximum payload limits for HGVs, including the latest increase to 44 tonnes in 2001, which reduced the cost of road haulage per tonne moved. The payload was increased to 32 tonnes in 1983 after the Armitage Report recommended in 1980 that the payload should be increased to 44 tonnes; the final increase to the current 44 tonnes was therefore 21 years after the original recommendation.
- The increase in the floor area available for loads in articulated vehicles, which doubled between 1955 and 1995.
- The increase in speed limits for HGVs, as improvements have been made to tyres, pavements and braking. In 1922 the speed limit for an articulated goods vehicle was 12mph, but this increased to 16mph in 1931, 20mph in 1920, 30mph in 1957, 40mph in 1967, 50mph in 1984

and 60mph on dual carriageways in 2015 (while remaining at 50mph on single carriageway roads). The increase in the speed limit for HGVs gradually reduced the door-to-door transport time, thereby providing service quality benefits and reducing time-based fixed costs.
- Development of the motorway network funded through general taxation as a public good. The first stretch of motorway was the Preston Bypass (now part of the M6) which opened in 1958, whereas the first major motorway to open was the M1 in 1959. The 1960s, 1970s and 1980s saw a gradual extension of the network to link all the major UK conurbations with each other and with some of the major ports; the motorway network also facilitated the development of the logistics 'golden triangle' for national distribution in the Midlands, which relied on hauliers being able to transport goods by road to most regions of GB within a day's round trip.

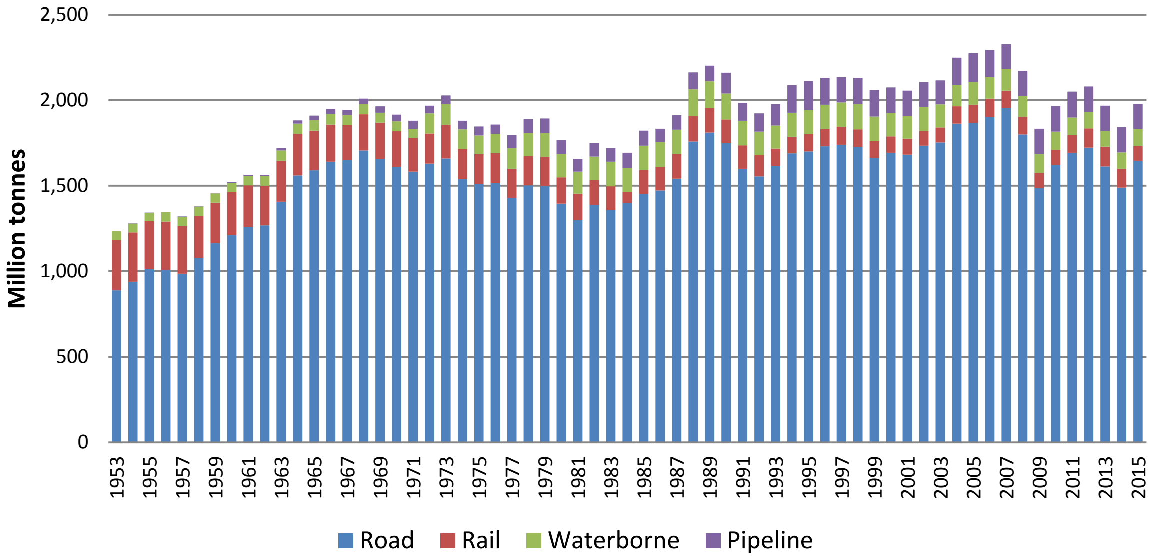
From the early 1950s official statistics were produced which allow a consistent time series of data to be produced and they show how road freight transport has increased its modal share since 1953 from 35% of tonne kilometres in 1953 to 53% in 1980 and 72% in 2015.

The volume of freight lifted by all inland modes (road, rail, pipeline and waterborne freight) in 2015 was 1.97 billion tonnes and this was roughly the same tonnage as in 1966, despite the significant changes in the structure of the UK economy since about 1980 (Figure 2). Whereas up to the 1970s there were concentrated flows of heavy commodities between small numbers of origins/destinations (such as movements of coal from mines to inland power stations and of iron ore and coking coal from ports to inland steelworks), much of the heavy industry that remains in the early 21st Century is located in or close to ports (so there is little or no inland movement of goods) and there are more diffuse flows of consumer goods to a greater number of destinations.

Figure 2 also shows the impact of economic shocks on demand in terms of freight tonnes lifted, with declines in freight tonnes during recessions in the mid-1970s to the early 1980s, in the early 1990s and in the Great Recession of 2008-09.

Figure 2: Inland freight transport demand in tonnes lifted by mode 1953-2015

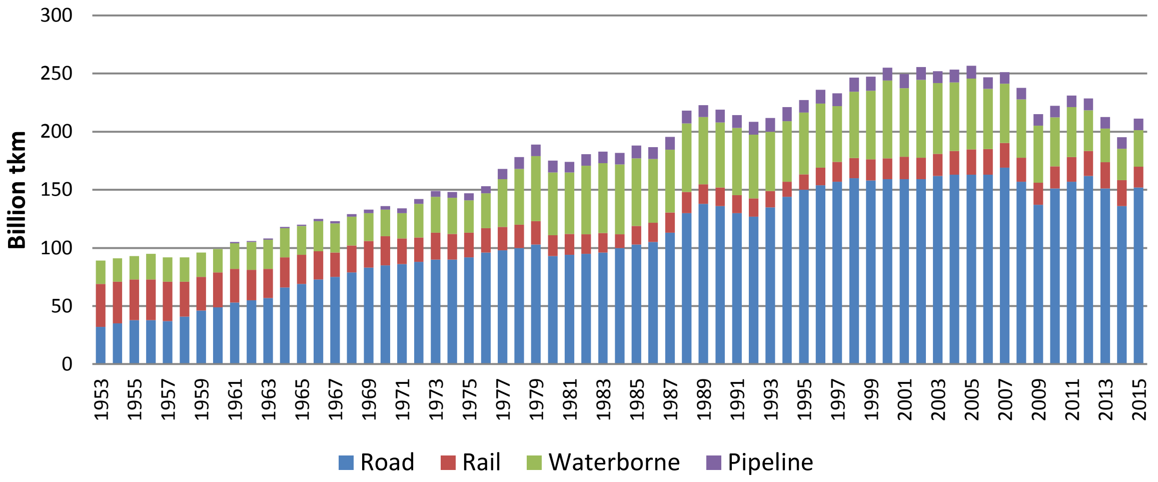
Source: DfT Transport Statistics Great Britain



The historic trend in tonnes moved by mode in tonne kilometres since 1953 (Figure 3) shows that the average length of haul has extended as, lighter and increasingly imported manufactured goods were moved over longer distances, whereas the decline in domestic manufacturing led to lower volumes of intermediate goods being moved between factories. In 1953 the average length of haul for all domestic freight was 72km, whereas by 1980 it had increased to 98km and by 2015 it was 107km.

Figure 3: Inland freight transport demand in tonnes moved by mode 1953-2015

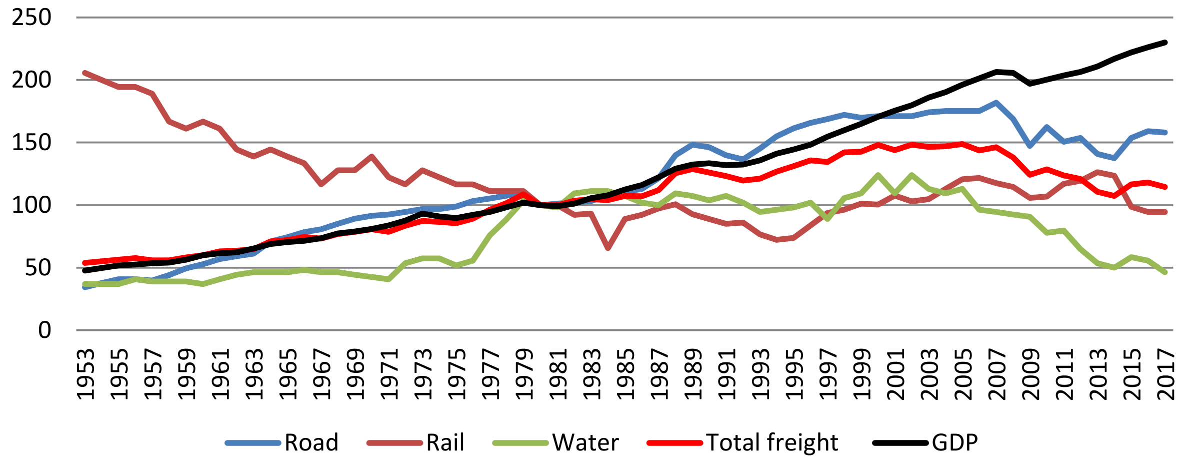
Source: DfT Transport Statistics Great Britain



There has also been a gradual de-coupling of freight moved/lifted from GDP from the early 1980s onwards due to this decline of heavy industry and manufacturing generally and a shift to a service based economy that is more reliant on imports of consumer goods (Figure 4). While freight transport in terms of tonne kilometres closely followed the trend in GDP up to the end of the 1970s, it gradually diverged up to the Great Recession in 2008-09 and then fell more rapidly during and after 2009 due to the downturn in economic activity. This more recent decline in freight activity since 2008-09 is also explained by the impact of Government energy policy, which has led to the closure of coal-fired power stations and lower demand for rail freight services to transport imported steam coal from UK ports to inland power stations.

Figure 4: Indexed trend in freight tonnes moved & GDP 1953-2017 (1980 = 100)

Source: DfT Transport Statistics Great Britain & Office for National Statistics



2.3 Road freight transport

Data since the 1950s that focuses only on road freight provides additional detail on some of the key trends. Figure 5 shows the change in road tonne kilometres in comparison to HGV kilometres since 1953 on an indexed basis. The gradual growth in HGV kilometres up to the late 2000s reflects the use of longer, heavier and taller HGVs which has allowed the road haulage industry to improve its productivity in terms of maximum payload per HGV.

Figure 5: Road freight moved and HGV kilometres: indexed, 1953 = 100

Source: DfT Transport Statistics Great Britain

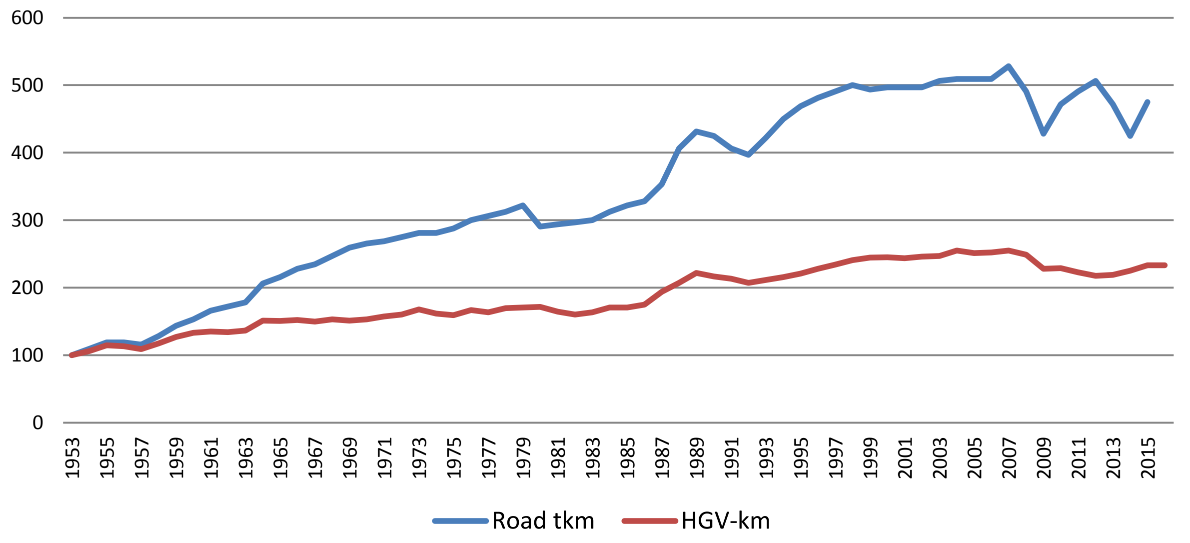
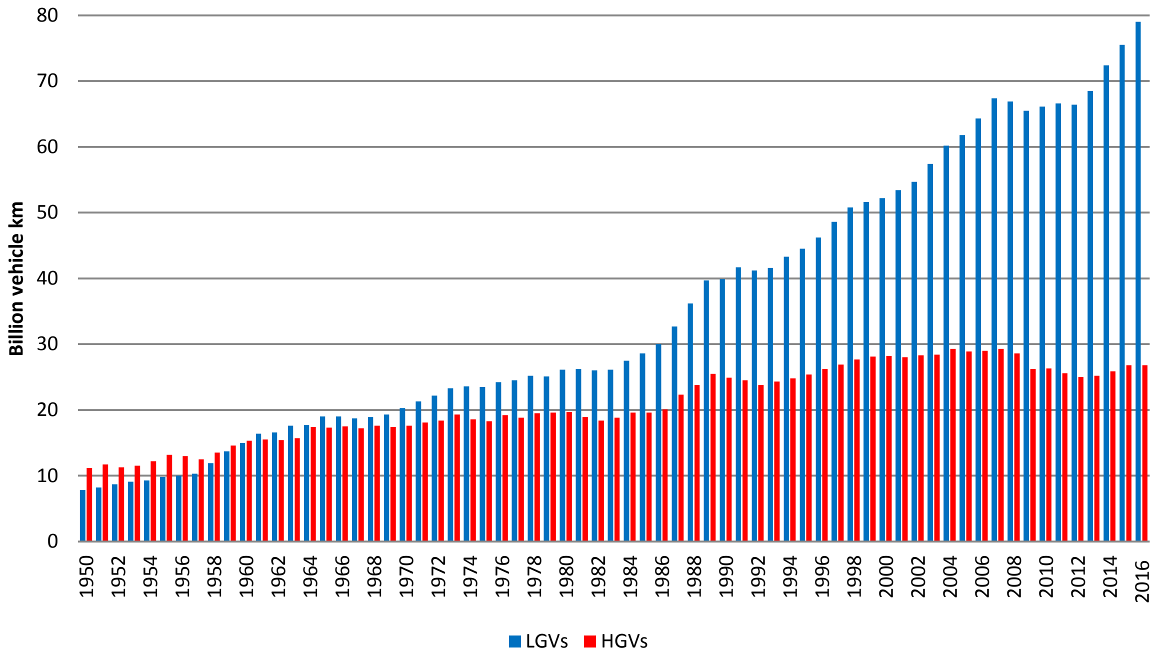


Figure 6 shows the change in HGV vehicle kilometres compared to LGV vehicle kilometres between 1953 and 2016. The long-term average growth rate in vehicle kilometres between 1953 and 2016 was 3.6% per annum for LGVs, but only 1.4% for HGVs; the growth rate between 2009 and 2016 alone was 3.2% per annum for LGVs, but had slowed to only 0.2% per annum for HGVs.

Figure 6: Road freight vehicle activity by type, 1950-2016

Source: DfT Transport Statistics Great Britain



While HGVs will almost always be transporting freight, LGVs are also used to provide services and for private journeys, as well as for delivering and collecting relatively lightweight freight. LGVs are often the 'vehicle of choice' for the service sector as they allow tools and equipment to accompany the person providing the service. The three-fold growth in LGV kilometres compared to HGV kilometres (less than 50% growth) since 1980 again highlights the shift of the UK economy to being more focused on services, whereas more recent growth in LGV km also reflects changes in the retail sector and the increase in the volume and market share of e-commerce. LGV vehicle kilometres have grown on average by 3.5% per annum over the period 1950-2016, whereas HGV vehicle kilometres have grown on average by only 1.3% per annum.

2.4 Rail freight

After World War 1 the railways had an extensive network of mainlines and branch lines, offering wagonload services for freight to local stations and final collection and delivery of the freight by horse and cart or lorry; however, the railway companies lacked the statutory powers to operate their own long distance haulage companies[ii]. They secured the statutory power to operate such services only in 1928, but tended to buy or seek alliances with the larger road hauliers that wanted greater regulation of the road haulage industry. Otherwise, the railways sought to compete in the 1920s and 1930s by developing relationships with manufacturers and retailers where they took control of the transport and storage of goods using rail-based transport chains just as third party logistics providers (using mainly road transport) do today; they also sought to improve the rail freight economics for wagonload traffic by using the greater range of road transport to make collections and deliveries from fewer main railheads rather than from local stations.

While road haulage has traditionally been operated by the private sector in a highly entrepreneurial environment, the railways were in public ownership for about 50 years from nationalisation in 1948 until privatisation between 1994 and 1997. Even before nationalisation, the railways tended to have a more corporate culture which was focused on safety and constrained by its network of tracks and timetables. They were required to accept freight for transport on the network on a common carrier basis to protect against abuse of local market power - in a similar way to the post office is required to handle letters whatever the geography and the associated costs.

By the early 1960s and the publication of the Beeching Report[iii] the nationalised British Railways was severely loss-making and rail freight was a significant contributor to the railway's poor financial position; this led to the publication of Richard Beeching's report in March 1963. The Beeching Report argued that the growth of the national rail network had increased the potential market for freight transport, but the British Rail (BR) freight network had numerous branches which led to very low volumes of wagonload traffic being transported to many of its 1,000 depots; this led to a requirement for intermediate marshalling of wagons. The report quotes the average loaded transit time for loss-making wagonload traffic as being one and a half to two days to cover 67 miles and commented, "These slow and variable delivery times are quite unacceptable for many forms of freight these days, when road deliveries over comparable distances can be made on the day of despatch". The only traffic which was (if only marginally) profitable was the transport of coal and BR already transported a high proportion of this traffic, as it did for minerals and other bulk traffics. The Beeching Report recommended the reduction of the number of freight depots to only 100 and the development of liner services for container traffic "to link main centres of industry and population by fast regularly scheduled, through-running trains" transporting containers carrying general merchandise. While the privatised rail freight industry continues to transport trainload volumes of bulk goods such as aggregates, its major source of growth has been in the liner container trains as described by Beeching, but with a greater focus on trains carrying imported general merchandise and therefore linking container ports to the main centres of population, a process that was well-established by the 1970s as the liner shipping industry itself invested in containerisation.

Rail freight's inherent competitive advantage is based on moving large volumes of goods in a single train between rail-served sites; road haulage, on the other hand, is ideally suited to moving smaller quantities on a 'just-in-time' basis between multiple origins/destinations due to its cost and inherent flexibility. Other developments, mainly related to changes in the regulatory environment since the 1950s, have increased the cost effectiveness and service quality of road haulage and therefore made the mode more competitive against rail freight except for a few well-defined groups of flows.

Figure 7 shows the change in rail freight moved in terms of tonne kilometres by broad cargo type in more recent years following privatisation. There has been a sharp decline in coal traffic since 2013-

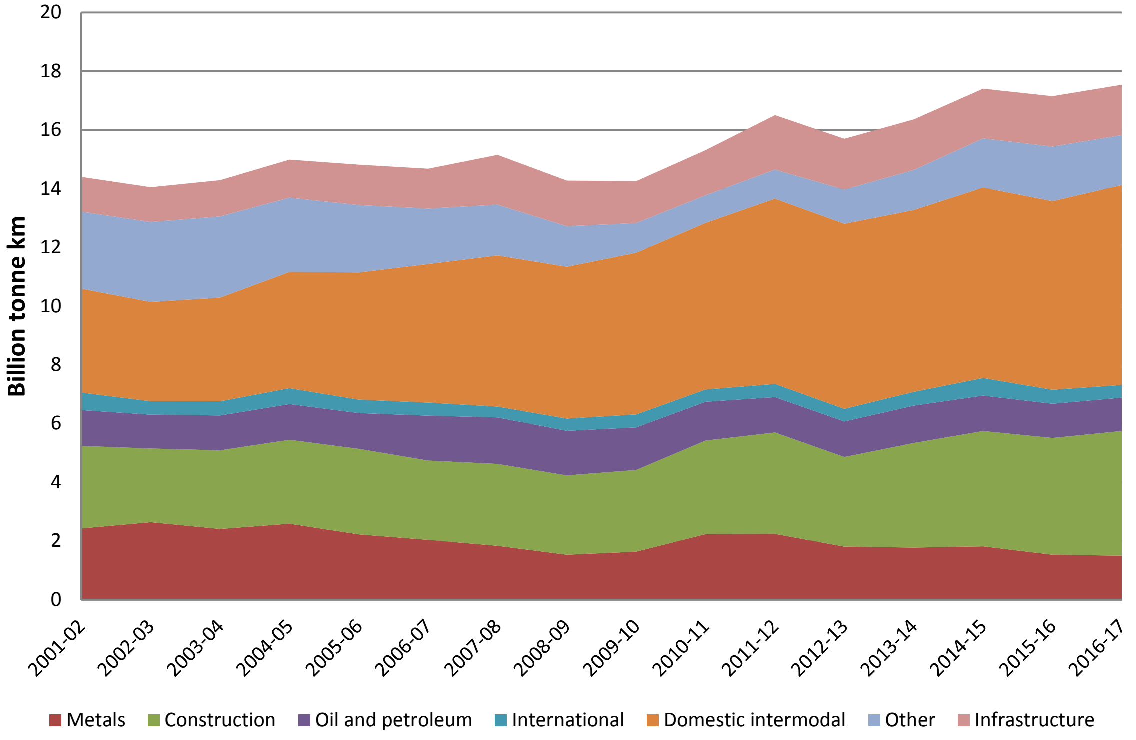
14 due to a shift away from coal-fired electricity generation as a result of a combination of legislation to reduce emissions from power stations and the Government's policy of phasing out coal-fired power stations completely by the mid-2020s to allow the UK meet its greenhouse gas reduction targets. This has led to an overall decline in rail freight activity from a high of 118m tonnes in 2013-14 to only 86m tonnes in 2016-17; however, the fall in coal volumes for electricity generation masks growth in other traffics.

This growth in non-coal traffic of 6% between 2013-14 and 2016-17 has been led by two key sectors:

- Construction materials traffic has grown by 19% from 3.6bn tkm in 2013-14 to 4.3bn tkm in 2016-17: these are principally aggregates flows from the Mendips and the Peak District to the areas that lack hard rock supplies, such as the South East of England;
- Container traffics between deep-sea ports and regional intermodal terminals and Strategic Rail Freight Interchanges and between Scotland and England have grown by 10% from 6.2bn tkm in 2013/14 to 6.8bn tkm in 2016/17.

Figure 7: Rail freight moved by broad commodity (excluding coal): 2001-17

Source: Office of Rail & Road



2.5 Shipping & ports

Waterborne freight

Freight moved by waterborne freight transport consists of:

- Coastwise traffic: freight moved around the coast of the UK;
- One-port traffic: freight moved between a UK port and offshore installations, such as offshore wind farms and oil and gas installations;
- Inland waters traffic: freight traffic carried by both barges and seagoing vessels along inland waters, both non-sea going traffic and sea-going traffic which crosses into inland waters from the sea.

Coastal shipping was able to be competitive against both rail and road haulage between the two world wars even for relatively high value cargoes such as tea on flows between London and Manchester but road haulage targeted these flows because it could offer a faster transit time and a more flexible door-to-door service. However, after World War 2 even some bulk shipping flows were switching to road haulage[iv].

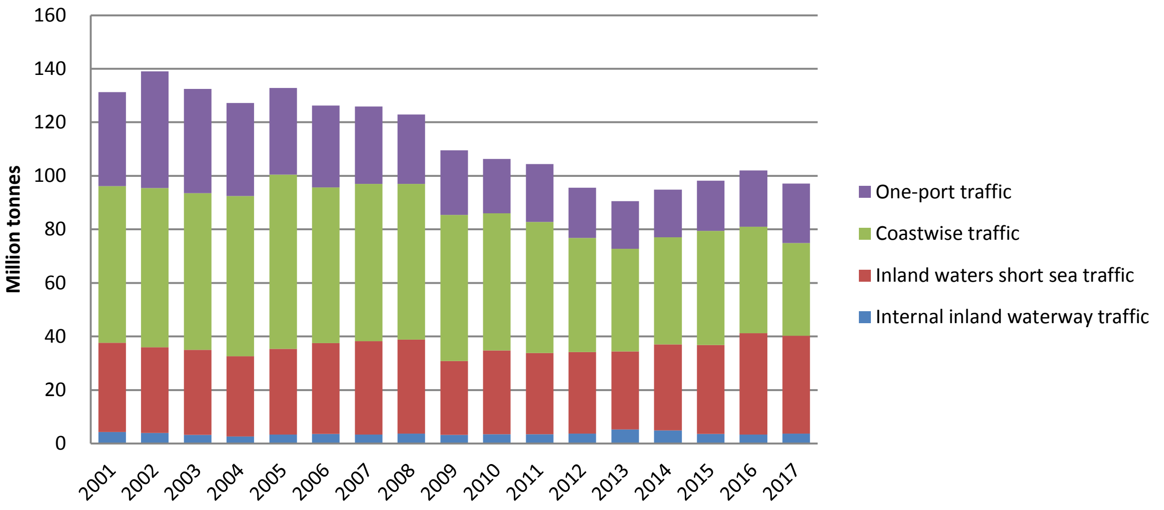
There was growth in waterborne freight up to the late 1980s, but the subsequent decline mainly reflects North Sea oil production, with crude oil being shipped as well as piped from oil platforms to shore-based storage, along with other structural changes in the market such as the introduction of a ban on dumping waste material at sea.

In 2017 96% of waterborne freight relates to movements by seagoing ships, either coastwise or one-port movements or to and from inland waters by sea-going vessels. The only movements on inland waterways are on the main river estuaries such as the Thames, Humber and Forth and on the Manchester Ship Canal, while the use of broad-gauge canals and other rivers for freight is limited due to the lack of economies of scale that are available and the limited connectivity provided by the network. There are no freight movements on narrow gauge canals.

Total freight lifted by waterborne freight in tonnes (Figure 8 below) has declined by 26%, particularly due to a fall in one port traffic between UK ports and offshore oil and gas installations as activity in the North Sea has declined and a fall in the movement of petroleum products coastwise between oil refineries and coastal tank farms.

Figure 8: Waterborne freight traffic 2001-17

Source: DfT Waterborne Freight Statistics



Port traffic

Figure 9 shows the change in tonnes handled at major UK ports between 1995 and 2017 by broad cargo type. Total traffic has declined from a peak of 570 million tonnes in 2005 to 471 million tonnes in 2017, due to a decline in dry bulk traffic (principally imported coal for electricity generation, only partially mitigated by an increase in biomass imports) and liquid bulks (declining North Sea oil production). However, roll-on roll-off (roro) and container traffics have grown significantly after the Great Recession, with roro traffic reaching a record high of 107 million tonnes in 2017 and container traffic reaching a record level of 65 million tonnes in 2016 before falling back to 64 million tonnes in 2017.

Figure 9: UK major port traffic by type, 1995-2017

Source: DfT Port Freight Statistics

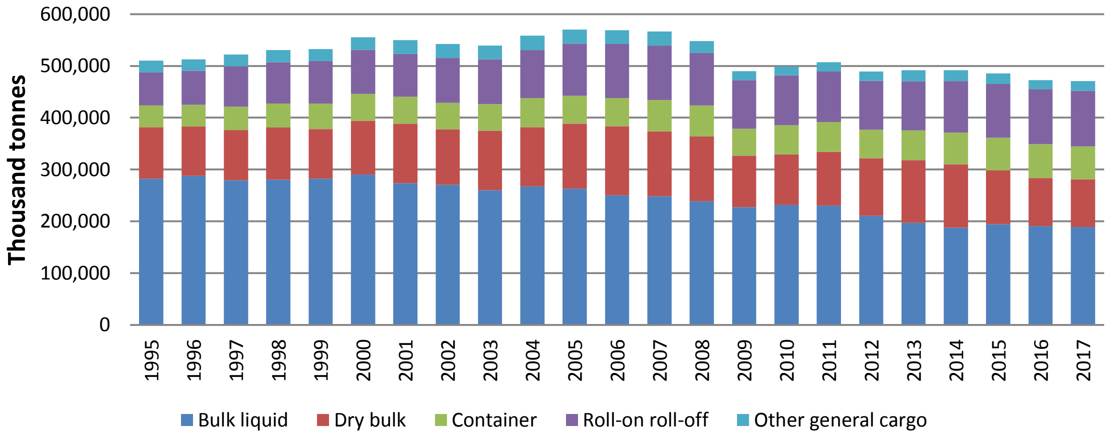


Figure 10 provides the indexed trend for port traffics through major UK ports between 1995 and 2017 and shows there has been a de-coupling of aggregate port traffic in tonnes and overall GDP. The trend for bulk and general cargoes reflects the relative decline of heavy industry and manufacturing exports, while unit load traffics (roro and containers) have broadly tracked GDP growth; this trend underlines the shift to a service based economy and greater reliance on imports of consumer goods. It also reflects the greater integration of the UK economy with the EU and the rest of the world, with the high value added manufacturing that remains often being dependent on imports of components.

Figure 10: UK Major Port Traffic (exluding Bulk Fuel) & GDP 1995-2017: indexed on tonnes (1995 = 100)

Source: DfT Port Freight Statistics

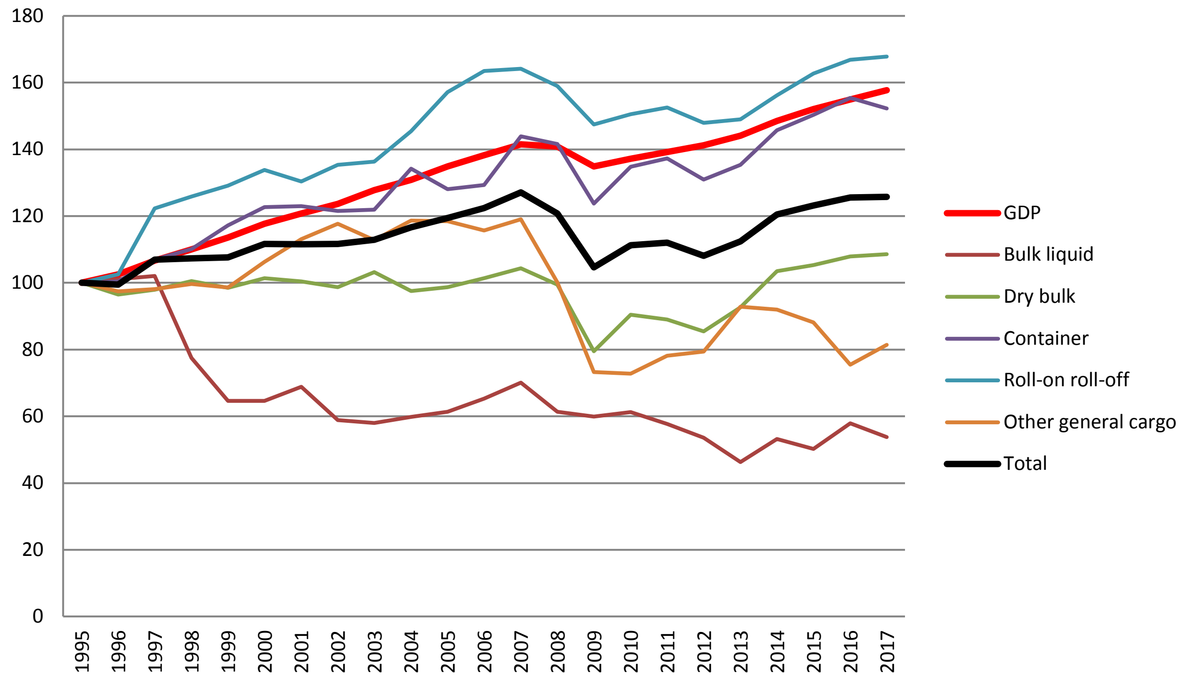
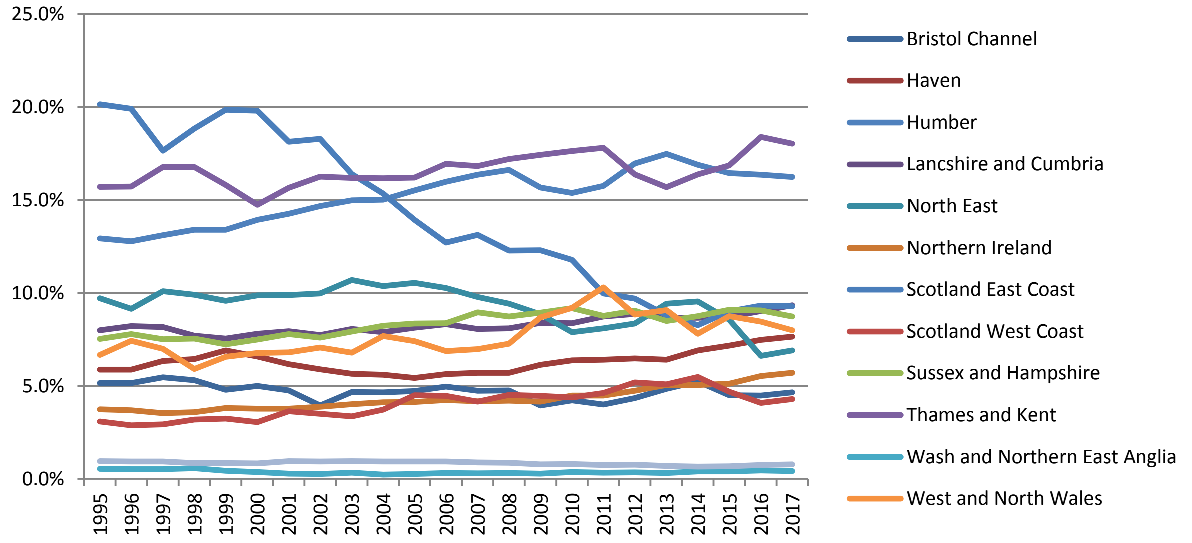


Figure 11 below provides the trend in port traffic market share by port region over the period 1995-2017 and shows how traffic has gradually shifted towards deep water ports that can handle the largest ships, particularly in the deep sea container sector. Thus, for example, the Haven port grouping (which includes Felixstowe), the Sussex and Hampshire port grouping (Southampton) and the Thames and Kent port grouping (London Gateway) have increased their market share. Multi-purpose deep water ports that handle significant volumes of roro traffic (such as Immingham in the Humber port region and Liverpool in the Lancashire and Cumbria port region) have also increased their market share as trade with the rest of the EU has grown. Port regions that have lost significant market share have tended to be those that have experienced a reduction in hydro-carbon traffic as North Sea oil has declined, such as the North East and the Forth.

Figure 11: UK port traffic 1995-2017: market share by port grouping

Source: DfT Port Freight Statistics



Roll-on roll-off

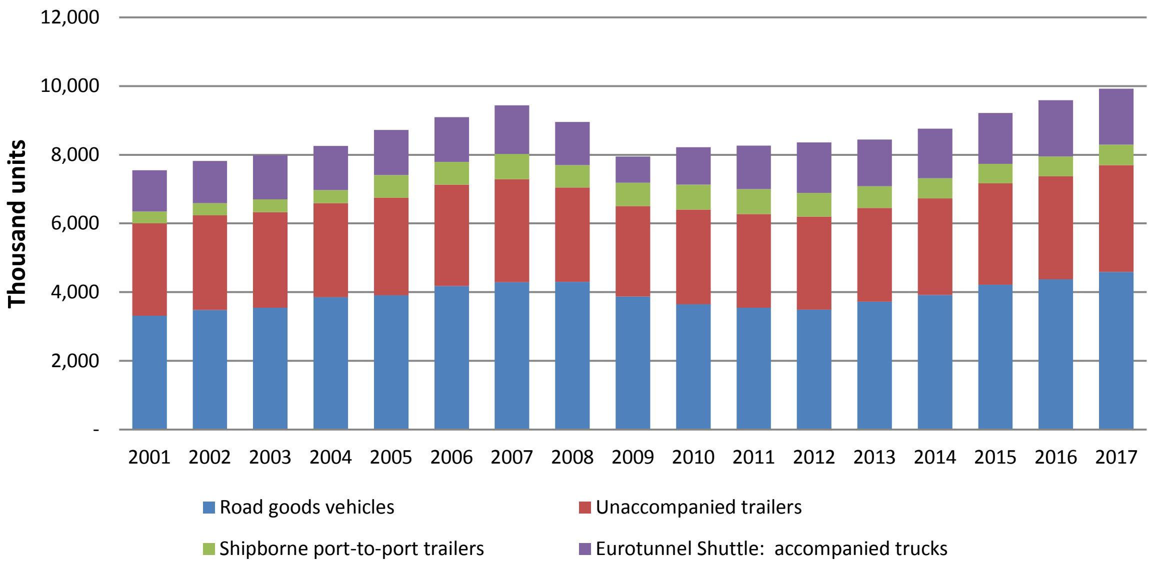
The roll-on roll-off ferry industry started in the UK in 1948 with a service between Preston and Larne in Northern Ireland and the first service to the continent opened between Tilbury and Antwerp in 1957[v]. The roro industry, which took off in the 1970s, was (and still is) effectively a maritime extension of the road haulage industry, providing road hauliers with a seamless journey across a stretch of water with no need to disturb the load. The introduction of the EU Single Market in 1993 and the opening of the Channel Tunnel in the same year (which forced the cross-Channel ferry industry to become more efficient) led to increasing volumes of freight traffic crossing the Dover Straits.

Roro has therefore been a major growth sector for short sea traffic between Great Britain and the Continental mainland and Ireland as shown in Figure 12. A 'unit' in this context is, in general terms, the equivalent of a 13.6 metre long semi-trailer which is transported by sea or on the Eurotunnel/Getlink Shuttle between Folkestone and Calais as either:

- An accompanied truck, which is transported on a ferry or on the Eurotunnel/Getlink Shuttle as an HGV accompanied by a driver;
- An unaccompanied trailer, which is transported on a ferry without a tractor unit and driver; or
- A container that is transported on a container ship or on a ferry ('shipborne port-to-port trailers').

Figure 12: UK short sea roro market 2001-2017

Source: DfT Port Feight Statistics & Getlink



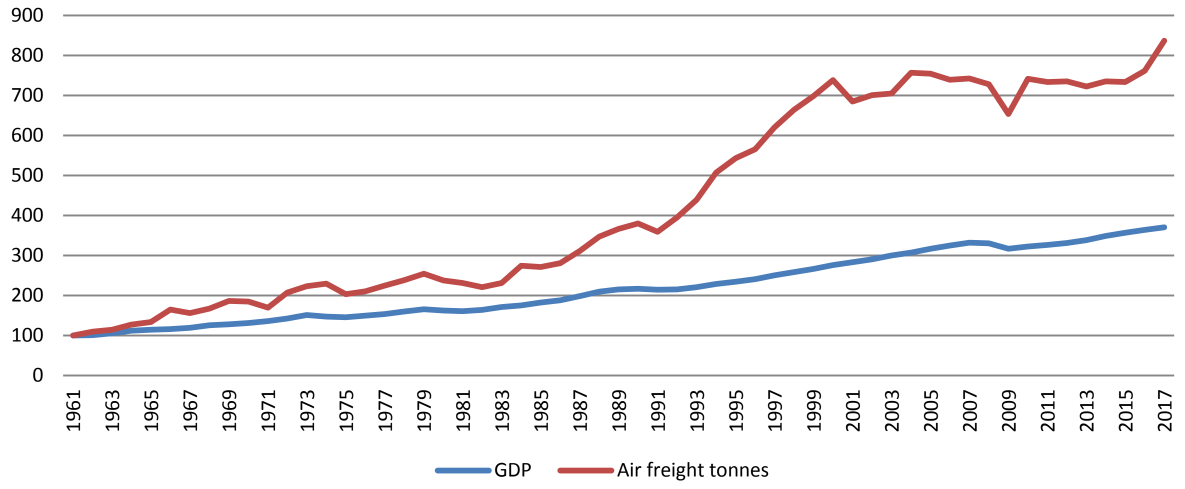
Short sea roro traffic overall grew from 7.5 million units in 2001 to 9.4 million units in 2007 before falling back to 8.0 million units in 2009 and then reached a new record high of 9.9 million units in 2017. The growth in the roro sector has been driven by increasing integration of the UK economy with that of the rest of the EU, so that, for example, parts for final assembly in UK factories and fresh produce for UK supermarket chains can be delivered on a just-in-time basis using accompanied HGVs from the continental mainland. The convenience of the frequent and short crossings of the Dover Straits has led to an increasing concentration of roro traffic on these routes, although there is also a network of mainly unaccompanied roro services operating between the continental mainland and the major east coast estuaries.

2.6 Air freight

Figure 13 provides the indexed trend for air freight traffics (including any transhipped traffic) through UK airports between 1961 and 2017 and shows that air freight volumes have increased well above the trend for overall GDP. However, air freight growth flattened out after 2001 which is likely to reflect the impact of the events of 9/11, the global slowdown in 2008-09 and also the growing cost competitiveness of the global container shipping industry as ship size increased in order to reduce unit costs. It remains to be seen whether the recent upturn in air cargo in 2016-17 is the start of a long-term trend.

Figure 13: UK Air freight lefted & GDP 1961-2017: indexed by tonnes (1961 = 100)

Source: Civil Aviation Authority & Office of National Statistics



Air freight volumes handled at UK airports totalled 2.6 million tonnes in 2017, representing about 0.5% of the traffic handled at UK ports in terms of volume. Although air freight has a much higher value per tonne than traffic handled at ports, it is less significant in terms of inland transport apart from around major air freight hubs such as London Heathrow, East Midlands and London Stansted Airports.

The long-term trend in air freight further demonstrates the shift to a service based economy and the increasing length of supply chains. Most of the growth has been at London Heathrow Airport, which has developed as a major hub airport for both passengers and freight; about one-third of Heathrow airfreight traffic is transhipped (moved between aircraft) or to/from mainland Europe. This increasing dominance of Heathrow has been assisted by the increasing carriage of freight on wide-bodied passenger jets on key trade-routes (e.g. Transatlantic and Far-East-Europe) rather than on freighters and an increase in the number of long-haul routes to and from Heathrow due to further liberalisation of the airline market.

2.7 Other modes

There are no official statistics available on trends in the use of the active modes of transport, namely cycling and walking, or other ‘alternative’ modes. There has been longstanding use of active modes of transport by Royal Mail for the delivery of letters and packets in towns and cities, but there is also increasing use of cycling and walking by courier companies to make final deliveries and collections of parcels in urban areas due to increasing road congestion and the need to operate within pedestrianized zones.

Deliveries of parcels by bicycle are therefore already possible in a number of urban areas for the delivery of light-weight and smaller parcels, particularly as separate infrastructure is developed for cyclists. With the increased importance of e-commerce, which involves the delivery of smaller parcels rather than larger consignments to retail outlets, the international parcels delivery companies that work for e-commerce retailers are more prepared to hand over parcels for 'last mile' deliveries to local courier companies for deliveries into the centre of urban areas. Bicycles can be used for a wide variety of deliveries and collections of goods such as prescription drugs and collections of waste as well as parcels and documents.

As urban centres have become pedestrianized with time windows that only allow road freight vehicles access at the beginning and the end of the day, final deliveries and collections are also carried out on foot by delivery staff.

There has been limited use of unmanned aerial vehicles ('drones') for the transport of freight for niche purposes, such as the delivery of medical supplies to Alpine communities. However, the wider application of this aerial mode of transport is being considered by e-commerce companies such as Amazon for the final delivery of parcels. In the long-term the drones are likely to be of two main types: vertical take-off and landing (VTOL) drones with relatively low payloads and making local deliveries; and fixed wing drones with higher payloads and a greater range, operating on inter-regional or even international routes. The final size of the probably niche potential market is likely to be determined by the quality of service that the drones could provide and the costs relative to the existing transportation solutions in the market segments that are most likely to be addressed. These could be particularly 'urgent' segments of the market for local deliveries (for VTOL drones) and inter-regional or international deliveries (for fixed wing drones), such as parts for production processes and pharmaceuticals and medical devices or even same-day e-commerce deliveries.

2.8 Relationship between economic activity and road freight tonnes

The relationship between changes in economic activity (changes in gross value added or GVA) and the amount of freight demand by relevant industry was of particular interest for the study to allow a view to be taken as to whether there was any observable trend in the intensity of use of road freight by sector as the level of activity changed; in other words, whether the sectors have generated more or less freight tonnes to produce the same amount of economic activity. This is important for the forecasting up to 2050 because provides evidence about the potential future relationship between GVA and demand for freight transport (see section 4.2 below).

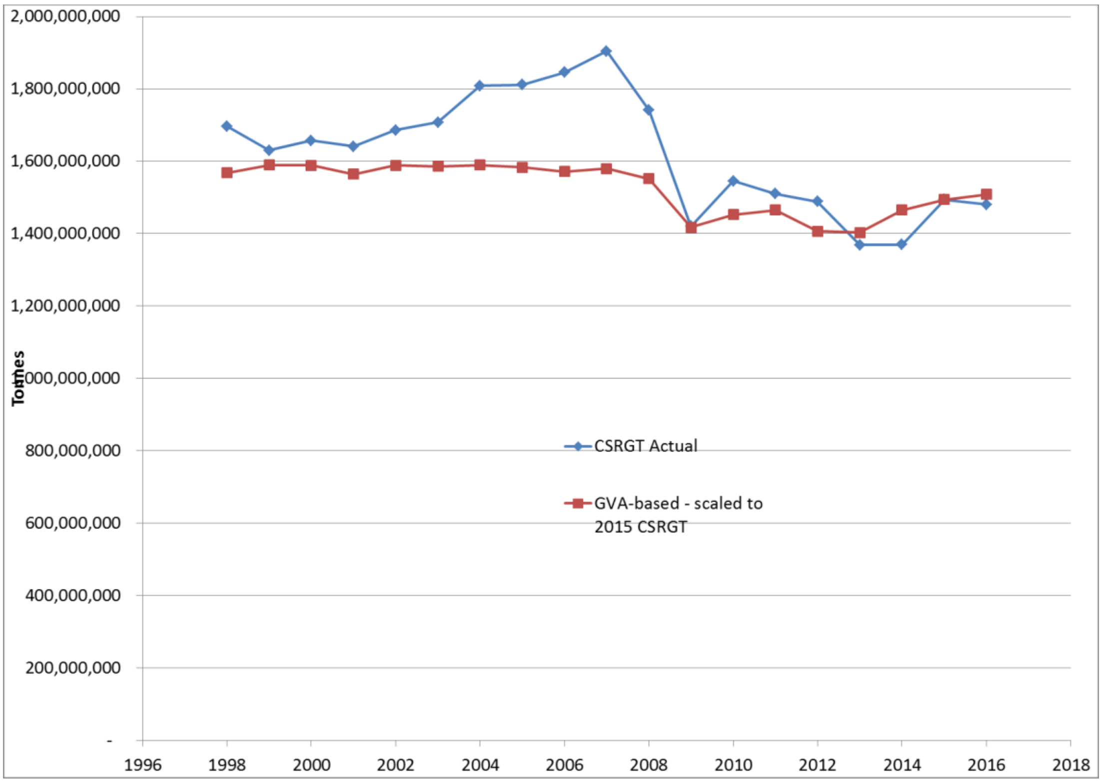
In order to examine the recent historic relationship between changes in economic activity and the amount of freight demand by relevant industry we compared:

- Supply and Use Tables[vi] for the UK, which provide estimates of industry inputs and outputs in tonnes for given GVA by industry sector; and

- Road freight tonnes by commodity as reported in the DfT's official survey of HGV road freight transport movements (the Continuing Survey of Road Goods Transport, CSRGT) (Figure 14).

While there were some significant variations in particular sectors, the aggregate position for all industry sectors is shown in the following chart, with the GVA-based tonnes calculated using the Supply and Use Tables and then scaled to the 2015 CSRGT figure.

Figure 14: Relationship between aggregate GVA by industrial sector and road freight tonnes lifted, 1998-2016



Prior to the Great Recession in 2008-09 the economy was, overall, consuming and generating an increasing number of tonnes per unit of GVA, which may have reflected increasing efficiency of production so that the same amount of GVA led to more tonnes. This was particularly the case for sectors that are important for construction and manufacturing, such as mining and quarrying (see Appendix 1 Chart 3), wood manufactures (Appendix 1 Chart 6), machinery and equipment (Appendix 1 Chart 11), furniture and other manufactures (Appendix 1 Chart 13) and secondary raw materials (Appendix 1 Chart 14). There was generally a closer correlation between freight tonnes and economic activity in sectors that are more closely related to consumption by final consumers, such as food and beverages (Appendix 1 Chart 4) and petroleum products (Appendix 1 Chart 7).

There was then a fall in the tonnes generated compared to GVA during and after the Great Recession in 2008-09 and this may indicate a trend towards the consumption and generation of higher value commodities, more rapid switching to a service-based economy and the closure of heavy industry which, prior to the downturn, tended to generate higher tonnages.

There is a closer correlation between overall GVA and road freight tonnes lifted since the economic downturn in 2008-09, but with GVA overall increasing at a slightly faster rate than freight tonnes. This may indicate that the Great Recession - the most severe economic crisis since the Great Depression in the 1930 - continued and perhaps in effect even 'completed' the process of de-industrialisation that began in the late 1970s and early 1980s. That is, the Great Recession effectively 'corrected' the economy in eliminating less competitive industrial activity which was generating relatively high freight tonnages. It also provides some evidence for the view that future economic growth may not be as 'freight intensive' as historic growth.

Having considered historic trends, both taking a long-term view and looking at more recent trends since the end of the Great Recession, the following sections considers the 'current' pattern of freight demand.

2.9 Current freight demand

Road and rail freight flows

In order to establish the aggregate demand for all UK domestic and international road and rail freight, domestic road freight data[vii] was combined with data on international road haulage[viii] and rail freight data from Network Rail (Table 1). Total freight lifted in the UK by road and rail in 2016 amounted to 1.6 billion tonnes of goods. Of the total goods lifted, 83.7% had an origin in England, 2.4% had an origin in Northern Ireland, 4.9% had an origin in Wales and 9.0% had an origin in Scotland.

Table 1: Total estimated UK freight lifted in tonnes by origin-destination region, 2016

Million tonnes

	Origin tonnes	Destination tonnes	Net export/(imports)
North East	58	56	2
North West	174	182	(8)
Yorkshire And The Humber	177	168	9
East Midlands	181	164	17
West Midlands	148	158	(10)
East of England	198	189	9
London	98	116	(18)
South East	187	199	(12)
South West	135	127	8
Wales	80	75	5
Scotland	145	146	(1)
Northern Ireland	39	39	-
Total	1,620	1,620	

Source: MDS Transmodal analysis of data from DfT's Continuing Survey of Road Goods Transport (GB & Northern Ireland), International Road Haulage Survey & Network Rail data

The balance of inwards and outwards flows for each region reflects their specific economic and demographic structure and whether they contain major generators of freight tonnes, such as extractive industries and deep water ports. The main net ‘importing’ regions tend to be those with the largest population centres that have inwards flows of finished retail products and construction materials, whereas the main net ‘exporting’ regions tend to contain quarries and deep water ports.

Freight moved in the UK by road and rail in 2016 amounted to an estimated 187 billion tonne kilometres, with each tonne being moved on average 116km (Table 2).

Table 2: Total estimated UK freight moved in tonne km by origin-destination region, 2016

	ORIGIN		DESTINATION	
	Origin billion tkm	Av. distance moved (km)	Destination billion tkm	Av. distance moved (km)
North East	6.7	114	6.2	111
North West	20.9	120	22.1	121
Yorkshire And The Humber	21.9	124	19.1	114
East Midlands	21.6	119	19.2	117
West Midlands	16.9	114	18.4	116
East Of England	23.1	117	22.0	116
London	6.3	65	9.3	80
South East	24.0	128	26.6	134
South West	15.9	118	14.9	117
Wales	10.3	128	8.9	120
Scotland	16.8	117	17.6	120
Northern Ireland	2.7	70	2.7	70
Total	187.2	116	187.2	116

Source: MDS Transmodal analysis of data from DfT's Continuing Survey of Road Goods Transport (GB & Northern Ireland), International Road Haulage Survey & Network Rail data

The average distances moved in each region reflect, once more, their specific economic and demographic structure, the geographic size of the region and therefore the maximum length of haul that is available, and whether they contain major generators of freight tonnes, such as extractive industries and deep water ports. For example, the region with the shortest average length of haul for both inward and outward flows is Northern Ireland, which mainly reflects its relatively small size; the comparatively short hauls for freight flows to and from London reflects the density of the economic activity and levels of congestion, with bulk construction flows being taken as close as possible to the final origin or destination, and retail and office supplies being distributed to the capital from warehouses located in the wider South East. On the other hand, the region with the longest average length of haul for both inwards and outwards flows is the South East, which has sizeable population centres served from warehouses but also contains major international gateways such as the Port of Dover, the Port of Southampton and the Channel Tunnel which cater for long distance flows to and from National Distribution Centres in the Midlands and direct flows to/from all the regions of the UK.

The rail modal share in terms of freight moved was an estimated 10% in 2016 (Table 3), with the highest share for rail being 16% in Yorkshire and the Humber where there are significant bulk rail movements to and from the port of Immingham, while the lowest market share was in Northern Ireland where there is no rail freight activity.

Table 3: Total UK freight by road & rail by origin region, 2016

Billion tonne km

	Road tkm	Road modal split %	Rail tkm	Rail modal split %	Total tkm
North East	5.9	88%	0.8	12%	6.7
North West	19.2	91%	1.8	9%	20.9
Yorkshire and the Humber	18.4	84%	3.6	16%	21.9
East Midlands	18.9	88%	2.7	12%	21.6
West Midlands	16.0	95%	0.9	5%	16.9
East Of England	20.8	90%	2.4	10%	23.1
London	5.9	93%	0.4	7%	6.3
South East	22.7	95%	1.3	5%	24.0
South West	14.0	89%	1.8	11%	15.9
Wales	8.8	85%	1.5	15%	10.3
Scotland	15.2	90%	1.7	10%	16.8
Northern Ireland	2.7	100%	0.0	0%	2.7
Total	168.4	90%	18.8	10%	187.2

Source: MDS Transmodal analysis of data from DfT's Continuing Survey of Road Goods Transport (GB & Northern Ireland), International Road Haulage Survey & Network Rail data

Road freight flows and the location of distribution centres

Figure 15 shows the estimated flows of HGVs on the GB road network, highlighting how the major flows are concentrated on the motorway and trunk road network which, according to Highways England, only accounts for only 2.4% of the total English road network. The road haulage industry is therefore highly reliant on the Strategic Road Network for the distribution of ‘heavy’ freight between major origins and destinations of freight (ports, factories, distribution centres, quarries, retail outlets), while they need to use more local roads for ‘last mile’ collections and deliveries.

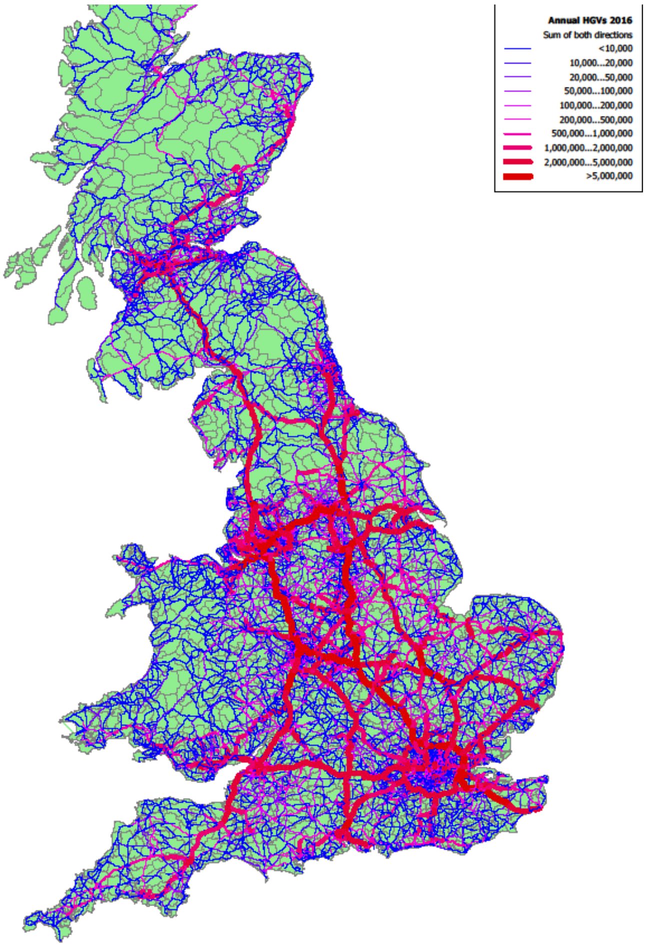


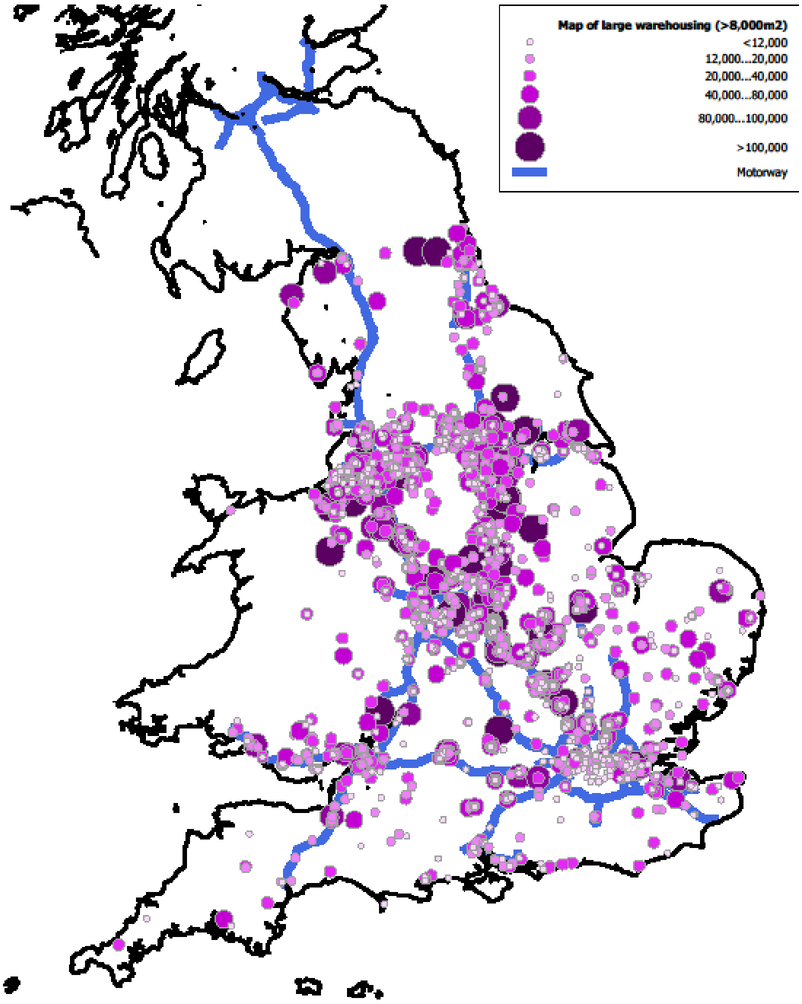
Figure 15: Annual HGV flows on the GB road network, 2016

Source: MDS Transmodal GB Freight Model

Distribution centres, where freight is stored and sorted, are key hubs in the ‘freight trasport system’. Figure 16 shows the location of ‘large’ distribution centres in England, defined as those with more than 8,000 square metres of storage space. The map shows there is a concentration of distribution centres (particularly National Distribution Centres serving the whole of GB and sometimes Ireland from a single location) in the so-called logistics ‘Golden Triangle’ in the Midlands, but there are also significant concentrations of Regional Distribution Centres (RDCs) located within or close to the major British conurbations. South Yorkshire and the North West also have concentrations of NDCs, as the ‘Golden Triangle’ has extended northwards to obtain lower land and labour costs, while still providing a competitive location for inbound and outbound transport costs.

Figure 16: The location of distribution space over 8,000 square metres in England and Wales in 2017

Source: MDS Transmodal, based on Valuation Office Agency data[ix]



The concentrations of distribution centres in different regions reflects their competitiveness in terms of total transport costs for inbound and outbound cargo, land values and the cost of labour. The Midlands and parts of the North of England tend to be the most favoured areas for NDCs because these areas minimise the overall costs when goods have to be received from both overseas and around Britain and then distributed to all other British regions. This is shown in Table 4 below, which compares the proportion of distribution centre space (medium and large-scale distribution centres over 5,000m^2) in England and Wales by region compared to the proportion of the population. Whereas London – with 15% of the total population of England and Wales and only 6% of the warehousing space – is relatively under-represented, the East Midlands – with only 8% of the population but 17% of the warehousing space – has a relative specialisation in providing distribution space serving a national hinterland. Similarly, the West Midlands and, to a lesser extent, the North

West and Yorkshire and the Humber specialise in providing National Distribution Centres as well as Regional Distribution Centres.

Table 4: Comparison of warehousing space with population for English regions & Wales in 2016-17

Region	Proportion of warehousing space (more than 5,000m2) in 2017	Proportion of population in mid-2016
East of England	10%	11%
East Midlands	17%	8%
London	6%	15%
North East	3%	5%
North West	15%	12%
South East	10%	15%
South West	6%	9%
Wales	3%	5%
West Midlands	16%	10%
Yorkshire and The Humber	12%	9%
Total	63.8 million m2	58.4 million

Source: MDS Transmodal Distribution Centre Database & Office for National Statistics

Table 5 provides estimates of the freight moved by Light Goods Vehicles (LGVs, defined as goods vehicles with a gross vehicle weight up to 3.5 tonnes) by region in terms of vehicle kilometres, derived from national surveys of LGVs carried out by the DfT in 2003-05. LGVs moving freight are estimated to cover 25.6 billion km per annum, with a much lower average distance per trip of 9.3km compared to HGVs; this reflects the use of LGVs in the freight market for relatively 'last mile' deliveries and 'first mile' collections of freight such as parcels, office supplies and foodstuffs focused mainly on urban areas.

The use of LGVs for freight deliveries and collections is fairly self-contained as logistics providers will generally use HGVs to minimise unit costs for the transportation of heavier and/or voluminous goods over longer distances. For example, HGVs are used for urban deliveries and collections when the shipper or receiver has a consignment of sufficient size (such as a delivery to a major supermarket chain) and where physical access for the larger vehicles is possible.

Table 5: Total estimated GB LGV freight moved by origin-destination region, 2016

Vehicle km

	ORIGIN		DESTINATION	
	Billion vehicle km	Av. distance moved (km)	Billion vehicle km	Av. distance moved (km)
North East	0.89	7.3	0.87	7.3
North West	3.14	9.5	3.10	9.5
Yorkshire and The Humber	2.29	8.6	2.19	8.6
East Midlands	2.32	11.3	2.30	11.3
West Midlands	2.12	11.2	2.18	11.2
East of England	2.87	10.9	2.91	10.9
London	1.95	7.0	1.99	7.0
South East	3.71	10.6	3.88	10.6
South West	2.87	9.4	2.78	9.4
Wales	1.51	7.2	1.52	7.2
Scotland	1.91	8.2	1.87	8.2
Total	25.58	9.3	25.58	9.3

Source: MDS Transmodal analysis of LGV data for the DfT National Transport Model

Figure 17 shows the aggregated flows of LGVs carrying freight on the GB road network, which shows greater concentrations of flows to, from and within urban areas rather than the inter-regional trunk movements that are observed for HGV flows (see Figure 14). These LGV flows add to congestion on urban networks during the morning and evening peaks (mainly caused by passenger cars), just as HGVs add to congestion mainly caused by passengers cars on more strategic road networks.

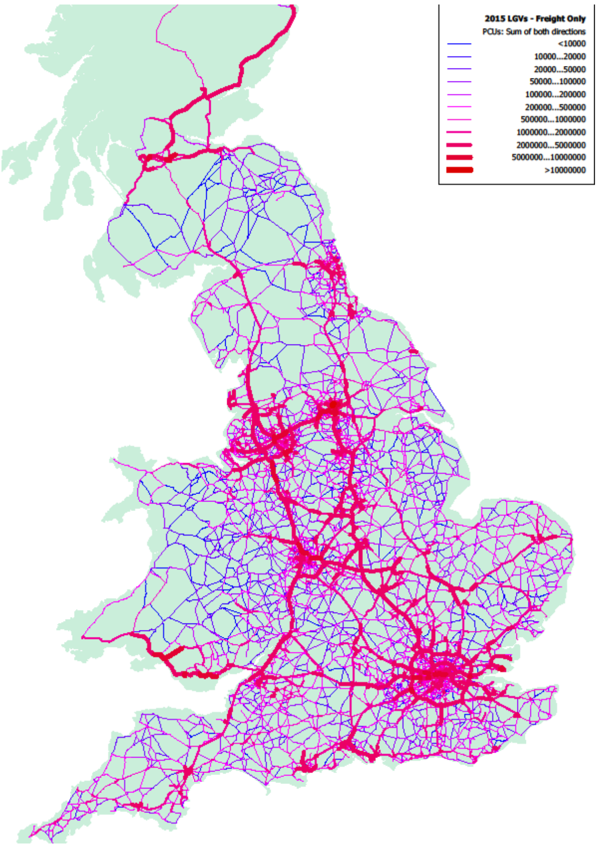


Figure 17: Annual LGV flows on the GB road network, 2016

Source: MDS Transmodal GB Freight Model

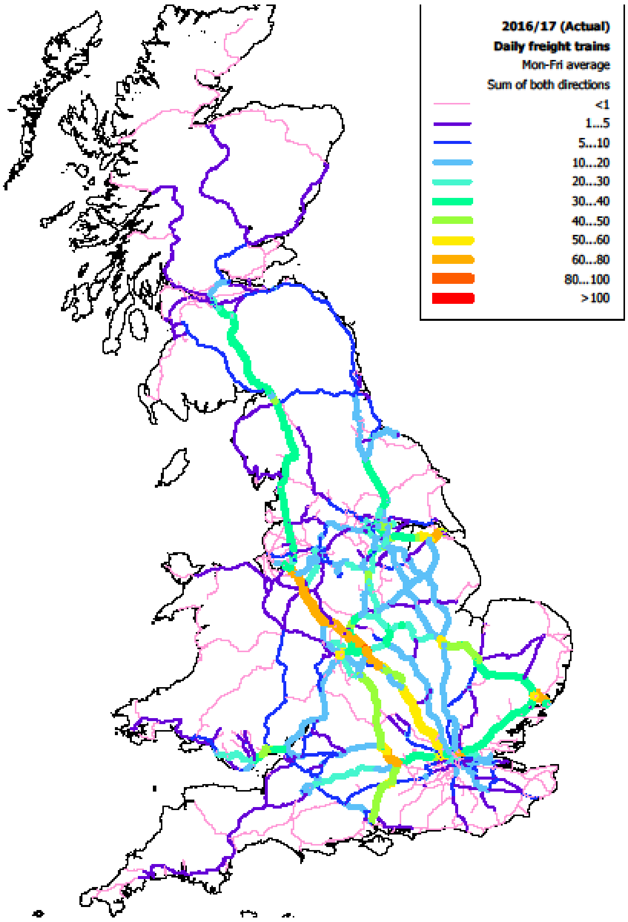
Rail freight flows and the location of rail-connected distribution parks

Figure 18 shows the estimated flows of rail freight services on the GB rail network in terms of average weekday trains in 2016-17, highlighting how the greatest concentrations of flows are on some key strategic corridors such as:

- The West Coast Main Line (London-Midlands-North West-Scotland);
- The East Coast Main Line (London-Leeds-Yorkshire-North East-Scotland)
- Between the two major deep sea container ports of Felixstowe and Southampton and the West Coast Main Line;
- Bulk cargo flows to/from the port of Immingham on the south bank of the Humber.

Figure 18: Average daily freight trains on the GB rail network 2016-17

Source: MDS Transmodal GB Freight Model



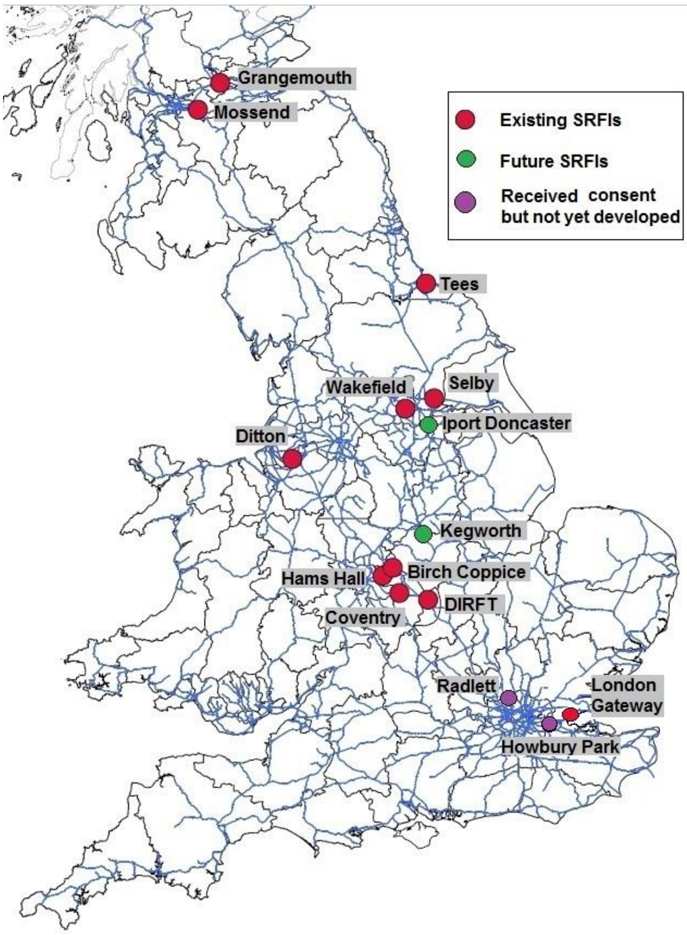
Rail freight terminals needed to transfer cargo between rail and storage facilities or other modes of transport are of three main types: bulk terminals, intermodal rail freight terminals and Strategic Rail Freight Interchanges (SRFIs). While bulk rail terminals are normally located on private sidings that are either owned or leased on a long-term basis by the shippers and receivers of the cargo, intermodal rail freight terminals are open access facilities designed to transfer unitised cargo (mainly in maritime containers) between rail and road There are existing intermodal terminals at the main deep sea container ports as well as some short sea container ports and in the British regions with major population centres (i.e. Greater Manchester, West Yorkshire, Liverpool, the West Midlands, Bristol, London, South Yorkshire and the Central Belt of Scotland). Most of these terminals, which were originally developed by British Rail in the 1960s and 1970s, have no distribution centres located on the same site.

The intermodal rail freight sector has seen growth in recent years and this is due partly to the growth in traffic via deep sea container ports, where the origin or destination is rail-connected (at the port) so that road collection or delivery is not required at one end of the transport chain. In the intermodal sector, therefore, the key factor in attracting traffic away from road transport, particularly over distances less than 250km, is the development of large scale distribution parks at sites with intermodal rail terminals in order to have both ends of the transport chain connected to the rail network. In planning terms, these rail-connected distribution parks are called Strategic Rail Freight Interchanges (SRFIs). When large distribution centres are located on rail-served sites (over 60 hectares, as defined in the National Planning Statement for National Networks[x]), rail is able to offer significant cost advantages over road transport and the concentration of large scale distribution centres on a single site also generates the requisite volumes of cargo to fill full-length trains. The Government has sought to promote their development by classifying them as Nationally Significant Infrastructure Projects (NSIP) and including them in the National Planning Statement for National Networks policy statement.

Figure 19 shows the location of existing Strategic Rail Freight Interchanges (SRFIs) in Great Britain, including those which have been granted consent and are currently under development. Consent for SRFIs at Radlett (Hertfordshire) and Howbury Park (Dartford) have previously been granted, albeit work has yet to commence on construction; in the case of Howbury Park, the consent time limit has passed and a fresh application is being progressed.

Figure 19: Location of Strategic Rail Freight Interchanges in Great Britain

Source: MDS Transmodal

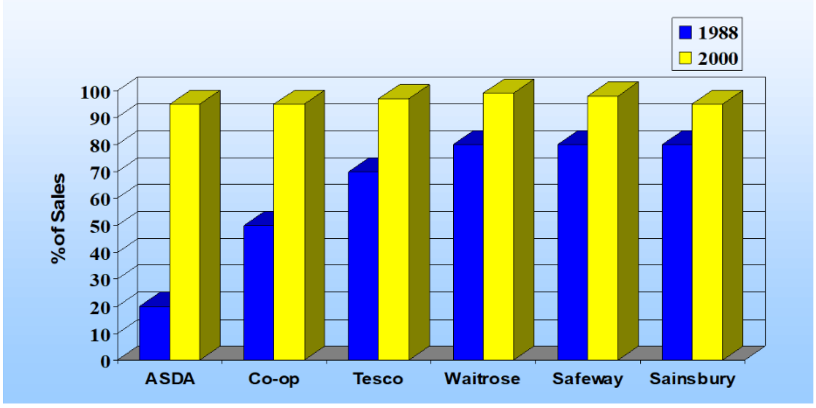


2.10 Trends in retail logistics

Centralization of retail logistics

Over the last 30 to 40 years there has been a process of centralization of retail logistics aligned to concentration of the retail market place. Effectively the major retailers have taken control of the supply chain and created their own networks of national and regional distribution centres to which suppliers and manufacturers deliver direct from national warehouses, factories or by container from international sources. The implication of this change is that manufacturers and suppliers have cut back on their distribution networks that were able to make small delivery drops direct to high street premises. Figure 20 below illustrates the centralization of distribution activity by the major food retailers.

Figure 20: Percentage of sales delivered by major retailers to their own outlets in 1988 & 2000



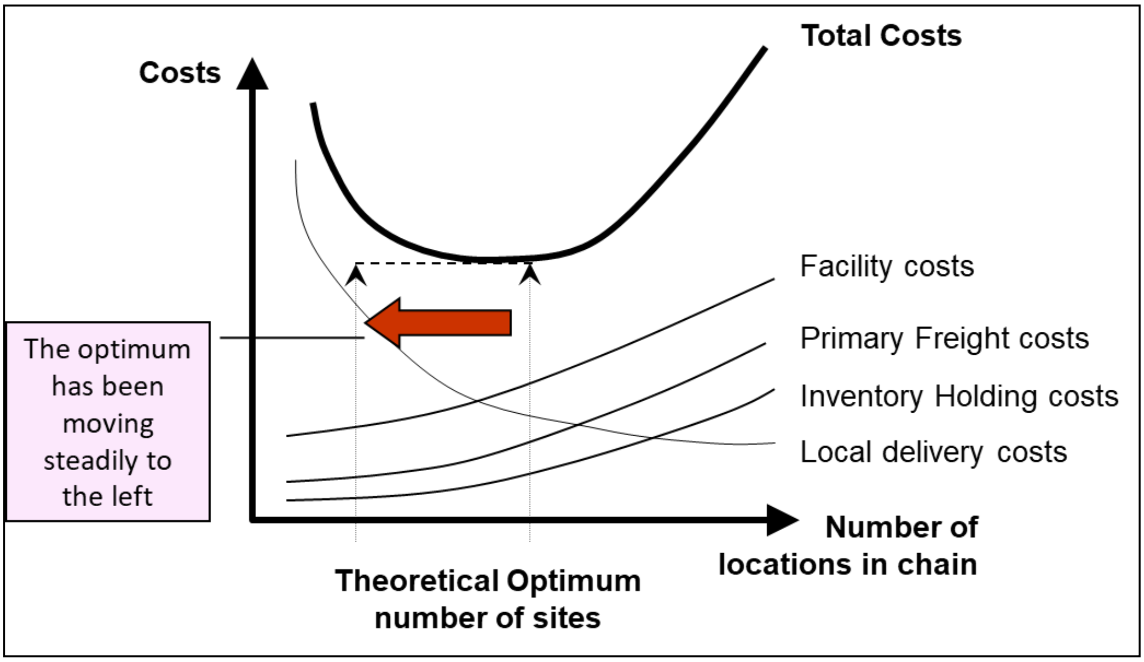
Source: Professor Alan McKinnon, Herriott Watt University

Figure 20 shows the major grocery chains completing their centralization process by 2000. This means that less than 5% of turnover is related to products that are delivered by suppliers directly to stores such as bread and daily newspapers where the need for 'freshness' is such that the goods cannot generally be handled through regional distribution centres; goods from local suppliers would be another example along with some non-food suppliers.

and the underlying supply chain and logistics theory in which using larger and fewer warehouses has more than offset the cost of the final delivery.

Figure 21 shows the supply chain and logistics theory which has been behind this process of centralization. The ability to organize and run increasingly large warehouses (often up to 70,000 m^2) offers lower overheads combined with reduced risk and a lower cost of stock holding for retailers; this more than offsets the higher cost of delivery to stores for the retailers. As Figure 21 shows the optimum has been moving steadily to towards a smaller number of larger distribution centres.

Figure 21



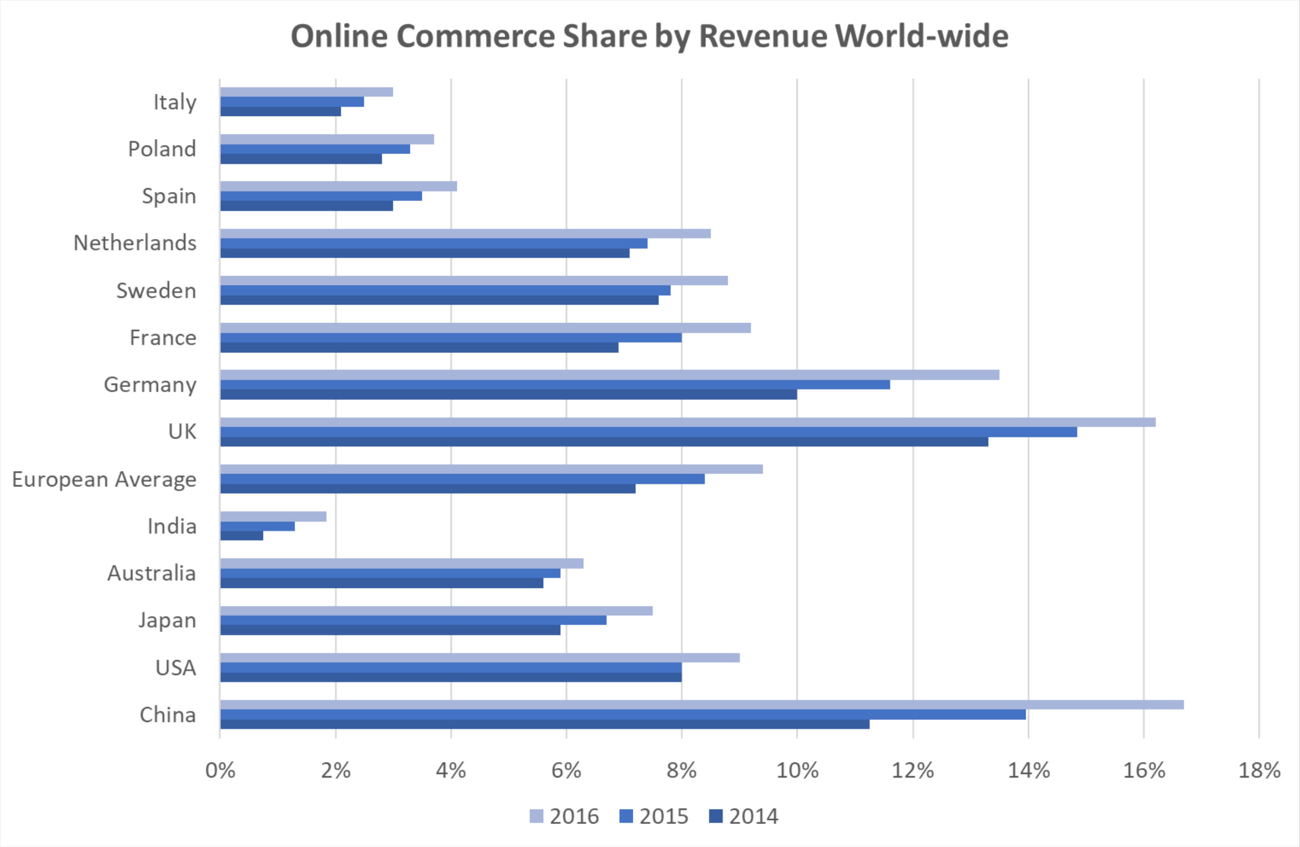
Source: Adapted from 'Business Operations Model – becoming a disruptive competitor' by Braithwaite, A and Christopher, M published by Kogan Page 2016

This trend has been supported by the increasing size of retail stores, which are able to hold more range and offer greater variety to customers. This has occurred across all sectors, not just food but also DIY, electrical, clothing, stationery and furniture.

The rise of e-commerce

A more recent trend than retail logistics centralization has been the meteoric growth in retail e-commerce. The UK has the highest penetration of any market in the world other than China as illustrated in Figure 22.

Figure 22: E-commerce market penetration by country, 2014-16



Source: Data combined and averaged from Forrester Research, the Centre for Retail Research and eMarketeer; graph first published by RAC Foundation in report: The implications of internet shopping on the van fleet and traffic activity.

A market share for e-commerce in the UK of between 16% and 20% conceals a much higher market share in some product segments, given that the current share in the food segment is around 9% but food is about 50% of all direct retail turnover. In other segments, such as books, media and clothing, the e-commerce market share is therefore much higher.

The physical logistics impacts of the combination of the process of centralisation and huge e-commerce growth, have, for most retailers, been centralised logistics with sophisticated warehouses containing levels of automation that are able to accommodate the range of items on sale. These sites are feeding the courier delivery networks, either through their hubs or directly into local depots or directly to retail stores.

The alternative e-commerce fulfilment model is ‘fulfil from store’ as exemplified by the food sector, where retail store picking is the most common method of e-commerce fulfilment. ‘Fulfil from store’ in other sectors is also making progress in the face of the need to provide same day fulfilment as a competitive weapon; Argos is perhaps the most notable example of this with its FastTrack service.

'Fulfil from store' leverages staff costs that would otherwise be less well utilized, promotes store footfall and drives stock turn; the downside is that each store may not have the full range due to space constraints and store stock accuracy is notoriously low making customer commitment difficult[xi].

2.11 Conclusions on the drivers of freight demand

The review of the history of freight transport and more recent trends suggests there are four main drivers of demand for freight transport, namely:

- The economy, which drives the aggregate amount of freight transport required both in terms of tonnes lifted and tonne kilometres;
- Consumer behaviour, which determines how and where retail goods are purchased and how these goods are delivered to consumers;
- Technology, which determines the cost and therefore competitiveness of each mode of freight transport and where goods can be sourced from;
- Policy and regulation, which also influences in particular the cost and competitiveness of each mode of freight transport.

Each of these key drivers of freight demand is considered in turn below.

The economy

There is a strong link between the state of the economy and demand for freight transport, as an increase in economic activity in a particular industry sector (for example, construction) would lead to an increase in the movement of freight (of aggregates and timber, for instance).

However, changes in the structure of the economy are also important, as some industrial sectors become less significant and others become more important. The most significant change since about 1980 has been the shift away from heavy industry and manufacturing (requiring the transport of a large volume of heavy raw materials, semi-finished intermediate goods and finished products) to a greater emphasis on service sectors which consume finished products that have increasingly been manufactured overseas. In many ways, the UK is an example of a post-industrial economy, even if some high value added manufacturing remains competitive (e.g. automotive, aerospace, pharmaceuticals).

Figure 4 in section 2.2 above shows how there was a close link between economic growth and freight transport demand up to 1980 due to importance of manufacturing industry, but after 1980 real GDP grew faster than freight transport demand in tonnes due to the rise of the service economy. However, freight demand in terms of tonne kilometres grew at a faster rate than tonnes as the average length of haul for road and rail increased due to sourcing over longer distances, including from overseas via the UK's international gateways.

Consumer behaviour

As a derived demand, the demand for freight transport does not come directly from consumer needs or wants but from private sector companies such as retailers and manufacturers. However such organisations are ultimately responding to consumer demand for goods and dealing with return flows such as unwanted or faulty goods and waste materials such as packaging for recycling or disposal. The level of demand for goods will be influenced by changes in tastes and fashions over time, as well as by the performance of the wider economy. Consumer behaviour is therefore another key driver of freight demand and consumers' demand for the convenience and cost effectiveness of e-commerce is rapidly changing the UK's retail industry and the way goods are purchased and delivered. Passenger trips to shops by consumers are being substituted increasingly by deliveries of parcels by freight transport operators to consumers' homes and offices and convenient e-commerce pick-up points, including traditional retail outlets (so-called 'click and collect').

Technology

Technological changes and innovation in freight transport have facilitated the development of mass and then lean production techniques, which have led to transformational changes in the UK economy since the 18th Century. Canals allowed raw materials and manufactured products to be distributed nationwide and to and from ports at a reasonable cost in the 18th and early 19th Centuries, while the railways provided high capacity freight transport with faster transit times from the latter half of the 19th Century.

The development and mass production of vehicles using the internal combustion engine in the early 20th Century and the development of the motorway network after World War 2 allowed road freight to increase its market share on longer distance hauls at the expense of the railways, without radically transforming the structure of the UK economy.

Containerisation of a wide range of cargoes since the 1960s, allied to the process of globalisation and investment in very large container ships, has made it easier for goods to be manufactured anywhere in the world and then distributed cost-effectively and securely to the UK[xii].

Greater use of integrated Information and Communications Technology (ICT) in supply chains since the 1980s have allowed companies to reduce their inventory, operate just-in-time supply of parts for assembly lines and operate increasingly lean manufacturing processes which has led to lower production costs and greater productivity for the UK economy.

As the history of transport since the Industrial Revolution in the 18th Century has shown, technological change in the freight transport sector has had a transformational effect on the economy and on society. This is likely to continue up to 2050 as the freight industry adapts to changing consumer demands, stronger environmental regulation and the challenges of an increasingly integrated global economy and is considered in more detail in section 3.6 below.

Public policy and regulation

Freight transport and logistics services are delivered almost exclusively by private sector companies, which invest heavily in fixed infrastructure such as port facilities, rail terminals, distribution centres, and mobile equipment such as trucks, vans, fork lift trucks, ships and railway locomotives and wagons. The private sector needs, however, to use publicly owned road and rail infrastructure and is subject to the taxation and regulatory regimes that the public sector puts in place. Furthermore the freight industry is competitive and is generally seen as a cost of production by manufacturers, which means there is constant pressure to minimise costs in order to remain competitive.

As the public sector is already a provider of transport infrastructure as a 'public good', it already has a significant impact on the competitiveness of the freight transport industry. However, the public sector can have a significant impact on freight transport demand in a number of other ways, as follows:

- Fiscal policy affects the relative economics of the different modes if the modes are taxed in different ways; examples of relevant taxes in the road haulage sector include fuel duty paid on the purchase of diesel and Vehicle Excise Duty paid on the vehicles.
- Energy and industrial policy affects total demand; for example, a generally non-interventionist industrial policy since the 1980s led to the decline of heavy industry and manufacturing in the face of overseas competition and removed sources of demand for the transport of raw materials and intermediate products for manufacturing processes. At the same time, it increased the demand for the transport of imported consumer goods via the ports and the Channel Tunnel. The UK's energy policy, as the UK seeks to reduce its greenhouse gas emissions, has led to the closure of coal-fired power stations and reduced the demand for imported steam coal via the ports and its inland distribution by rail.
- Environmental policy affects the choice of mode; for example, the introduction of Clean Air Zones in some urban areas, designed to reduce emissions that are harmful to human health, will have an effect on the costs of road freight transport operators as they transition to lower emission vehicles.
- Trade policy, which until very recently was moving gradually in the direction of lowering trade barriers, has increased the UK's propensity to import goods;
- Public funding of transport infrastructure affects modal economics in that greater capacity or new routes for a particular modal network can reduce the door-to-door journey time and reduce costs. This investment also has an impact on levels of road congestion, mainly caused by passenger cars, which affects the efficiency of the road freight industry.
- Regulations, particularly in relation to the size and weight of loads, have a significant impact on the economics of the different modes.

- Planning policy affects the location of the origins and destinations of freight transport movements. In particular, rail- and water-connected distribution parks require large-scale sites close to the major conurbations to justify the investment in rail and waterborne freight infrastructure, as well as road access, and such large sites may be difficult to find without encroaching on the greenbelt. The UK Government also has a direct planning role in decision-making for major infrastructure schemes that have an impact on the freight transport system, such as the third runway at Heathrow.

Public policy and regulation therefore has a significant impact on the behaviour of the freight industry and any change in the 'political economy of freight' may lead to more efficient (or potentially more inefficient) outcomes for society as a whole. At the same time any changes in policy and regulation will also affect the costs of the freight industry and the value of private sector investments that have been predicated on the existing fiscal and regulatory position.

2.12 Conclusion

The analysis of long-term trends suggests there has been a gradual de-coupling of aggregate freight moved/lifted and GDP from the early 1980s onwards due to the decline of heavy industry and manufacturing and the shift to a more service-based economy.

There has been overall growth in road freight modal share at the expense of rail freight since the inter-war period, although privatisation of the rail freight industry in the early- to mid-1990s arrested this decline. A recent and structural decline in the movement of imported coal by rail (driven by regulation and policy) has masked growth in the construction and intermodal sectors of the rail freight industry.

There has been a long-term trend since the 1950s for LGV road traffic to grow faster than HGV traffic, although only about one-third of LGV traffic is related to the movement of freight with the other LGV movements being related to the service sector and private use. The growth in LGV traffic since the 1980s has therefore mainly been due to the switch to a more service-based economy, but also, more recently, to growth in e-commerce which has substituted LGV movements for passenger car trips.

The relatively rapid growth in sourcing of goods from the EU and the rest of the world, substituting for domestic production, shows how deregulation, market liberalisation and the process of globalisation have led to greater integration of the UK economy with the EU and the rest of the world. With manufactured goods being transported by sea and air from the Far East, supply chains are probably reaching their maximum length. With domestic production declining, lower volumes of raw materials and intermediate manufactured goods are transported to supply domestic factories. The result is that freight transport services have increasingly been moving lighter consumer goods over longer distances.

Allied with an energy policy which is incentivising decarbonisation of the economy, these structural changes in the UK economy has led to a decline in the volume of bulk traffic through ports in the last ten years. Roro and lolo traffic in the other hand has reached record levels in 2016-17 and generally been in line with, or grown faster than, GDP growth. The growth trend in air freight volumes has also exceeded that for GDP.

In conclusion, our analysis of the history of freight transport since World War 1, analysis of statistical trends and the existing position in the freight market suggests that the key drivers of freight demand are:

- The state and structure of the economy, which leads to changes in the volume and mix of freight flows generated by different industrial sectors and affects the location of production and consumption. A key issue up to 2050 is the extent to which the UK might experience a renaissance in manufacturing, if only of high value manufactured products.
- Consumer behaviour, particularly in the retail sector which requires a market-led response from the private sector. While the retail sector has always been highly responsive to consumer trends, the importance of these trends has accelerated in the last decade as the internet has allowed consumers to purchase a wider range of products at any time of day and have them delivered to their home or place of work.
- Technological change, leading to changes in the relative cost effectiveness of the different types of ‘vehicles’ used to transport freight and therefore changes in modal share. For instance, the greater introduction of electric vehicles and the further deployment of connected and autonomous vehicles may have a significant impact on the relative cost of the different modes up to 2050.
- Public policy and regulation: changes in regulations, policies, taxation and land use planning in response to, for example, the need to reduce carbon emissions. Such changes in the political economy of freight transport affect the economics of the different modes of transport.

The switch towards a service-based economy since the 1970s was hastened by industrial policies in the 1980s, which gradually led to fewer concentrated flows of bulk commodities between mines and power stations and between ports and manufacturing plants, but greater flows of consumer goods either manufactured domestically in many different diffuse locations or imported via a number of different ports. This switch in the economic geography of freight flows favoured the flexibility provided by road haulage and reduced the flows available for bulk trainload and coastwise shipload volumes.

The main impact of technological and logistical change since World War 1 has been to allow the production and consumption of goods to move further apart. The canals allowed the initial process of industrialisation in the 19th Century and the railways drove the growth of industrial output during the late 19th and early 20th Centuries. Road haulage services, along with roro and container shipping services, have allowed the development of just-in-time supply chains and lean manufacturing in the late 20th and early 21st Century where, for example, automotive parts can be imported from the rest of the EU or the rest of the world for assembly in a car plant in the UK. The on-going process of the globalisation of industrial production beyond the major industrialised economies in the EU, North America and Japan has been driven by lowering trade barriers and cost-effective container shipping services so that consumer goods can now be manufactured in China or Vietnam and then shipped by container to the UK. We may now have reached the point where the distance between global production and global consumption cannot be extended.

How these key drivers may affect the future development of freight transport is considered in section 3 of the report.

3 SCENARIO DEVELOPMENT

3.1 Introduction

This section of the report sets out the approach to, and the results of, the process of developing qualitative scenarios for the future of freight demand up 2050. It includes the results of a review of previous freight transport demand forecasts since 2001 (the detail from which is included as Appendix 3), a description of the issues that were considered for each key driver of freight demand and a description of the final qualitative scenarios.

3.2 Review of previous freight demand forecasts

In order to ensure that the scenarios for freight demand up to 2050 learn some of the lessons from the previous development of national freight demand forecasts up to 2018, we completed a review of forecasting exercises since 2001. The detailed results of the review are provided in Appendix 3.

Most of these freight demand forecasting exercises since 2001 have been carried out by MDS Transmodal using its Great Britain Freight Model (GBFM), although rail freight forecasting was also carried out by Sinclair Knight Mertz for the Strategic Rail Authority using another model in 2003 and rail freight forecasts (without, as far as we can tell, the use of a freight transport demand model) were produced by ARUP for the DfT in 2016.

GBFM uses all the publicly available sourced data (DfT CSRGT data, Eurostat data, Network Rail data, DfT Port Freight Statistics) to develop a baseline origin-destination freight matrix for both domestic and international flows and then ‘explains’ these flows in terms of generalised costs for road, rail and maritime transport; these cost models have been validated to the costs experienced in the market. The model is calibrated to reproduce base year modal shares and routeings. The road freight origin-destination matrices for both HGVs and LGVs within GBFM have also been incorporated into the DfT’s National Transport Model in 2018. The model was audited by external experts in 2003-05 before it was included for the first time in the suite of models that form the DfT’s National Transport Model and, again for the DfT, in 2016 when it was used to produce pan-regional freight transport forecasts and modelling for Transport for the North.

The development of official freight demand forecasts by the public sector - for what is a private sector owned and operated sector – has generally been to meet specific policy needs, such as defining the ‘reasonable requirements’ for capacity for the rail freight industry (in the context of the Office of Rail and Road’s role in monitoring Network Rail) and the national need for infrastructure capacity for the ports industry that is subject to EU Habitats legislation. The other main reason for producing freight transport forecasts is to provide a view on the likely future demand for networks for planning purposes.

The methodology used to forecast aggregate freight demand has tended during the period since 2001 to move away from trend-based forecasting to determining the economic drivers for individual major commodities; independent forecasts for the relevant economic drivers can then be used to develop forecasts for the future period. For example, Government forecasts for electricity generation (for coal, gas, nuclear, renewables etc.) can be used to forecast the demand for rail freight transport services carrying imported steam coal between ports and inland power stations.

The choice of mode, routeing and, for international flows, port is generally based on the lowest generalised cost between individual origin-destination pairs expressed in terms of:

- Fixed (time-based) transport costs for equipment & labour etc.
- Variable (distance-based) transport costs such as fuel etc.

The modelling of freight transport has usually assumed that the capacity of the infrastructure is unconstrained, as the outputs from the modelling of freight demand is usually combined with passenger demand for the analysis or appraisal of mixed use road and rail networks.

The results of a review of the forecast levels of demand against actual demand experienced reflect the impact of changes in the macro-economic and policy context such as:

- The economic shock in 2008-09, which led to lower overall demand for freight transport from manufacturing industry and lower port traffic volumes and delay in investment in SRFIs by developers;
- The dramatic decline in the transport of coal moved due to the faster than expected closure of coal-fired power stations as a result of government energy policy;
- An actual reduction in the oil price, whereas a price increase was assumed by DfT in its transport planning guidance.

In response to the degree of uncertainty that is reflected in the above changes in the macro-economic and policy environment, there has been an increasing trend towards testing a range of scenarios rather than providing only a ‘central forecast’ of freight transport demand.

The scenario development for this study therefore focused on developing a number of scenarios, which seek to incorporate a range of possible answers for how the future of freight demand might develop up to 2050 to take account of the inherent uncertainty.

3.3 The scenario development process

The approach taken to develop the scenarios has involved:

- Determining the key drivers of freight demand (see section 2 above);
- Selecting variants for each driver to allow for inherent uncertainties;

- Defining a Business as Usual (counterfactual) scenario to allow comparisons to be made with other views of the future where significant change is being forecast;
- Defining themes for qualitative scenarios so there is an overall rationale for the selection of variants of each driver for each scenario;
- Workshops with both the NIC and with representatives of key stakeholders to test the plausibility of the qualitative scenarios;
- Modelling of the scenarios using the GB Freight Model to translate the qualitative scenarios into quantified forecasts of transport demand (see section 4 below).

The scenarios that have been produced make a number of essential assumptions about the UK in 2050. These ‘givens’ are as follows:

- Politics: The UK will be a parliamentary democracy and policies in relation to freight transport will be applied on a consistent basis across the UK.
- Economy: The UK will be an essentially open, market-based economy, focused mainly on providing services.
- Modes: Innovative modes such as drones, delivery robots, e-bikes and hyperloop, will offer opportunities in niche markets but will not radically change the freight transport market because of the economies of scale, flexibility and existing infrastructure that is available for existing bulk freight transport modes (road, rail, waterborne freight and shipping).
- Localised manufacturing: 3D printing at a local level will increasingly penetrate some important niche markets (e.g. the manufacture of spare parts) but will not be able to radically challenge the economies of scale available for most products from lean manufacturing processes in centralised factories.
- Global trade: Trade will remain essentially open with a high degree of free trade (i.e. the world does not seek in the long term to raise protectionist barriers to trade).
- Population centres: The location of major urban centres, as final points of consumption, will remain largely unchanged.
- Housing: Society will choose to make use of the existing housing and commercial property stock (subject to some natural turnover), with the existing urban landscape largely unchanged except for the possible re-use of commercial space in town and city centres for other purposes.

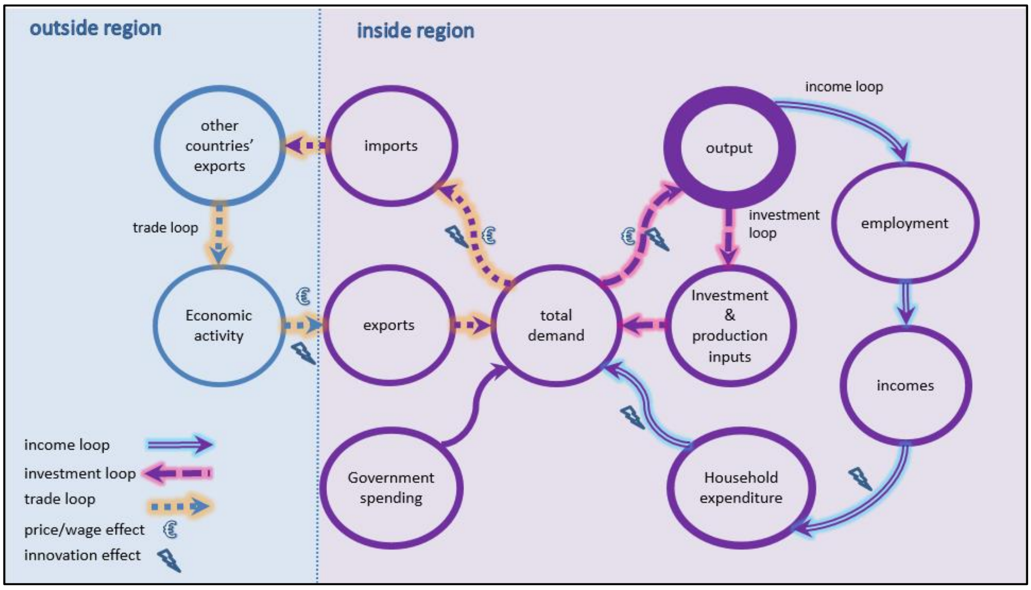
3.4 Economic scenario variants

Background to macro-economic model

The economic scenario variants have been based on existing macroeconomic forecasts produced by Cambridge Econometrics using E3ME, which is a computer-based model of the global economic and energy systems and the environment. It was originally developed through the European Commission's research framework programmes and is now widely used in Europe and beyond for policy assessment, forecasting and research purposes[xiii].

Although E3ME can be used for forecasting, the model is more commonly used for evaluating the impacts of an input shock through a scenario-based analysis. The shock may be either a change in policy, a change in economic assumptions or another change to a model variable. Figure 23 below portrays how E3ME's economic module is solved for each country. Most of the variables mentioned in the chart are solved at the sectoral level. The whole system is solved simultaneously for all sectors and all countries, although single-country solutions are also possible.

Figure 23: E3ME basic model structure



As highlighted above, E3ME entails both an investment and a trade loop. In the former, when firms increase output (and expect higher levels of future output) they must also increase production capacity by investing. This creates demand for the production of the sectors that produce investment goods (e.g. construction, engineering) and their supply chains. In the latter, an increase in demand is met by imported goods and services. This leads to higher demand and production levels in other countries. Hence there is also a loop between countries.

Components of demand

Intermediate demand (the sum of demand from other production sectors) is determined by the input-output relationships in the model. When one sector increases its production, it requires more inputs to do so. The sectors in its supply chain thus see an increase in demand for their products.

Consumer spending by country is derived from functions estimated from time-series data. These equations relate consumption to personal disposable income by country, a measure of wealth for the personal sector, inflation and interest rates.

Government consumption is exogenous and given by assumption, split into the main different components of spending.

To estimate international trade, E3ME makes use of the time series of bilateral trade that are available from Comtrade and the OECD. The approach has four stages:

- For each country total imports are estimated using equations based on time-series national accounts data. Import volumes are determined primarily by domestic activity rates and relative prices.
- Separate bilateral equations for import shares are then estimated for each destination country, sector and origin country.
- Bilateral imports are then scaled so that they sum to the total estimated at the first stage.
- Finally, export volumes are determined by inverting the flows of imports.

Gross fixed capital formation (i.e. investment in assets) is determined through econometric equations estimated on time-series data. Expectations of future output, which are endogenously determined in the model relying on the previous 5 years of historical data, play an important role in its determination, but investment is also affected by relative prices and interest rates.

Total product output, in gross terms, is determined by summing intermediate demand and the components of final demand described above. This gives a measure of total demand for domestic production.

Regions and local areas

The UK employment and GVA results for each scenario from E3ME were disaggregated to NUTS 1 regions using a disaggregated database of employment and GVA projections by sector from 1981 for all regions in the UK, and all unitary authorities and local authority districts in Great Britain. The UK E3ME results were used to produce detailed economic forecasts for each region under each scenario and these in turn were used to produce forecasts by sector for local areas (e.g. Manchester).

The employment forecasts for a region were based on historical growth in the region relative to the UK over the period 1994-2015 on a sector-by-sector basis and assume that those relationships will continue into the future. Thus, if a sector in a region outperformed the sector in the UK as a whole in the past, then it will be assumed to do so in the future. Similarly, if it underperformed the UK in the past then it will be assumed to underperform the UK in the future.

The local area forecasts were produced using a similar methodology, based on historical growth in the local area relative to the region or the UK (depending on which area it has the strongest relationship with) over 1994-2015, on a sector-by-sector basis.

Results from the macro-economic model

The results for the period 2015 to 2050 are set out below for the three scenarios that were selected for use in this study and which represent a potential plausible range of outcomes (Table 6). They take into account the UK's historic economic growth, productivity and employment trends, and potential future trading relationships and investment and migration patterns. The three scenarios are:

- 'Business as Usual': no change from the existing position in 2015 before the EU Referendum, where the UK remains within the Single Market and Customs Union. The historical trends in economic growth, productivity and employment continue up to 2030 and beyond to 2050. This scenario reflects the base case produced by DG EcFin (2015). This study was published before the Brexit referendum, and gives a long-term perspective on government revenues and liabilities pre-Brexit, given demographic trends. It is commonly referred to as the 'ageing report'[xiv]. GDP projections are formed by attaching an estimate of productivity growth to expected changes to the size of the labour force.
- 'European Trade Focus': the UK remains in the EU Customs Union, but leaves the Single Market after a two year transition period following the UK's departure from the EU in March 2019; this leads to additional non-tariff barriers to trade after the end of the transition period. The increase in non-tariff barriers causes an increase in costs to businesses, making the UK a less attractive place for multinationals to export its goods and services to the rest of the EU, and so dampening business investment.
- 'Global Trade Focus': the UK leaves the EU in March 2019 on WTO rules with no transition period and all trading partners are treated equally with additional tariff and non-tariff barriers to trade under WTO rules. Businesses' costs increase even more than the 'European Trade Focus' scenario as both tariff and non-tariff barriers increase. The movement of component goods needed in the production process and staff between other branches in the rest of the EU also become more costly and difficult, causing a stronger slowdown in investment than the 'European Trade Focus' scenario.

The results from the model for the 'Business as Usual' scenario were scaled to be consistent with the most recent short-term macro-economic forecasts produced by the Office of Budget Responsibility

(OBR). To forecast up to 2050, E3ME was re-run, extending assumptions related to import and export prices, investment and productivity by sector and migration to provide forecasts to 2050.

Table 7: Modelled average annual percentage change in GVA by industry sector & other macro-economic indicators, 2015-50

		'Business as Usual'	'European Trade Focus'	'Global Trade Focus'
GVA by sector	A : Agriculture, forestry and fishing	0.50%	0.35%	-0.09%
	B : Mining and quarrying	-2.00%	-2.00%	-1.99%
	C : Manufacturing	1.23%	0.94%	0.81%
	D : Electricity, gas, steam and air conditioning supply	1.21%	1.17%	1.16%
	E : Water supply; sewerage, waste management and remediation activities	1.23%	0.82%	0.62%
	F : Construction	2.18%	1.75%	1.56%
	G : Wholesale and retail trade; repair of motor vehicles and motorcycles	2.16%	2.08%	2.03%
	H : Transportation and storage	2.29%	2.21%	2.16%
	I : Accommodation and food service activities	2.49%	2.44%	2.41%
	J : Information and communication	2.43%	2.31%	2.26%
	K : Financial and insurance activities	2.44%	2.38%	2.36%
	L : Real estate activities	2.46%	2.42%	2.40%
	M : Professional, scientific and technical activities	2.45%	2.33%	2.27%
	N : Administrative and support service activities	2.43%	2.28%	2.21%
	O : Public administration and defence; compulsory social security	1.32%	1.29%	1.27%
	P : Education	1.32%	1.32%	1.32%
	Q : Human health and social work activities	1.32%	1.32%	1.32%
	R : Arts, entertainment and recreation	1.33%	1.15%	1.05%
	S : Other service activities	1.33%	1.08%	0.93%
	Total	**2.01%**	**1.89%**	**1.83%**
Employment		**0.78%**	**0.72%**	**0.68%**
Population		**0.48%**	**0.39%**	**0.34%**

Source: Cambridge Econometrics E3ME

Population

The population forecasts that were implicit in the macroeconomic forecasts (before scaling to the OBR forecasts) are shown in Table 8 below.

Table 8: UK population forecasts 2015-50

Population	'Business as Usual'	'European Trade Focus'	'Global Trade Focus'
2015	65.1	65.1	65.1
2030	71.3	70.3	69.7
2050	76.9	74.6	73.2

Source: Cambridge Econometrics

No explicit assumptions were made for the size of the resident population, which were based on the underlying trends in natural change in line with the Greater London Authority (GLA) 2016-based population projections for the UK. However the following assumptions were made about net migration and these assumptions led to differences between changes in the size of the total population:

- 'Business as Usual': net migration of 232,000 in 2020, falling to 220,000 in 2030;
- 'European Trade Focus': net migration of 144,000 from 2020 onwards;
- 'Global Trade Focus': net migration of 99,999 from 2020 onwards.

A change in migration was modelled as a change in population in the model. Assumptions for population changes by age group and gender were developed to input in to the model. Working age population was multiplied by participation rate in the model, which will provide total labour supply. Depending on demand for labour, the additional workforce will either end in employment or unemployment (which will have further impacts in the model). The 'Global Trade Focus' scenario assumed that the Government's tens of thousands migration target would be achieved. The 'European Trade Focus' scenario built up to this target from the Business as Usual scenario, in which migration was based on the GLA's 2016-based population projections. These are straightforward assumptions that do not account for the various types of visa systems the UK could adopt in the future, which is politically uncertain and consequently difficult to model. The migration assumptions were then used to develop population assumptions, taking into consideration natural change. The difference in net migration across scenarios was assumed to be driven by changes in both EU and non-EU migration, but the assumptions did not specifically look at changes in the origins of international migrants, or the impact a change in international migration may have on internal migration (people migrating from one area of the UK to another).

3.5 Consumer behaviour & retail supply chains

UK retail to 2050

A time horizon of over 30 forecasting difficult since the outcomes will be the result of a combination of retail technology and customer preferences interacting with corporate manoeuvring as business ebbs and flows. The range of outcomes to cater for the inherent uncertainty can best be described through scenarios.

In broad terms the expectations, compiled from a range of sources and expertise including BearingPoint's consulting engagements, are:

- An inexorable increase in e-commerce with sustained growth in 'click and collect' capping parcel and delivery volumes;
- Continued decline in large stores in both the grocery and non-food sectors;
- Reduced store numbers for most retailers, except hard-discount stores which will not participate in e-commerce to any great extent;
- Continued increase in convenience retail for grocery which will allow people to shop on the go;
- Transformation of high streets and malls to retail experiences, with food, drink and entertainment being central;
- Re-purposing small stores to residential and food, drink and entertainment.
- Re-purposing in high streets to provide micro-hubs and 'click and collect' facilities

The key question is at what level the penetration of e-commerce in the retail market will naturally slow as it approaches the asymptote of the trend. All markets have a natural saturation level but can also be overtaken by new technologies, products, services, demographics and consumption patterns.

It seems reasonably certain that in 2050 people will still be living in houses but that those dwellings will be totally digitally enabled. On the expectation that people will work from home more (increasingly but not exclusively, depending on occupation), car ownership will decline and more people will use shared autonomous vehicles or personal pods, the limit to e-commerce penetration can be expected to be much higher than the 25% that was being suggested a couple of years ago by experts such as the Interactive Media in Retail Group (IMRG). The constraints will more likely be the availability of economically sustainable services in the face of declining basket size, shorter and shorter lead times for same day delivery and quite simply the value/margin relationship of the products.

On this basis, the e-commerce retail share in 2050 could easily be 50%, with food at 35% and non-food at 65%, as compared with an estimated 20% in 2018, with food at 9% and non-food at 35-40%). This is summarized in the Table 9 below.

Table 9: Summary of potential retail trends to 2050

Trend	Retail Segment		
	Food retail	**General merchandise**	**Restaurant / food service**
e-commerce	E-commerce to 35%	E-commerce to 65%	Growth in home delivery with services like Just_Eat and Deliveroo
Convenience retail	Continued growth of convenience stores in city centres and towns	E-commerce is the convenience so no observable trend	n/a
Hard discount formats	Continued growth as a destination store perhaps to 35% of the market	E-commerce is the hard discount channel	n/a
Large store formats	In structural decline – space being sub let to surgeries, beauty salons etc	Department stores and large formats in structural decline – can't hold the range or afford the space	Large centres converting to food / restautant courts and entertainment venues
Click and collect	Increasing and service changing to more local rather than store based	Will be more than half the market in 10 years	n/a

Source: Bearing Point

The barriers to this growth up to 2050 will be the many product categories where e-commerce does not work as economically, such as the hard discount food and grocery sector or building materials, plants and greetings cards. The other constraint will be where the convenience of time and place utility is the consumer driver to 'pick and go'.

The logistics and infrastructure impacts

The logical logistical impacts of this level of penetration and the associated growth in convenience channels combined with demanding, same day, customer fulfilment criteria will require a measure of de-centralisation as retailers work to get their range or products closer to customers. This is already apparent with Amazon, which holds the core of its range in many sites across the country to manage capacity and reduce transport costs and delivery lead times.

The fragmentation of conventional retail channels alongside the growth in e-commerce and in the context of the probability of restricted access to cities for freight (based on both time of day and vehicle type and supported by charges and kerb-side constraints) will tend to drive networks towards:

- Regional distribution growth reversing the trend observed in section 2.x, with these regional distribution centres servicing both e-commerce and retail stores;
- Edge of conurbation consolidation (located on many sites with different sectors serviced by each) to access capacity of electric vehicles, minimize movements and achieve compliance with regulations introduced by local authorities;
- In-conurbation micro-hubs (again segment specific) serving quite tight localities with both micro van / e-bike deliveries and 'click and collect'.

This is likely to require integrated land use planning, including safeguarding strategic sites, rather than the current market-based property value maximisation, alongside consistent regulation by local authorities to ensure equipment is economically interchangeable and routes are viable.

While retail space demand will decline over the forecast period and will need to be re-developed or re-purposed, the demand for warehousing capacity will increase and existing warehousing sites (classified as B1 and B8 in planning terms) can be re-purposed. Sections of the property market may find retail site valuations in decline and this will be a barrier to change alongside planning regulations; the property sector will resist capital depreciation and planners will face intense pressure. Ultimately, if the planning conditions are not put in place to support the consumer and fulfilment trends, this will lead to a slowdown on the rate of change and be a barrier to cleaner air and lower levels of congestion in our cities.

Consumer behaviour variants for scenarios

The main variants in relation to consumer behaviour relate to the likely retail market share that e-commerce (including 'click and collect') can secure by 2050. As the e-commerce market approaches saturation, charges for delivery are likely to adjust to more economic levels, whereas at present the retailers are not passing on the full-cost of e-commerce fulfilment because of the need to maintain and grow market share in the face of fierce competition[xv]. Once consumers bear the full cost of home delivery, this may restrict demand for this channel and boost click and collect as that is a cheaper option for both retailers and consumers.

Overall, two main variants emerge from this analysis in relation to consumer behaviour, namely:

- 'E-commerce Domination': where consumer requirements allow e-commerce to reach 65% of general merchandise and 35% of food. This would reflect an assumption that the convenience of home delivery is considered to justify the cost for a relatively wide range of goods.
- 'E-commerce Consolidation': where consumer requirements allow e-commerce to reach only 45% of general merchandise and 20% of food. This would reflect an assumption that the convenience of home delivery is considered to justify its cost for a reduced range of goods than in the 'E-commerce Domination' scenario and that 'click and collect' fills a larger part of the fulfilment mix.

3.6 Technological variants

Certain technologies are assumed to be available and commercially viable in 2050 (based mainly on the work for the NIC of CEPA and Fraser-Nash Consultancy on *Reducing the Environmental Impact of Freight*) and the extent of their use would depend essentially on the policy and regulatory environment and the relative economics of the different modes.

The technologies that are expected to be most likely to be commercially viable are as follows:

- Electric HGVs: zero emission HGVs, which would use one or other of three main potential technologies for long distance trunk hauling: 1. battery electric, involving re-charging en route or swapping batteries; 2. e-highways using overhead wires on a limited core network and a smaller battery for 'last mile' movements off the core network; 3. e-highways using electric conduction technology on a limited core network and a smaller battery for 'last mile' movements off the core network.
- Electric LGVs: zero emission LGVs using battery electric technology for relatively short distance 'last mile' movements.
- Electric railway locomotives: electric locomotives using overhead wires on a core electrified network, with a battery for movements off the core network.
- LNG for shipping/waterborne freight: ships powered by lower carbon fuels such as LNG, but the majority of vessels will not be able to adopt zero carbon technologies such as battery electric.
- Connected Autonomous Vehicles (CAV): full autonomy available for HGVs, locomotives and ships (so that drivers/crew are not always required), but a driver is needed for LGVs in order to allow for deliveries to and collections from residential and commercial properties.
- 'Digital efficiency': the availability and use of 'big data' related to the cargo and the vehicles and the latter's relationship with network infrastructure to move towards the optimisation of vehicle operation and supply chains. This would lead to reduced operating costs for all vehicles.

The assumptions made in the different scenarios allow a number of variants for the availability of the different technologies, depending on the policy and regulatory environment assumed under each scenario.

3.7 Policy scenario variants

The future political economy of freight could have a very significant impact on the origins and destinations of some freight movements through its impact on the location of distribution centres, on the economies of scale available and, above all, the relative costs and use of each mode.

Four main policy variants were developed based on some of the likely key themes for policy and regulation for 2050, as follows:

- 'Environmental regulation': Government policy develops to minimise emissions from freight vehicles of all kinds to protect human health and reduce the effects of climate change. This would be achieved by regulating the use of more polluting vehicles, allied with the take-up of low emission vehicles. It would involve a ban on the sale and operation of both diesel powered LGVs (already Government policy) and diesel-powered HGVs; there would also be a ban on the use of diesel locomotives and a requirement for shipping to use lower carbon fuels (e.g. LNG).

- 'Road pricing': Government fiscal policy develops to include the internalisation of external costs of road haulage, which in a zero carbon future would focus mainly on the cost of infrastructure development and maintenance and the costs of congestion rather than environmental emissions. The road pricing scheme would be a distance- and time-based system whereby the cost of congestion varies according to the distance travelled and the time of day and would replace existing forms of taxation of road haulage (Vehicle Excise Duty, the HGV Levy and Fuel Duty.
- 'Logistics concentration': the planning system would proactively facilitate the co-location of distribution centres, rail/water terminals and freight consolidation centres on large multimodal sites near conurbations (even on what is currently greenbelt) so there are sufficient economies of scale to justify greater use of rail and shipping for inter-regional freight movements and use of electric HGVs for final deliveries and collections from distribution centres on the same site. There would also be an expansion of distribution centre capacity on or close to port estates ('port-centric distribution') to store and add value to imported goods prior to inland distribution.
- 'Regulatory efficiency': Government would allow longer and more efficient autonomous HGVs to operate on the road network, while also allowing longer freight trains to operate on infrastructure without capacity constraints. This would have the effect of reducing the costs per tonne moved but also assumes more efficient use of scarce network capacity.

The policy variants, which would provide the policy levers for Government, assume that technology will allow the operation of zero emission vehicles and the implementation of a fair and efficient form of road pricing for freight vehicles in 2050. They also assume that regulation would evolve to improve the economies of scale of both road vehicles and trains. Finally, planning policy could be used to actively promote co-location of distribution centres on rail and water-connected sites to increase the opportunities for using non-road modes for long distance freight transport movements.

3.8 Summary of scenario variants

The scenario variants are set out in summary form below. While the choice of macro-economic variant determines the aggregate size of the freight market in tonnes due to changes in the amount of economic activity in different sectors, the impact of consumer behaviour is regarded as essentially market-led and would require a response from freight operators to meet the demand. There are no variants for technology as such, but we assume that certain technologies would be available and commercially viable in 2050; the technologies (with their associated cost structures) would then be deployed by freight operators in a competitive market place.

The policy variants provide 'packages' of potential responses by the public sector to market failure and offer a means to intervene in the market to secure wider social and economic benefits for society; the policy 'packages' would affect, in particular, the relative competitiveness of the different modes of transport as freight operators would change their behaviour in order to maintain the competitiveness of their service for their customers, while also having the potential to change the patterns of distribution activity through changes in planning policy. The variants are summarised in Table 10 below.

Table 10: Summary of variants for incorporation into the scenarios for 2050

Macro-economic	Consumer behaviour (exogenous)	Technology (exogenous)	Policy responses
Determines overall aggregate demand in tonnes, based on link with economic activity by individual industry sector	*Market-led changes in consumer behaviour affecting pattern of retail distribution*	*Assumptions about availability of technologies, with associated relative costs (affecting mode used); choice of technology by freight industry based on relative costs*	*Policy responses to resolve market failure; affect choice of mode & patterns of distribution activity*
'Business As Usual'	**'E-commerce domination'**	**Available technologies** • CAVs • Electric (battery & e-highway) • LNG for shipping • Greater digital efficiency	**'Environmental Regulation'**
'European Trade Focus'	**'E-commerce consolidation'**		**'Road Pricing'**
'Global Trade Focus'			**'Logistics Concentration'**
			'Regulatory Relaxation'

Source: MDS Transmodal

3.9 The qualitative scenarios for 2050

Introduction

Four scenarios were developed with the assistance of the NIC and stakeholder representatives, including a 'Business as Usual' (counterfactual) scenario against which three future scenarios that involve significant change could be measured. The three scenarios, which involve significant change from the existing position (including the availability of autonomous HGVs) have been designed to reflect the range of potential changes in technology, policy, consumer behaviour and the impact of different macro-economic scenarios up to 2050. In the event that autonomous HGVs do not emerge as a practical technological solution by 2050, but the planning system leads to greater clustering of distribution centres on rail-connected distribution parks, there would be a substantial increase in rail freight.

The quantification of the scenarios through the definition of input assumptions to a freight transport demand model (the GB Freight Model) and the results are provided in Chapter 4. The four scenarios (including the counterfactual), each with their own theme, are summarised below.

'Business as Usual' scenario

The 'Business as Usual' scenario provides a counterfactual scenario for 2050 against which the other scenarios can be compared and involved effectively no change from the existing position except that existing Government policy will have led to the end of diesel and petrol LGVs. It assumes that the economic trends in terms of growth, productivity and employment continue up to 2050. The economy would remain focused on services but a high value added manufacturing sector is maintained and the UK economy would remain highly integrated with that of the EU, while continuing to trade extensively with the rest of the world.

Consumer demand would have led to an increase in e-commerce's market share to 65% of the general merchandise market and 35% of the food market due to its convenience and cost effectiveness; this would have led to a significant switch way from passenger trips to retail outlets, mainly using private cars, to home deliveries by battery operated LGVs.

'Carbon Reduction' scenario

The 'Carbon Reduction' scenario in 2050 assumes that the UK chooses to focus on minimising its emissions of carbon in order to reduce the impact of global warming and reduce its other environmental emissions from freight vehicles to protect human health. Government policy would have led to the end of the use of diesel and petrol for both LGVs and HGVs, due to a ban on the sale of such vehicles allied to the availability of commercially viable zero emission vehicles for all modes.

While LGVs would use enhanced battery technology for deliveries and collections within urban areas and individual regions, HGVs would also use electric propulsion based either on e-highways on a core freight network and batteries for movements in urban areas and more remote areas or the use of enhanced battery technology with longer ranges and, for longer trunk hauls, involving battery re-charging or battery swapping. Rail freight services would operate on a core electrified network, with battery technology for operation on non-electrified branch line routes and within terminals. Shipping services would use electric propulsion for some short journeys (such as along estuaries and for manoeuvring in ports) but would otherwise have switched to low sulphur and lower carbon fuels such as LNG.

The UK would have left the EU and no longer be in the Single Market, but would have retained membership of the Customs Union; the economy would have remained largely focused on services but maintained its manufacturing base in high added value sectors. The Government would have introduced an array of policies to reduce carbon emissions and increase the efficiency of both road and rail modes. This would have been achieved by:

- Increasing the length of HGVs and trains, therefore reducing the unit costs and increasing the efficiency of the use of infrastructure capacity;
- A system of taxation that uses a system of infrastructure pricing that charges HGVs and LGVs for their use of the network based on the distance travelled on different types of road and the time of day and replacing the existing system of taxation on a fiscally neutral basis.
- The planning system, with the development of large rail and/or water-connected sites located adjacent to major urban areas so that rail and waterborne freight services could compete more effectively with long distance road freight services. These Multimodal

Distribution Parks (MDPs) would also act as bases for fleets of electric LGVs making 'last mile' deliveries and collections in and around urban areas.

Long distance freight movements between ports and distribution centres and between distribution centres and consumers, mainly living in urban areas, would be by means of a mix of autonomous road and rail services and, where geography and the commodity allows, waterborne freight transport services. Distribution centres would also be highly automated, allowing efficient storage of goods and synchronised cross-docking of freight between inbound and outbound vehicles.

Given the market penetration of the retail market by e-commerce (involving home deliveries), HGVs would deliver pre-packaged goods to consolidation centres/depots located on the edge of urban areas (located at MDPs where they are serving larger urban areas), which would then be delivered by manned LGVs to ensure the successful fulfilment of deliveries in residential areas and commercial districts.

In some city and town centres, where there are additional restrictions on vehicle movements to maximise the quality of life of residents and visitors, further transhipment of parcels may be required for final delivery by e-bikes or, where appropriate, robots. The market for e-commerce deliveries would have matured so that the full cost of delivery on a door-to-door basis would be incurred by the consumer; this would have limited the market penetration of e-commerce to 45% of the general merchandise market and 20% of the food market with consumers having a higher propensity to pick up their parcels from local collection points using an autonomous passenger vehicle.

'Carbon Survival' scenario

The 'Carbon Survival' scenario in 2050 assumes that the UK chooses to focus on minimising its emissions of carbon as far as possible, but without electrifying the movement of heavy freight because the benefits would not outweigh the costs involved in developing the required additional fuelling infrastructure or due to the immaturity of the technologies involved. While Government policy would have led to the end of the use of diesel and petrol for LGVs, HGVs and rail freight will continue to use diesel. Shipping services would have switched to low sulphur and lower carbon fuels such as LNG to meet IMO regulations on the reduction of sulphur emission from shipping. Otherwise the scenario would be the same as for 'Carbon Reduction' except that consumers would have accepted to pay the full cost of e-commerce deliveries and e-commerce market penetration would be 65% of the general merchandise market and 35% of the food market (as in the Business as Usual scenario).

'Manufacturing Renaissance' scenario

The 'Manufacturing Renaissance Scenario' in 2050 assumes that the UK chooses to develop an industrial strategy that focuses to a greater extent on developing additional manufacturing capacity as well as minimising its emissions of carbon. The UK would have left the EU and would no longer be in the Single Market or the Customs Union and would choose to develop its manufacturing capacity, with a focus on exporting to markets around the world; this would be achieved by developing additional high added value manufacturing in deep water ports with spare capacity and incentivised by additional friction costs in trading with the EU, relatively low costs of shipping in containers and advances in technology which allow almost all goods to be transported in containers around the globe. Otherwise the scenario is the same as for 'Carbon Reduction' but consumers would have accepted to pay the full cost of e-commerce deliveries and therefore e-commerce market penetration will be 65% of the general merchandise market and 35% of the food market.

Each of the four scenarios consists of the economic, technological, consumer behaviour and policy variants that are most relevant to the theme of that scenario. These are summarised in Table 11 below.

Table 11: Summary of qualitative scenarios for 2050

	Description	Economics	New technology	Consumer behaviour	Policy
'Business as Usual'	'What will happen anyway without significant change?'	Business as Usual	Electric LGVs	E-commerce domination: 35% of food retail & 65% of general merchandise.	Ban on sale of diesel/petrol LGVs & taxation via VED. No ban on diesel HGVs; taxation of HGVs unchanged (VED/HGV Levy plus Fuel Duty)
'Carbon Reduction Scenario'	'What will happen if commercially viable technological solutions are found to provide zero emission HGVs/trains and society seeks to reduce carbon emissions as much as possible?'	EU Trade Focus	Electric LGVs & HGVs Hybrid electric locomotives Automated HGVs, LGVs & trains	E-commerce consolidation: only 20% of food retail & 45% of general merchandise due to consumer response to increased delivery charges.	Ban on sale of diesel/petrol LGVs & HGVs. Taxation through distance-based road pricing. Changes to planning system leads to more warehouses being located on rail and water-connected distribution parks. Longer HGVs and trains.
Carbon Survival Scenario	'What will happen if no commercially viable technological solutions are found to provide zero emission HGVs and trains? '	EU Trade Focus	Electric LGVs Automated HGVs, LGVs & trains	E-commerce domination: 35% of food retail & 65% of general merchandise.	As for 'Carbon Reduction' but no ban on diesel HGVs and diesel locomotives.
Manufacturing Renaissance Scenario	'What will happen if the UK becomes more successful as an advanced manufacturing economy, leading to additional high value exports of goods and the UK trades more extensively with deep sea countries?'	Global Trade Focus, with more manufacturing output & more trade with deep sea countries, leading to manufacturing capacity being located at ports.	Electric LGVs & HGVs Hybrid electric locomotives Automated HGVs, LGVs & trains	E-commerce domination: 35% of food retail & 65% of general merchandise.	Ban on sale of diesel/petrol LGVs & HGVs. Taxation through distance-based road pricing. Changes to planning system leads to more warehouses being located on rail and

	water-connected distribution parks. Longer HGVs and trains.

Source: MDS Transmodal

4 THE MODELLED SCENARIOS

4.1 Introduction

This section of the report sets out the results of the quantitative modelling using the GB Freight Model of the four qualitative scenarios described in section 3 above. The modelled results should be seen as describing different outcomes for the future of freight transport in 2050, based on different scenarios for how the economy, consumer behaviour, technology and policy/regulation may develop. The results provide a range of potential future outcomes for:

- Aggregate demand for freight transport in tonnes and tonne kilometres for each scenario;
- The shares of that aggregate demand that each mode of transport could secure and the entry and exit points for international trade under each scenario.

The modelled results of the scenarios cannot be used for detailed analysis of the potential impact of individual policy options without modelling each of these options individually and then examining the incremental impact. The results of the modelling should be seen mainly as presenting different 'pictures' of how the future of freight transport could evolve over the next 30 years.

A distinction is made in the modelling between 'heavy' freight that is transported in HGVs, by rail and on shipping services (generally for the medium to long distance transport of goods both within the UK and internationally) and 'light' freight transported in LGVs (generally used for the more local delivery and collection of lightweight goods).

4.2 Methodology & assumptions

'Heavy' freight

Aggregate demand in each of the four scenarios is based on assuming a relationship between forecast growth in GVA by industry sector from the E3ME macro-economic model and growth in freight tonnes. Freight tonnes by industry sector were assumed to increase at a slower rate than any forecast increase in GVA, based on the evidence over the last 20 years, which suggests there may be a continuing gradual increase in the proportion of each industry sector's GVA which will be related to the provision of services rather than generating additional freight tonnes. GVA by sector has grown by around 0.5% per annum more than tonnages generated, reflecting a switch away from manufacturing to a more service-based economy which tends to consume lighter and more voluminous finished goods.

The aggregate freight demand was then provided as an input to the GB Freight Model (GBFM), which is a multimodal freight transport demand simulation model that has been used by the Department for Transport for modelling and forecasting freight transport within the National Transport Model.

The model includes a calibrated base case for 2015 which 'explains' the movement of freight by inland mode and port of entry and exit using generalised costs. GBFM therefore includes validated freight cost models for each mode of transport and provides outputs in terms of tonnes and tonne kilometres by mode.

The assumptions for each quantitative scenario as described in section 3 above were interpreted as detailed inputs into the modal cost models for HGVs, rail freight and short sea shipping freight rates and then the model was run to produce quantified results for each scenario for 2050. This therefore involved the development of cost models for electric LGVs and connected and autonomous (CAV) HGVs in 2050, the costs for which are inherently uncertain at this stage in development. Details of the assumptions made are provided in Appendix 5.

'Light' freight

The basis for the LGV forecasts produced for this study was a 2015 base year 'freight van' origin-destination matrix which was generated for use in the most recent version of the DfT's National Transport Model. The data that was included in the matrix was grossed up from data that was available from official surveys of LGVs carried out by the DfT in the early to mid-2000s; the data is therefore not recent. The data set covers company owned and personally owned LGVs making journeys for the purposes of carrying freight and travelling between service-related jobs, but does not include LGV journeys for personal travel. As the subject of this study is freight transport only, rather than the use of LGVs for the transport of personnel and equipment between jobs in the service sector, only the LGV journeys carrying freight were included in the following analysis.

Forecasts of LGV movements up to 2050 were produced by:

- Using GVA forecasts by geographic area as an independent variable to forecast 'baseline' growth in LGV traffic; statistical analysis has shown there is a close correlation between historic growth in LGV traffic and GVA growth over the period 1949 to 2015.
- Supplementing this baseline growth in LGVs carrying freight on multi-stop journeys with additional journeys carrying e-commerce goods; this is due to forecast growth in this sector up to 2050 for both the 'E-commerce Domination' and 'E-commerce Consolidation' variants included in the scenarios. Due to the very high potential market penetration of e-commerce in 2050 compared to 2015, the multi-stop journeys segment of LGVs carrying freight in the scenarios that included the 'E-commerce Domination' variant were increased by a factor of 3.7 for the 2050 BAU scenario, Carbon Survival and Manufacturing Renaissancescenarios.

4.3 Aggregate freight demand to 2050

‘Heavy’ freight

Modelled aggregate demand in tonnes lifted for ‘heavy’ freight transported in HGVs or by rail is shown in Table 12 below.

Table 12: Modelled aggregate demand for ‘heavy’ freight transport

Billion tonnes lifted

	2015	Business as Usual (BAU) 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing Renaissance 2050
Freight tonnes lifted	1.97	2.86	2.60	2.62	2.49
Total growth 2015-50	-	45.3%	32.2%	33.4%	26.5%
Compound average growth rate 2015-50	-	1.1%	0.8%	0.9%	0.7%

Source: MDS Transmodal GB Freight Model

Total heavy freight is forecast in the BAU 2050 scenario to increase by 1.1% per annum to reach 2.86 billion tonnes of freight lifted in 2050; annual average growth rates for the other three scenarios are lower, ranging from 0.7% to 0.9% compound average growth rate, and reflect the lower levels of forecast economic growth in these scenarios. These growth rates compare with a long-term historic growth in tonnes lifted by road of 1.0% per annum for the period 1953-2015.

‘Light’ freight

Table 13 provides the modelled results for trips by LGVs transporting freight, as opposed to those involved in the provision of services or being used solely as a means of passenger transport.

Table 13: Modelled demand for freight transport in LGVs in trips

	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing & Global Trade Renaissance 2050
Freight transported in LGVs (billion trips)	2.76	9.24	5.44	8.92	8.74
Growth 2015-50		235%	97%	223%	217%
Compound average growth rate 2015-50		3.6%	2.0%	3.5%	3.4%

Source: MDS Transmodal GB Freight Model

Total light freight in terms of trips is forecast in the BAU 2050 scenario to increase by 3.6% per annum to reach 9.24 billion trips in 2050; annual average growth rates for the Carbon Survival and Manufacturing Renaissance scenarios are lower at 3.5% and 3.4%, reflecting the lower levels of forecast economic growth in these scenarios. The growth rate for the Carbon Reduction scenario is lower at 2.0%, which reflects a lower penetration of the retail market by e-commerce as consumers are assumed to be paying for the full cost of the e-commerce deliveries and choose to maintain a higher proportion of their retail expenditure in 'bricks and mortar' shops.

Table 14 provides the modelled results for LGVs transporting freight in terms of vehicle kilometres. The freight moved in LGVs increases in the Business as Usual, Carbon Survival and Manufacturing Renaissance Scenarios at an average annual rate of up to 3.5% compared to the 2015 base case, mainly due to the assumed increasing penetration of the retail market by e-commerce. However, in the Carbon Reduction Scenario this growth is restricted to only 1.9% per annum for the reasons explained above. There are no official statistics on the long-term historic growth rate only for LGVs carrying freight, but the growth rate for total LGV vehicle kilometres between 1950 and 2016 was 3.5% per annum, while the annual growth rate for the period 2009-16 alone was 2.7%. The forecast growth rates, which are the result of forecast greater penetration of the retail market by e-commerce, are therefore in line with historic trends.

Table 14: Modelled demand for freight transport in LGVs in vehicle kilometres

	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing & Global Trade Renaissance 2050
Freight transported in LGVs (billion km)	25.6	81.6	48.3	78.6	69.5
Growth 2015-50		219%	89%	207%	172%
Compound average growth rate 2015-50		3.5%	1.9%	3.4%	3.0%
Average length of trip (km)	9.3	8.8	8.9	8.8	8.0

Source: MDS Transmodal GB Freight Model

4.4 Modal split

Road and rail modal split for inland freight transport in Great Britain

GBFM includes generalised cost models for HGVs and rail freight services and this allows the potential impact of the scenarios on modal split between the two inland modes in 2050. The modelled modal split for 'heavy' road freight (transported in HGVs) and rail freight in terms of tonnes moved (the most appropriate measure of modal split) is shown in Table 15.

Table 15: Modelled 'heavy' road & rail freight transport in tonne kilometres

		2015	Business as Usual 2050*	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing Renaissance 2050
ROAD	Road tkm by HGVs (billion)	164	223	180	179	168
	Growth in road tkm by HGVs 2015-50	-	36.4%	9.8%	9.3%	2.5%
	Compound average growth rate for road tkm by HGVs 2015-50	-	0.9%	0.3%	0.3%	0.1%
	Average length of road haul by HGVs (km)	87	81	72	71	71
RAIL	Rail tkm (billion)	15	21	19	23	27
	Growth in rail tkm 2015-50	-	35.6%	23.0%	54.4%	79.1%
	Compound average growth rate 2015-50	-	0.9%	0.6%	1.3%	1.7%
	Average length of rail haul (km)	167	191	183	197	212
	Rail modal split in tkm	8.5%	8.4%	9.4%	11.6%	13.9%

Source: MDS Transmodal GB Freight Model

* Excludes additional clustering of warehousing on rail- and water-connected distribution parks

Note: Rail traffics not including Network Rail engineering, other, nuclear, empty returns of waste containers and, for intermodal, the weight of containers.

The rail modal split in terms of tonne kilometres falls from 8.5% in 2015 to 8.4% in the BAU 2050 Scenario – which does not include the additional clustering of warehousing on rail- and water-connected distribution parks - and mainly reflects an increase in the number of HGVs required for the 'bulk' transport of more voluminous e-commerce parcels between regional distribution centres and local sorting offices rather than more consolidated loads from distribution centres to retail outlets as at present.

The increased modal split for rail of between 9.4% and 13.9% in the other 2050 scenarios is mainly the result of a combination of other factors:

- The greater clustering of distribution centres on rail- and water-connected distribution parks which improves the cost effectiveness of intermodal rail freight transport chains by ensuring that a final road collection or delivery leg is not required at, at least, one end of the intermodal transport chain.

- The greater concentration of freight origins and destinations in the 2050 Manufacturing Renaissance scenario at deep sea ports (receiving higher volumes of deep sea trade and also generating manufactured goods within their port estates) with their associated rail connections, therefore providing a critical mass of cargo for intermodal rail freight services.

This growth in rail freight is despite other factors that would tend to increase road haulage, namely:

- The assumed availability of autonomous HGVs which significantly reduces fixed labour costs and therefore improves the cost effectiveness of road haulage in competition with rail;
- The assumed availability of electric HGVs, which reduces the variable costs of road haulage in the Carbon Reduction and Manufacturing Renaissance scenarios and therefore improves the cost effectiveness of road haulage in competition with rail; this impact is reduced through the introduction of road pricing which increases the .

The most significant factor in improving the modal split for rail is likely to be the clustering of distribution centres at locations that are connected to the rail network, which incentivises a switch of heavy freight traffic from road to rail. This clustering effect helps rail to increase its modal split in terms of freight moved despite the reduction in the costs of road haulage as a result of the assumed introduction of autonomous HGVs by 2050. In addition, in the 2050 Manufacturing Renaissance scenario the major deep sea (and rail-connected) ports are handling greater volumes of trade and manufactured goods which are suitable traffics for inland distribution by rail.

Apart from the BAU Scenario, the 2050 scenarios all assume significant technological advances by 2050 involving the successful implementation of autonomous HGVs on a large-scale, which would require not just technological solutions but also a suitable legal framework and public acceptance; this leads to a significant modal switch away from rail to road for the transport of ‘heavy’ freight. Another scenario, which does not assume such technological changes by 2050 and is essentially the Business as Usual scenario with additional clustering of warehouses on rail-connected distribution parks has been run by MDS Transmodal using GBFM for TfN and Network Rail. This resulted in rail securing about 160 million tonnes of traffic or about 15% modal split in terms of tonne kilometres in 2050 and provides some additional sensitivity testing of a scenario where such significant technological change is not achieved.

The modelled modal split for ‘heavy’ road and rail freight services in terms of tonnes lifted is shown in Table 16.

Table 16: Modelled 'heavy' road & rail freight transport in tonnes

		2015	Business as Usual 2050*	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing Renaissance 2050
ROAD	Road tonnes lifted in HGVs (million)	1,876	2,752	2,499	2,506	2,361
	Growth in road tonnes lifted in HGVs 2015-50	-	46.7%	33.2%	33.6%	25.8%
	Compound average growth rate for road tonnes lifted in HGVs 2015-50	-	1.1%	0.8%	0.9%	0.7%
RAIL	Rail tonnes lifted (million)	91	107	102	118	128
	Growth in rail tonnes 2015-50	-	18.1%	12.3%	30.5%	40.8%
	Compound average growth rate for rail tonnes 2015-50	-	0.5%	0.3%	0.8%	1.0%
	Rail modal split in tonnes lifted	4.6%	3.8%	3.9%	4.5%	5.1%

Source: MDS Transmodal GB Freight Model

* Excludes additional clustering of warehousing on rail- and water-connected distribution parks

Note: Rail traffics not including Network Rail engineering, other, nuclear, empty returns of waste containers and, for intermodal, the weight of containers.

Rail freight in tonnes increases from 91 million tonnes in 2015 to reach 102 million tonnes in the Carbon Reduction Scenario in 2050. While the clustering of distribution centres on rail-connected sites and the introduction of a form of road pricing in this scenario assists rail in maintaining its market share, the introduction of autonomous HGVs (with an assumed two-thirds reduction in the cost of drivers/operators) has a significant impact in reducing the fixed operating costs of HGVs. The net result is an increase in the HGV modal share. Rail freight secures 128 million tonnes of freight and an increased modal share in the 2050 Manufacturing Renaissance Scenario because a higher proportion of total traffic would be containerised and passing through deep sea ports and therefore provides increased demand for competitive intermodal rail freight services.

The increased modal split for rail in terms of tonnes lifted in the other 2050 scenarios is lower than in terms of tonnes moved because road freight transport is also required for collection and delivery between ports and clusters of distribution centres at rail- and water-connected sites. This leads to a decline in the average length of road haul from 87km in 2015 to only 81km in the 2050 BAU scenario and to just over 70km in the other 2050 scenarios.

Overall the modelling suggests that, despite improvements in the economics of road freight as a result of the introduction of electric autonomous vehicles, rail freight could remove some medium to long distance flows from the road network as long as distribution parks are located on rail- and or water-connected sites or within or adjacent to port estates with access to deep water.

Modal split for inland freight transport: Wales, Scotland and the English administrative regions

The modelled road and rail modal shares in terms of freight moved from Wales, Scotland and the English administrative regions are provided in Table 17 below.

Table 17: Modelled modal split for road & rail by origin region

Billion tonne km & modal split %

NUTS1 Region	2015 freight moved from origin region	2015		2050 BAU*		2050 Carbon Reduction		2050 Carbon Survival		2050 Manufacturing Renaissance	
	Billion tkm	Road	Rail	Road	Rail	Road	Rail	Road	Rail	Road	Rail
North East	7.6	85%	15%	95%	5%	91%	9%	90%	10%	88%	12%
North West	20.6	94%	6%	95%	5%	92%	8%	90%	10%	86%	14%
Yorkshire and the Humber	23.4	87%	13%	89%	11%	88%	12%	86%	14%	84%	16%
East Midlands	19.7	93%	7%	94%	6%	91%	9%	90%	10%	91%	9%
West Midlands	16.5	94%	6%	92%	8%	92%	8%	88%	12%	86%	14%
East of England	22.4	92%	8%	86%	14%	86%	14%	84%	16%	77%	23%
London	5.2	95%	5%	97%	3%	94%	6%	91%	9%	84%	16%
South East	23.3	97%	3%	95%	5%	95%	5%	93%	7%	90%	10%
South West	14.1	90%	10%	93%	7%	91%	9%	89%	11%	90%	10%
Wales	9.0	86%	14%	84%	16%	87%	13%	86%	14%	86%	14%
Scotland	17.0	89%	11%	88%	12%	91%	9%	86%	14%	90%	10%
Total Great Britain	178.9	92%	8%	92%	8%	91%	9%	88%	12%	86%	14%

* Excludes additional clustering of warehousing on rail- and water-connected distribution parks

Source: MDS Transmodal GB Freight Model

The modelled rail modal shares by region in the 2050 BAU scenario mainly reflects the lack of clustering of distribution centres on rail and water-connected sites, so that growth in freight demand is accommodated by road haulage.

However, in the other 2050 scenarios rail freight is able to secure greater modal share in most regions, particularly due to the clustering of distribution centres on rail-connected sites which improves the economics of rail freight despite the assumed introduction of more cost effective autonomous HGVs. This effect can be seen in the regions which accommodate large volumes of distribution centres in the logistics ‘golden triangle’ and are essentially land-locked; rail modal share for the East Midlands, for example, increases from 6% in the 2050 BAU scenario to 9/10% in the other 2050 scenarios; similarly, the rail modal share for the West Midlands increases from 8% in the 2050 BAU scenario to as much as 14% in the 2050 Manufacturing Renaissance scenario.

The impact of the switch in the UK's trade away from the EU and towards the rest of the world, along with more manufacturing activity in ports, assumed in the 2050 Manufacturing Renaissance scenario has the effect of increasing the volumes of containers handled at deep sea ports and this, in turn, increases the rail modal split through the relevant regions. The East of England (containing the Port of Felixstowe), London and the South East (London Gateway and the Port of Southampton), the North West (the Port of Liverpool), the North East (Teesport and the Port of Tyne) and Yorkshire and the Humber (the Ports of Immingham and Hull) all see significant increase in the rail modal share in this scenario compared to the 2050 BAU scenario.

4.5 Ports and shipping

This section considers the results from the modelled scenarios for shipping and port traffic both for short sea unit load traffic between Great Britain and the European continental mainland and Ireland and for deep sea container and bulk traffic.

Short sea unitload traffic by mode of appearance & port grouping

Given the importance of ports in the UK's freight transport system and the UK's trading links with Ireland and the European continental mainland, Table 18 provides the modelled results for short sea unitload traffic through ports and via the Channel Tunnel by mode of appearance. Short sea traffic includes freight transported on ferry services, container services and the Eurotunnel Freight Shuttle that link Great Britain to Ireland, France and the rest of North West Europe, Iberia, Scandinavia and the Baltic. The vast majority of this traffic has an origin and destination in the EU, but there are also trade flows to and from non-EU countries such as Switzerland, Norway and Turkey.

The results also show the potential impact of the scenarios on the different 'modes of appearance' that can be used by shippers and freight forwarders on these routes, which are defined as follows:

- Accompanied HGV: an HGV with a tractor unit and driver that drives onto a ferry or the Eurotunnel Freight Shuttle;
- Unaccompanied trailer: a trailer that is transported on and off a ferry without a tractor unit or driver;
- Shipborne port-to-port trailer: a low height trailer (not licensed for use on the road network) that can carry two containers double-stacked on a ferry;
- Load on Load off (LoLo): containers loaded onto a container ship;
- Channel Tunnel through rail: units loaded onto an intermodal rail freight service, which then passes through the Channel Tunnel between Great Britain and the European continental mainland.

Table 18: Modelled short sea unitload traffic by mode of appearance at ports

Million units

	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing & Global Trade Renaissance 2050
Accompanied HGV	5.37	4.61	14.42	14.23	5.60
Unaccompanied trailer	2.35	7.20	1.77	1.79	0.69
Shipborne port to port trailer	0.82	2.23	1.06	1.10	0.41
Lolo	1.09	4.38	0.78	0.83	0.30
Chan Tunnel through rail	0.04	0.72	0.02	0.10	0.00
Total	9.60	19.14	18.05	18.05	7.00

Source: MDS Transmodal GB Freight Model

The overall size of the market increases from 9.6 million units in 2015 to 19.1 million units in the 2050 BAU scenario, reflecting the assumed close integration of the UK economy with that of the EU in this scenario. While the size of the short sea market declines to about 18 million units in the Carbon Reduction and Carbon Survival scenarios (due to the lower degree of integration with the EU economy that is assumed in these scenarios), there is a very significant reduction to only 7.0 million units in the Manufacturing Renaissance Scenario as the latter scenario assumes that the UK refocuses its trade on non-EU markets as a result of its departure from the EU.

In the 2050 BAU Scenario increasing road haulage costs for diesel-powered and driver accompanied HGVs leads to a switch towards the unaccompanied modes (unaccompanied trailers and shipborne-port-to port trailers on RORO services, containers on short sea LOLO services and Channel Tunnel through rail services); while the unaccompanied modes represented about 44% of the short sea unitload market in 2015, this increases to 76% in the 2050 BAU Scenario.

The modelling suggests that the introduction of autonomous HGVs in the other 2050 scenarios (involving a two-thirds reduction in labour costs) would lead to a switch back to accompanied roro; while this mode of appearance accounts for some 56% of the market in 2015 it would have an almost 80% share in the 2050 Carbon Reduction Scenario. This is because the reduction in the driver costs due to the deployment of autonomous vehicles means that the cost of accompanied HGV roro services (the trailer plus tractor unit on a ferry) falls as drivers are not required for automated ('self-loading') of trucks onto ferries and 'wasteful' driver time is not required during the crossings.

Table 19 provides the modelled results for short sea traffic by port grouping (the major ports in each port grouping are provided in Appendix 4).

Table 19: Modelled short sea unitload traffic by port grouping

Million units

	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing Renaissance 2050
Thames and Kent	5.05	6.21	5.02	4.80	1.93
Humber	1.26	3.33	4.64	4.51	1.80
Lancashire and Cumbria	0.89	3.30	2.90	2.63	1.14
Haven	0.77	2.10	0.99	1.37	0.38
Sussex and Hampshire	0.26	1.05	2.66	2.62	1.04
North East	0.28	0.86	0.98	0.92	0.38
West and North Wales	0.50	0.46	0.37	0.55	0.15
Scotland West Coast	0.41	0.61	0.42	0.52	0.17
Channel Tunnel	0.04	0.72	0.02	0.10	-
Scotland East Coast	0.11	0.29	0.03	0.02	0.01
Bristol Channel	0.01	0.19	0.01	0.02	-
West Country	0.02	0.03	-	-	-
Total	9.60	19.14	18.05	18.05	7.00

Source: MDS Transmodal GB Freight Model

The modelling suggests that the introduction of measures to reduce carbon emissions and the introduction of autonomous HGVs would lead to a switch of traffic to the North Sea corridor ports such as those on the Humber (28% market share in the Carbon Reduction Scenario compared to only 17% in the BAU Scenario) and to Western Channel ports such as Sussex and Hampshire ports (15% market share in the Carbon Reduction Scenario compared to only 5% in the BAU Scenario). The modelling would suggest that this switch would be to both longer distance accompanied and unaccompanied roro services via the east coast as the driver costs are lower when autonomous HGVs are assumed to be available.

Deep sea container traffic by port grouping

Table 20 provides the modelled results for deep sea container port traffic by port grouping (the ‘major’ ports in each port grouping are provided in Appendix 4). The deep sea container traffic includes both containers carrying goods traded with non-European countries that are unloaded from or loaded to deep sea containerships and containers to and from the same overseas markets that are transhipped at ports such as Rotterdam and Antwerp and then fed in smaller container ships to ‘regional’ British ports.

Table 20: Modelled deep sea container traffic by port grouping in 2050

Million units (deep sea gateway & feeder)

Port grouping	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing & Global Trade Renaissance 2050
Thames and Kent	0.04	0.07	0.07	0.07	0.21
Humber	1.29	2.06	1.93	1.93	5.11
Lancashire and Cumbria	0.05	0.10	0.09	0.09	0.28
Haven	0.17	0.33	0.31	0.31	0.98
Sussex and Hampshire	0.08	0.11	0.10	0.10	0.27
North East	0.05	0.11	0.10	0.10	0.40
West and North Wales	0.00	0.01	0.01	0.01	0.07
Scotland West Coast	0.63	0.94	0.88	0.88	2.34
Scotland East Coast	0.30	0.63	0.61	0.61	2.07
Bristol Channel	0.00	0.00	0.00	0.00	0.00
West Country	0.00	0.00	0.00	0.00	0.00
Total	2.62	4.36	4.11	4.11	11.74

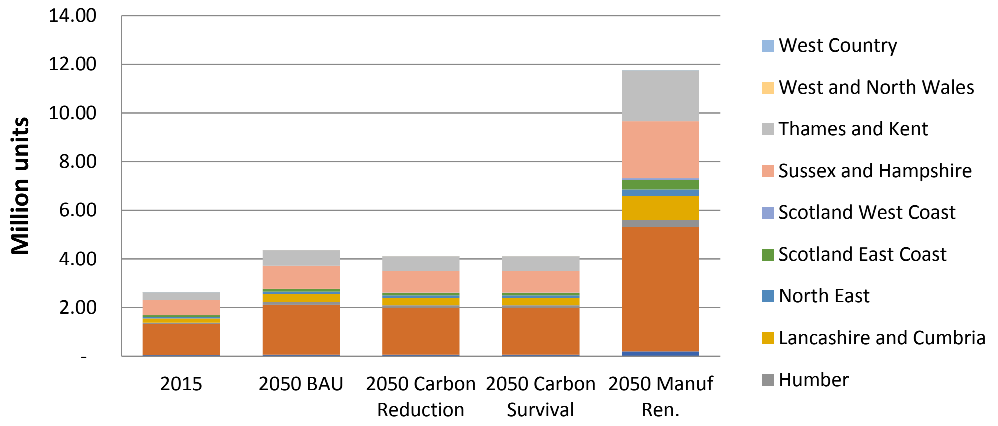
Source: MDS Transmodal GB Freight Model

Deep sea container traffic is forecast to increase from 2.6 to 4.4 million units in 2050 (growth of 66%) between 2015 and 2050 in the 2050 BAU scenario, but market growth would be slower in the 2050 Carbon Reduction and Carbon Survival scenarios because of the assume lower economic growth.

However, the 2050 Manufacturing Renaissance scenario leads to 348% growth in deep sea container traffic because of the assumed switch of trading focus from trade with the EU to trade with the rest of the world. This results in significant increases in traffic handled at port groupings that contain the deep sea container ports as shown in Figure 24 below; these are principally the Haven (the Port of Felixstowe), Thames and Kent (London Gateway), Sussex and Hampshire (Port of Southampton) and Lancashire and Cumbria (Port of Liverpool), but other 'regional' ports that handle feeder services would also secure additional traffic.

Figure 24: Modelled deep sea container traffic by port grouping 2050

Source: MDS Transmodal GB Freight Model



Deep sea bulk traffic by port group

Table 21 provides the modelled results for bulk traffic by port grouping; this only includes bulk port traffic that is distributed inland by road and rail, excluding in particular port traffic distributed by pipeline, and consists of dry bulk traffic (aggregates, cereals etc.), liquid bulk traffic (petroleum products, chemicals etc.) and semi-bulk traffic (packaged timber and steel etc.)

Table 21: Modelled bulk traffic by port grouping in 2050

Million tonnes

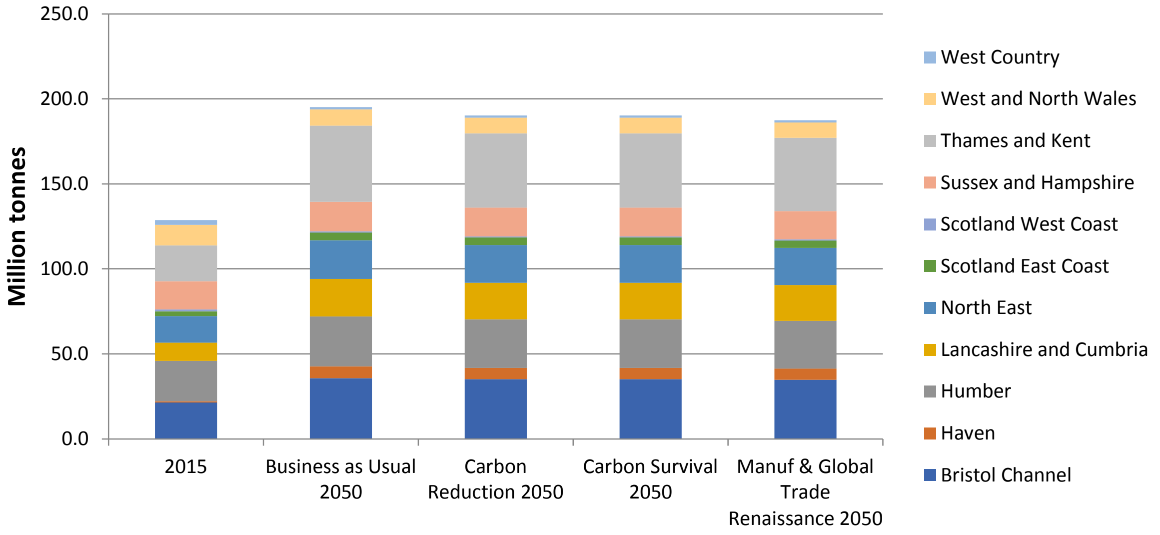
Port grouping	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing & Global Trade Renaissance 2050
Thames and Kent	21.3	35.7	35.0	35.0	34.7
Humber	0.8	6.9	6.7	6.7	6.6
Lancashire and Cumbria	23.7	29.5	28.6	28.6	28.2
Haven	10.8	22.1	21.4	21.4	21.0
Sussex and Hampshire	15.7	22.6	22.1	22.1	21.8
North East	2.8	4.6	4.5	4.5	4.5
West and North Wales	1.1	0.6	0.6	0.6	0.6
Scotland West Coast	16.6	17.4	17.0	17.0	16.7
Scotland East Coast	21.1	44.8	43.6	43.6	42.9
Bristol Channel	11.9	9.5	9.2	9.2	9.0
West Country	2.8	1.4	1.4	1.4	1.4
Total	128.6	195.2	190.2	190.2	187.4

Source: MDS Transmodal GB Freight Model

The total volumes of bulk traffic generally reflect the levels of economic activity in each of the scenarios, with a 52% increase in traffic between the 2015 base case and the 2050 BAU scenario and slightly lower levels of bulk traffics passing through ports in the other 2050 scenarios because of lower levels of aggregate economic activity (as shown in Figure 25). Bulk traffic is overwhelmingly attracted to users that are adjacent to ports and therefore there is relatively little competition between port areas.

Figure 25: Modelled bulk traffic by port grouping 2050

Source: MDS Transmodal GB Freight Model



4.6 Geographic impacts

This section of the report considers the geographic distribution of road and rail freight traffic for the modelled scenarios based on assignments of the traffic to the relevant inland transport networks. The geographic distribution of this traffic includes both domestic traffic with origins and destinations in Great Britain and international traffic that has passed through ports or via the Channel Tunnel.

Impact on the road network

The modelled impact of these changes on the road network is illustrated in Figures 26 and 27, which show the flows of annual HGVs in both directions on each link in 2015 and the 2050 BAU Scenario.

Figure 26 provides the modelled distribution of HGVs flows in 2015 and shows that the greatest concentrations of traffic are located on the Strategic Road Network, consisting of the motorways and major A roads.

Figure 26: HGV flows in 2015

Source: MDS Transmodal

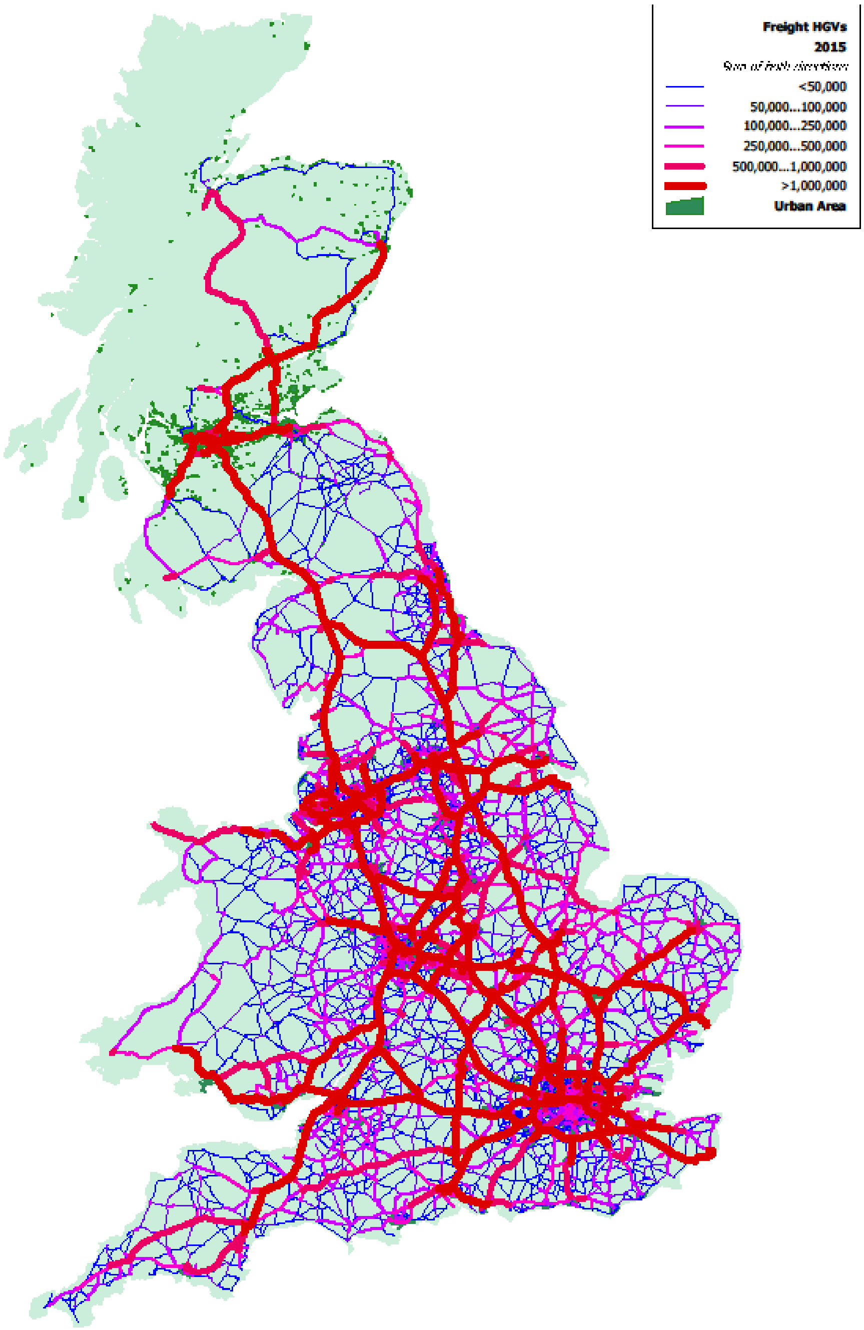


Figure 27 provides the modelled distribution of HGV flows for the 2050 BAU scenario.

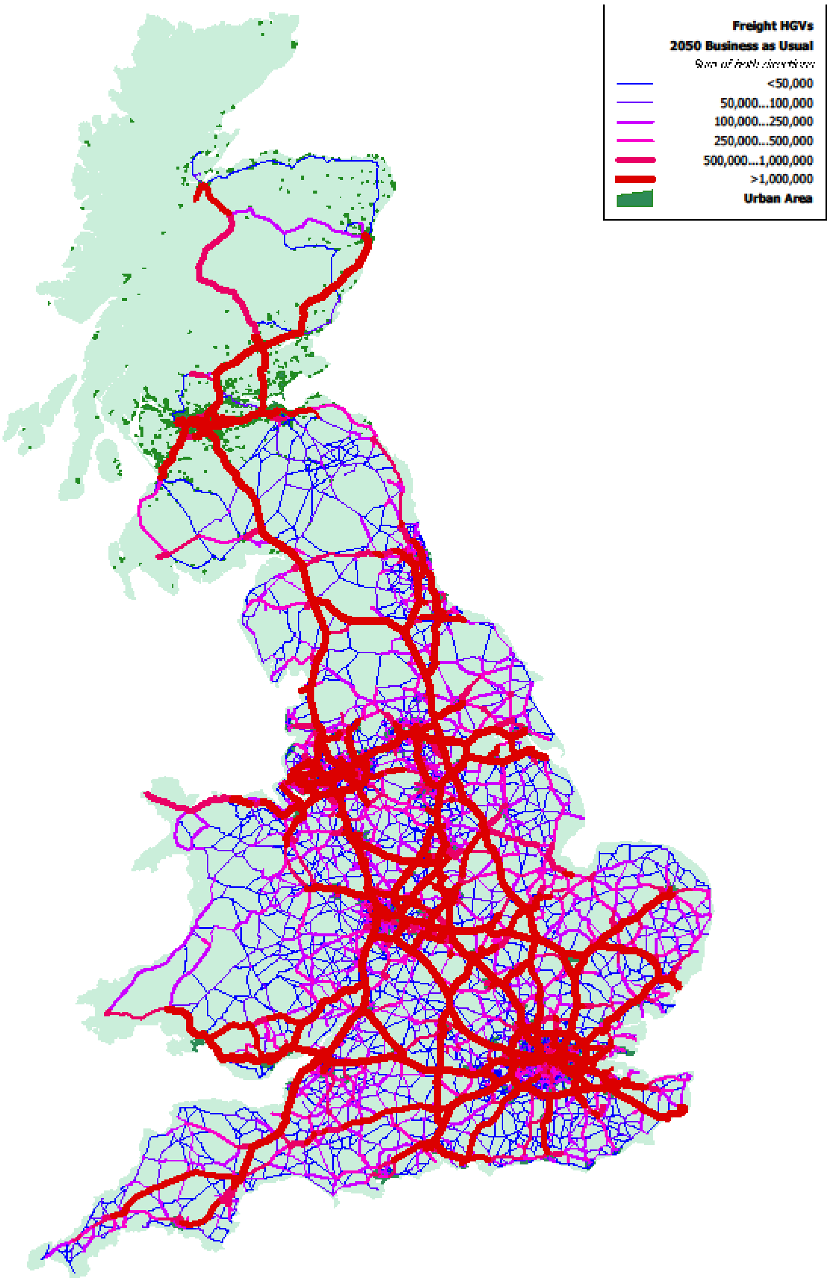


Figure 27: HGV flows in 2050 BAU Scenario
Source: MDS Transmodal

The modelling suggests that the 36% additional road freight tonne km in 2050 in the BAU scenario compared to 2015 adds more traffic to effectively the same links on the Strategic Road Network that are already intensively used.

The impact of a 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario is to reduce the overall number of HGVs on the road network on many links as shown in Figure 28; the mapped results for the 2050 Carbon Survival and 2050 Manufacturing Renaissance Scenarios are very similar and therefore have not been included. This reduction in HGV flows is partly due to the lower volumes of HGV movements as a result of lower levels of economic activity, but also due to an increase in intermodal rail freight services to and from rail-connected distribution parks as a result of the greater clustering of distribution centres on rail-connected sites.

There are, however, some increases in HGVs flows in and around the major conurbations and to and from some ports with short sea ferry links that offer longer distance services to the continental mainland and Ireland. These increases in traffic are due to:

- More HGV movements being required for the distribution of more voluminous e-commerce parcels between regional distribution centres and urban areas;
- Accompanied roro services to and from estuaries such as the Humber, Mersey, Haven, Solent and Tees attracting traffic on longer crossings at the expense of the shorter crossings of the Dover Straits and the Irish Sea.

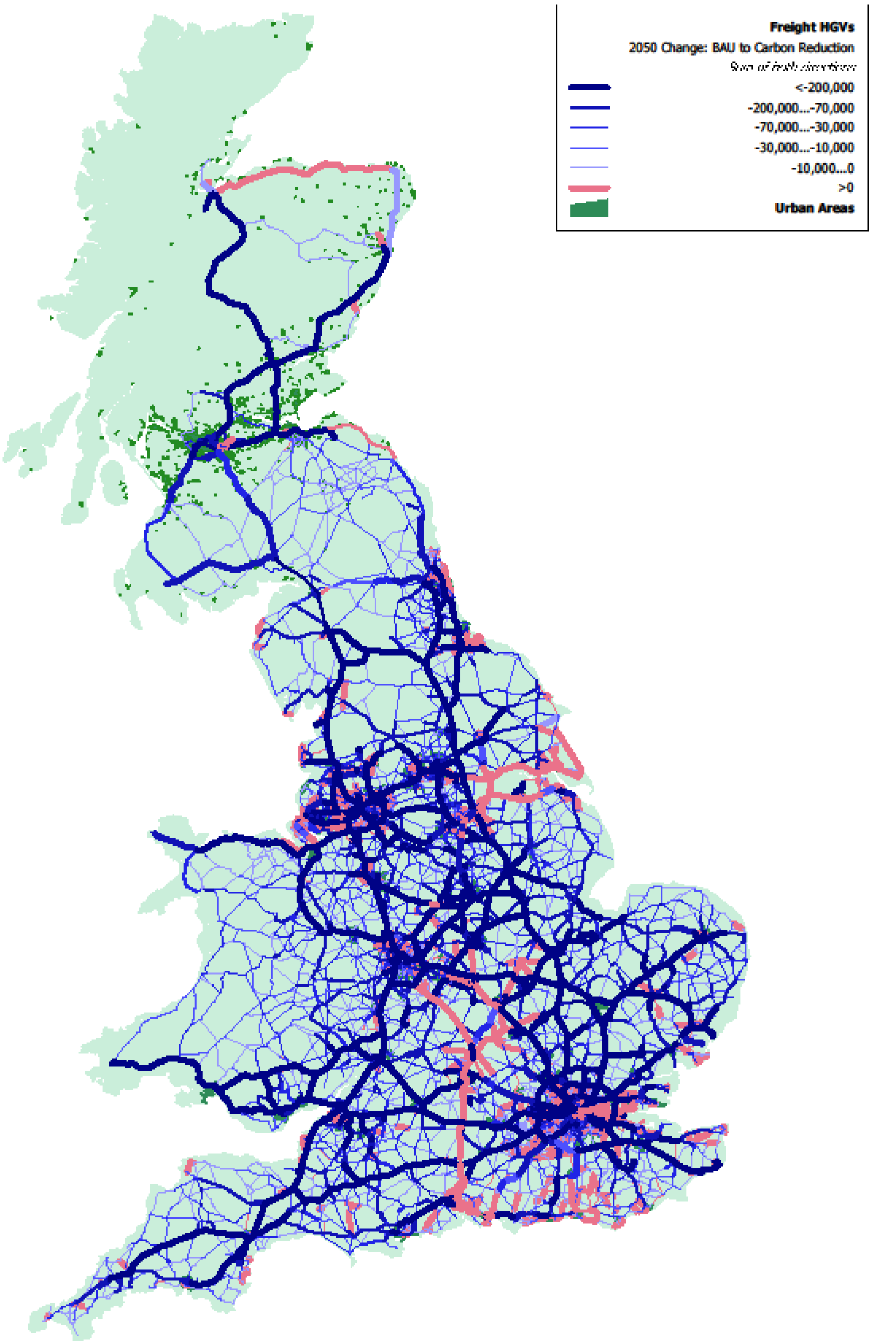


Figure 28: HGVs flows - absolute change in 2050 Carbon Reduction scenario vs BAU
Source: MDS Transmodal

Impact on the rail network

The modelling suggests that the 36% additional rail freight tonne km in 2050 in the BAU scenario adds traffic to the essentially the same links on the rail network as in 2015. The modelled impact of these changes on the rail network is illustrated in Figures 29 and 30, which show the flows of daily rail freight services in 2015 and the 2050 BAU Scenario.

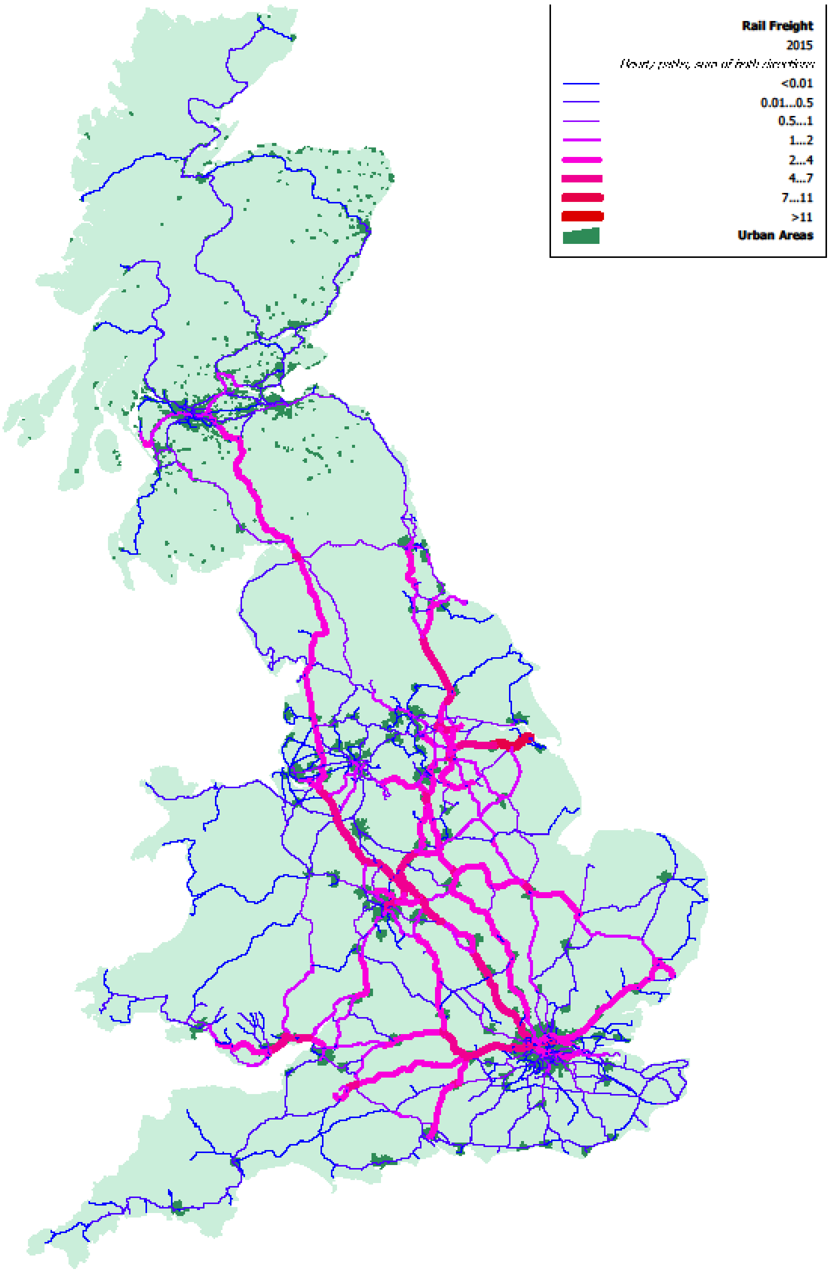


Figure 29: Rail freight in 2015

Source: MDS Transmodal

Figure 30: Rail freight in 2050 BAU Scenario

Source: MDS Transmodal

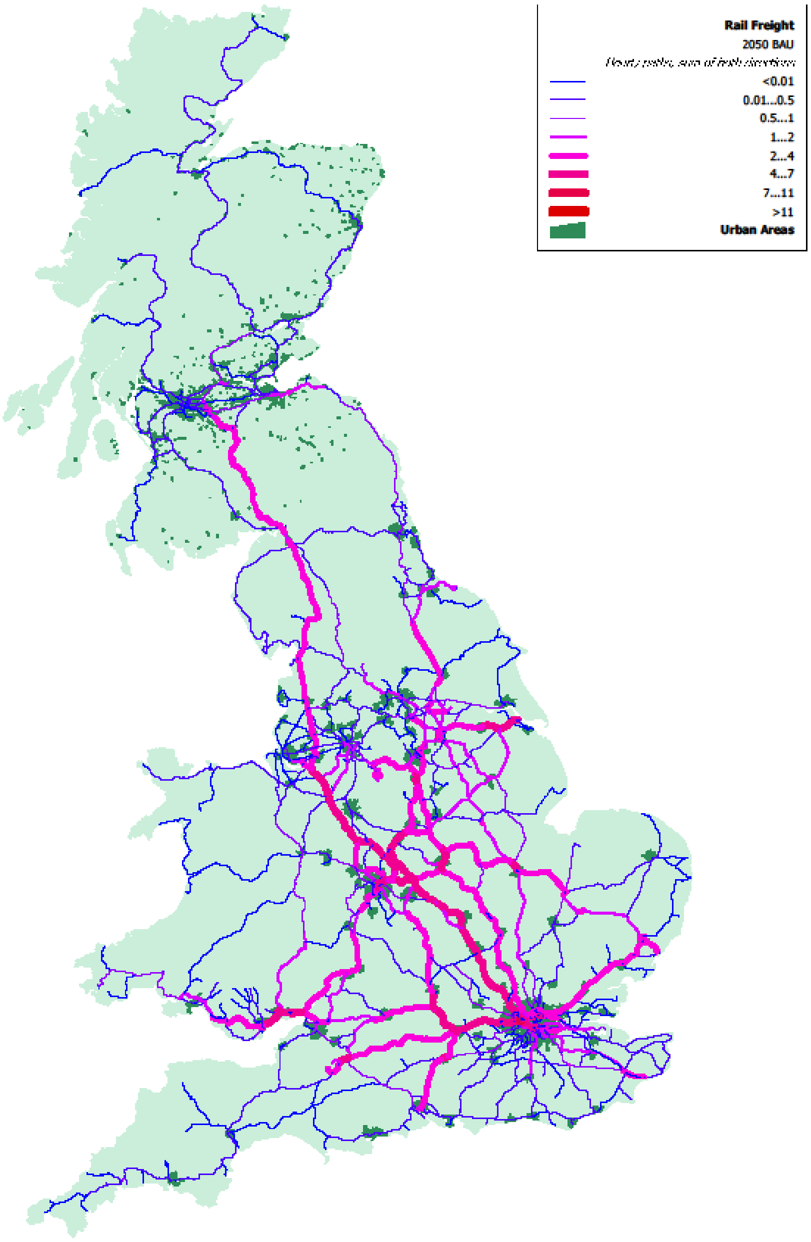


Figure 31 shows the absolute change in the number of trains operating on the network in the 2050 Carbon Reduction scenarios compared to the BAU scenario.

The impact of a 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario is to increase the number of trains on some sections of the West and East Coast Main Lines and to and from some deep water ports and reduce the number of trains through the Channel Tunnel.

This is mainly due to the greater clustering of distribution centres on rail-connected sites, which attracts more domestic and international traffic to and from the deep sea container ports to intermodal rail freight services. Rail freight growth is concentrated on north-south routes.

Figure 31: Rail freight - absolute change in 2050 Carbon Reduction vs BAU

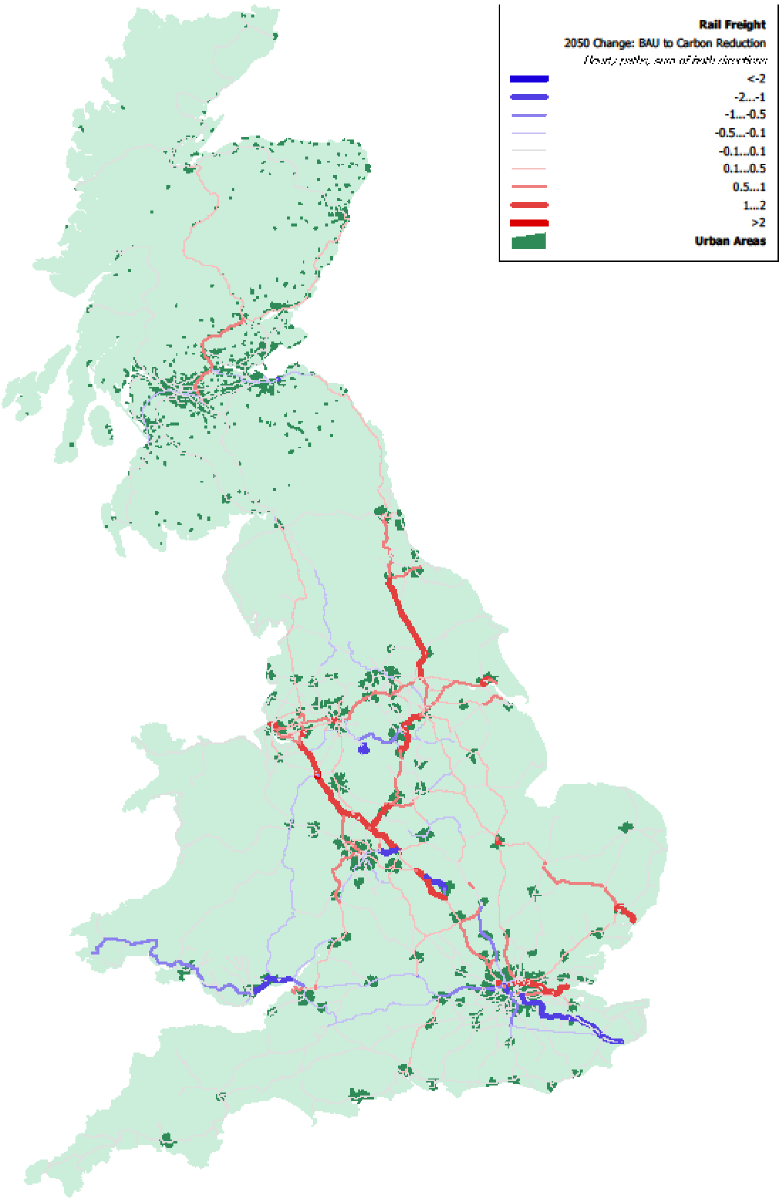


Figure 32 shows the absolute change in the number of trains operating on the network in the 2050 Carbon Survival scenarios compared to the BAU scenario.

The impact of a 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario is to further increase the number of trains on some sections of the West and East Coast Main Lines and to and from some deep water ports. This is mainly due to the assumed lower capital cost of using existing, older diesel locomotives in this scenario rather than the newer and more expensive electric locomotives that are assumed in the 2050 Carbon Reduction and Manufacturing Renaissance scenarios.

Figure 32: Rail freight - absolute change in 2050 Carbon Survival vs BAU

Source: MDS Trasmodal

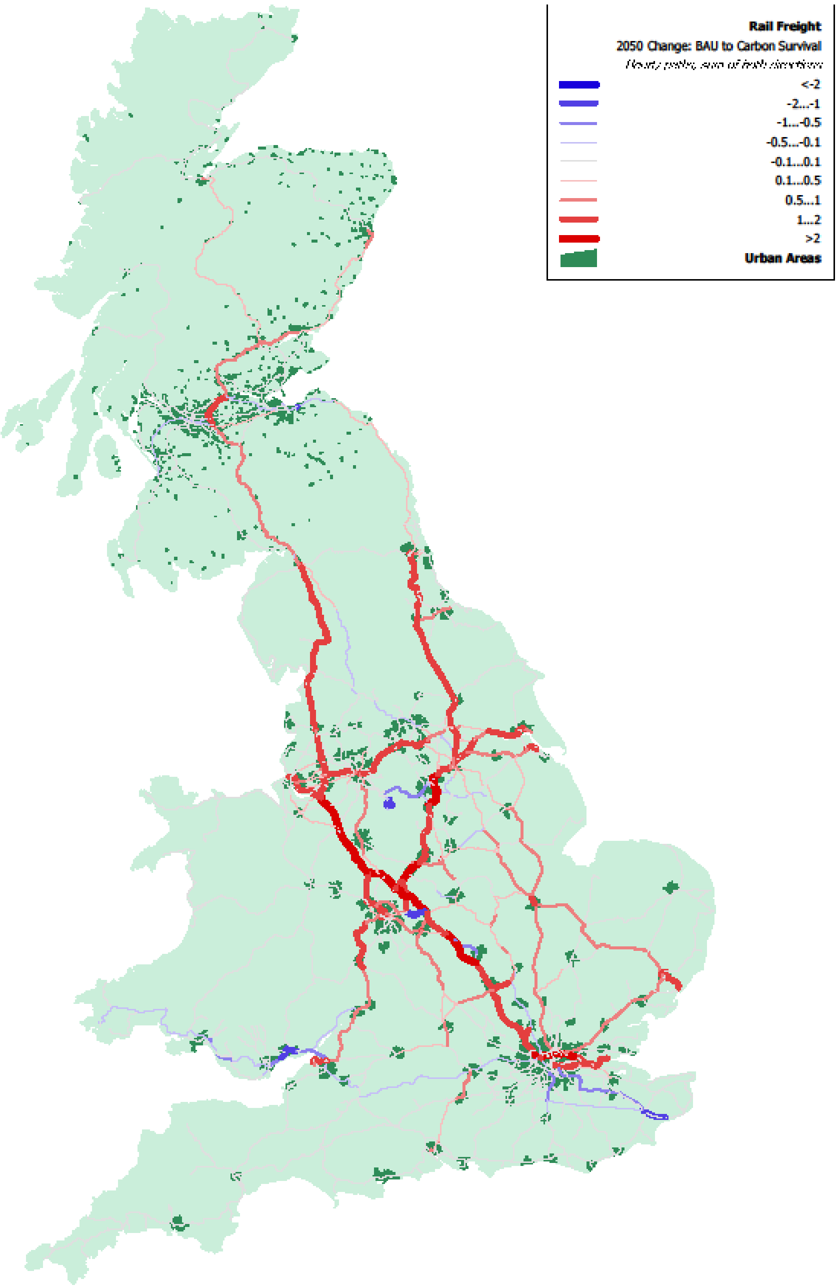
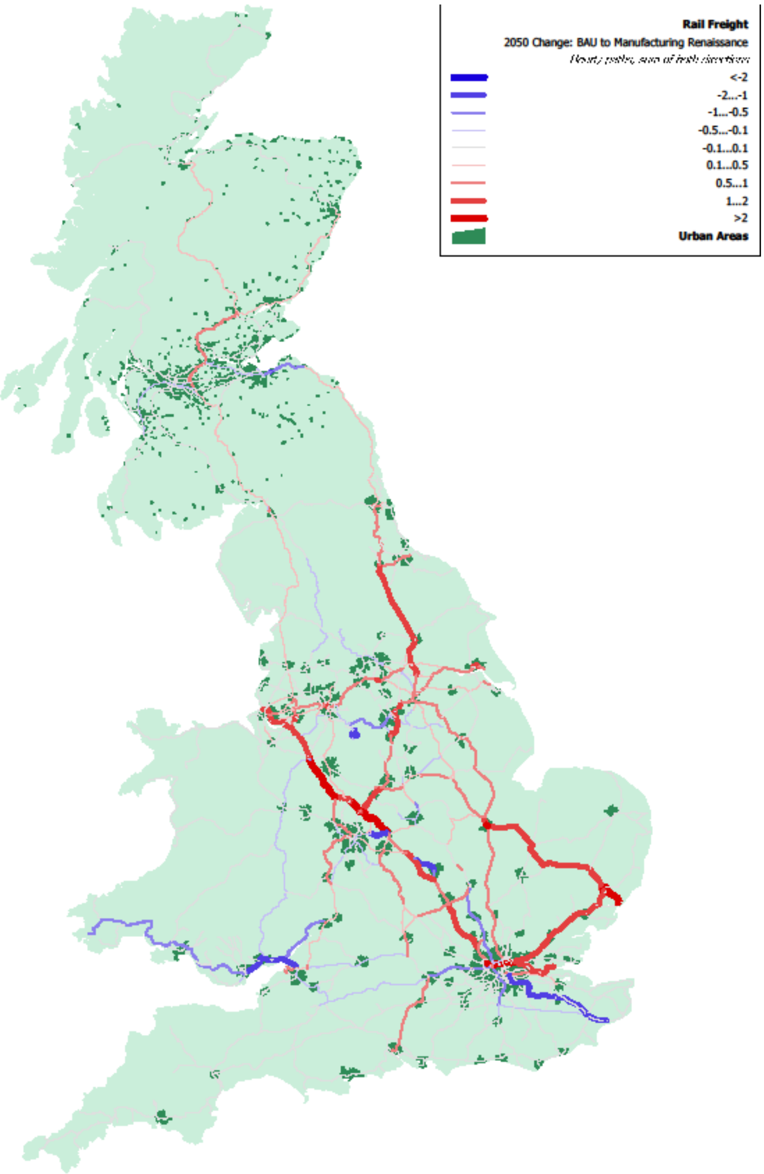


Figure 33 shows the absolute change in the number of trains operating on the network in the 2050 Manufacturing Renaissance Scenario compared to the BAU Scenario.

The impact of a 2050 Manufacturing Renaissance Scenario compared to the 2050 BAU Scenario is to further increase the number of trains on some sections of the West and East Coast Main Lines and to and from some deep water ports. This is mainly due to the assumed increased in the critical mass of deep sea container traffic handled at deep sea container ports as a result of a switch of the UK's trade away from the EU and towards non-EU markets.

Figure 33: Rail freight - absolute change in 2050 Manufacturing Renaissance vs BAU



Freight transported in light goods vehicles

The modelled impact of these changes in LGC traffic on the road network is illustrated in Figures 34 and 35, which show the flows of annual LGVs in both directions on each link in 2015 and the 2050 BAU Scenario.

Figure 34 provides the modelled distribution of HGVs flows in 2015 and shows that the greatest concentrations of traffic are located in and round the major conurbations with the greatest populations, while Figure 35 shows there would be significant increases in traffic volumes to be accommodated on the same network links in 2050 in the BAU Scenario.

Figure 34: LGV flows in 2015

Source: MDS Transmodal

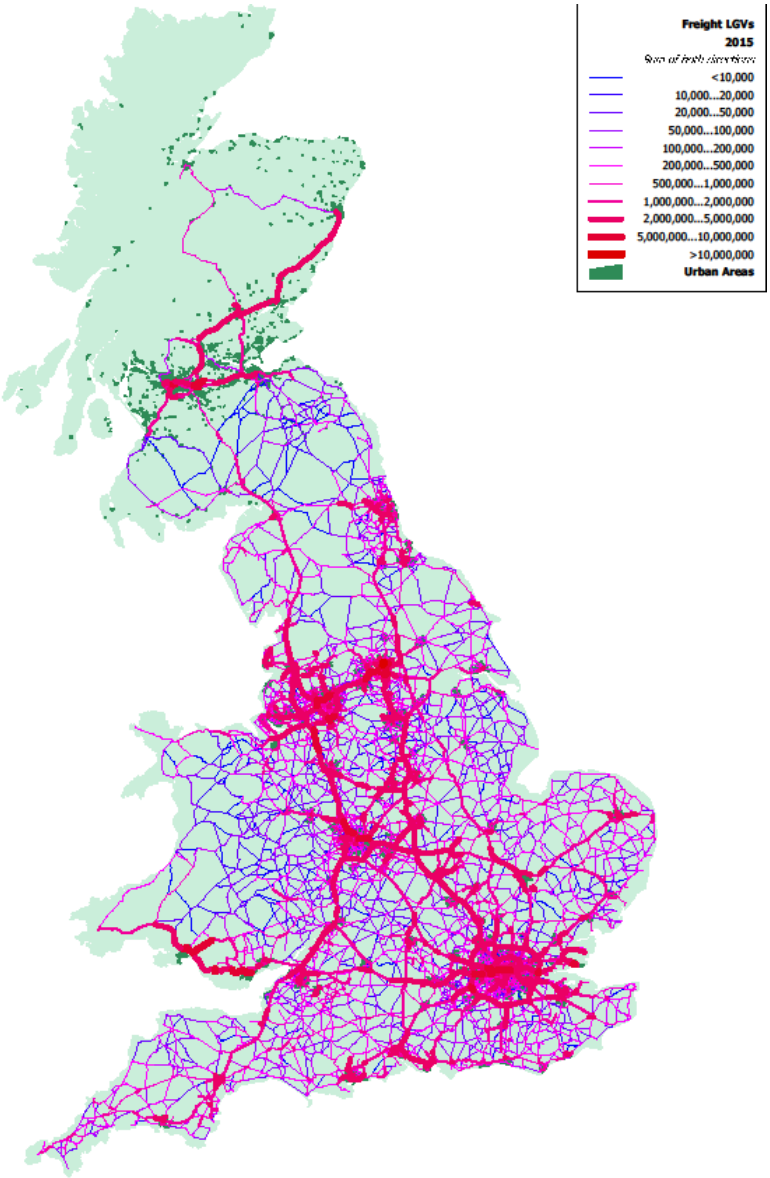
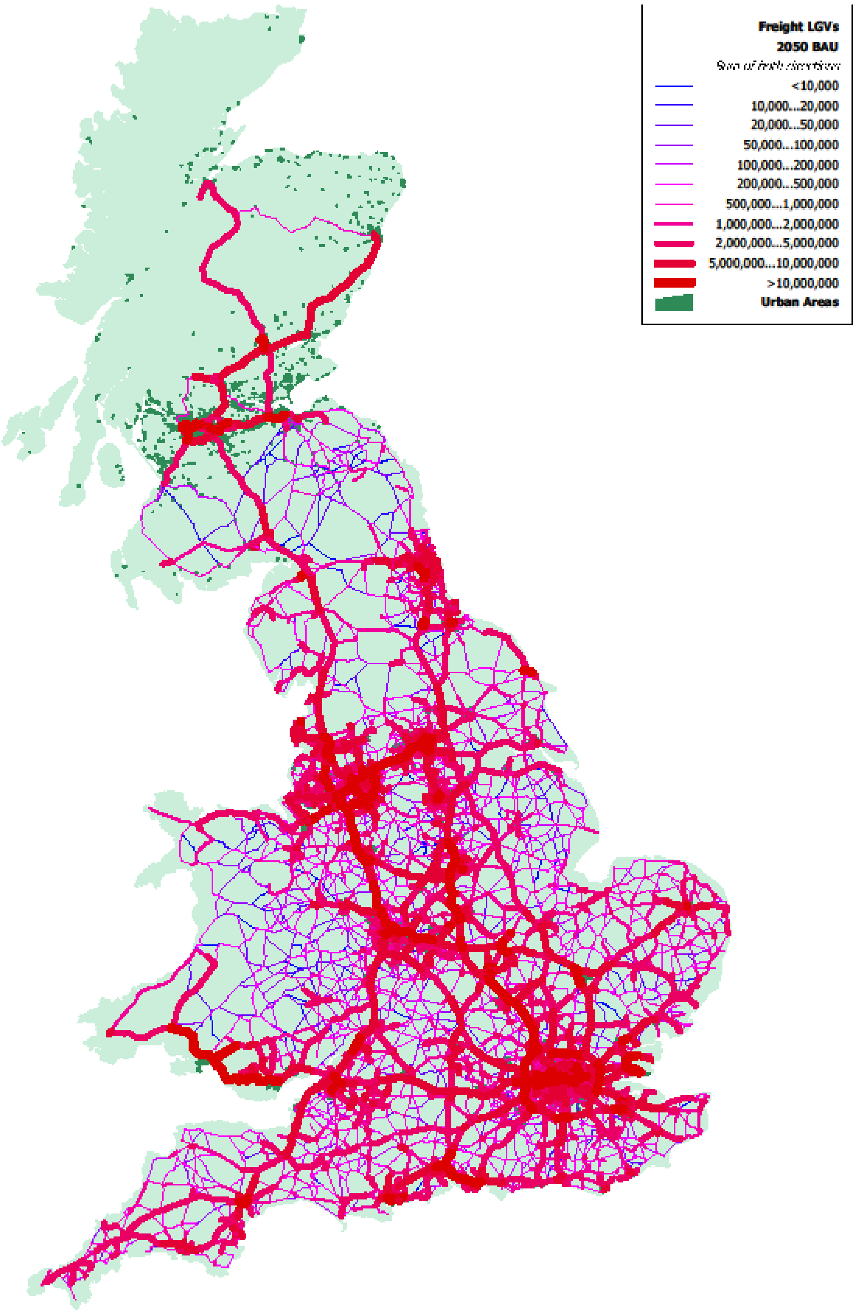


Figure 35: LGV flows in the 2050 BAU Scenario

Source: MDS Transmodal

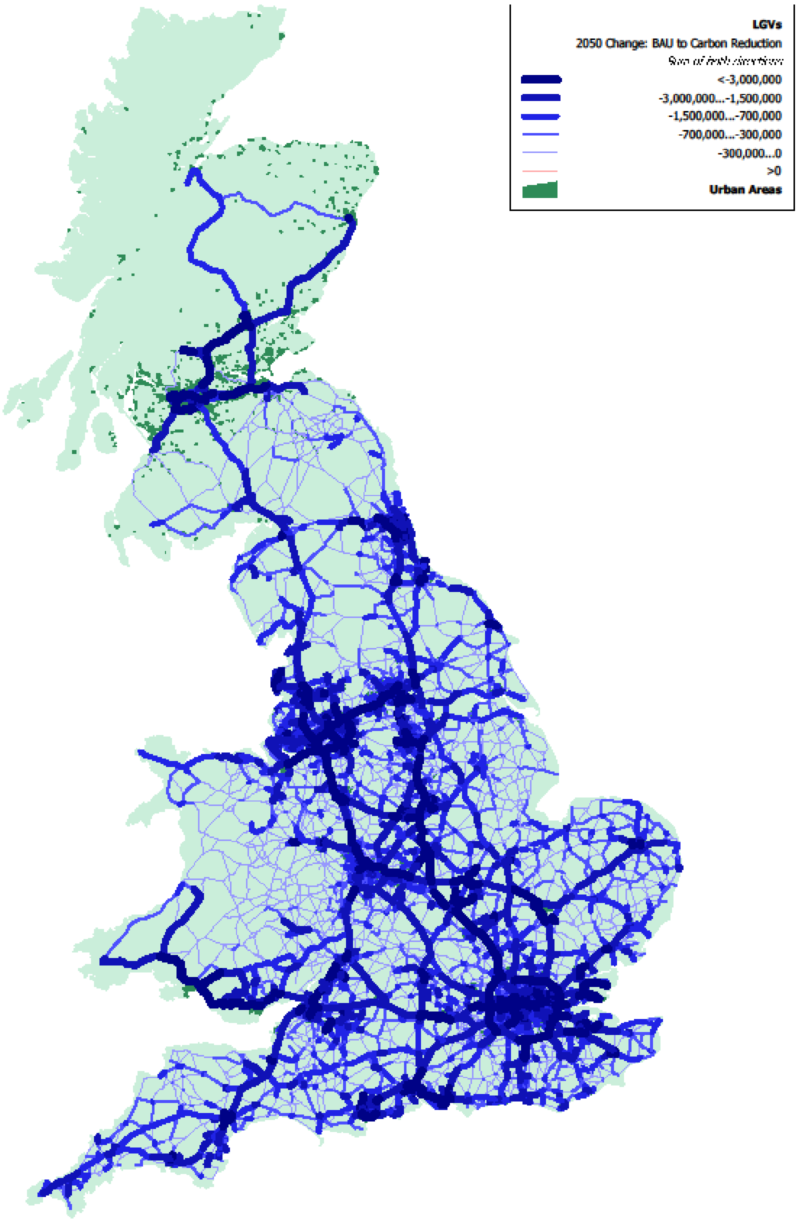


The modelled impact of changes in LGV traffic for the other 2050 model scenarios compared to the 2050 BAU Scenario are shown in Figures 36, 37 and 38 below, which show general reductions in traffic volumes across the road network. As there is no potential modal response included within the modelling as there is assumed to be no cost effective alternative to LGVs for the delivery and collection of lightweight parcels in urban areas, the reductions in LGV traffic flows in each scenario compared to the 2050 BAU Scenario are due to the lower levels of overall economic activity that are assumed compared to the 2050 BAU Scenario.

The greatest reductions in traffic are in the 2050 Carbon Reduction Scenario (Figure 36) because of the lower penetration of the retail market by e-commerce, so that a lower proportion of passenger trips to retail outlets are substituted by LGVs making parcel deliveries.

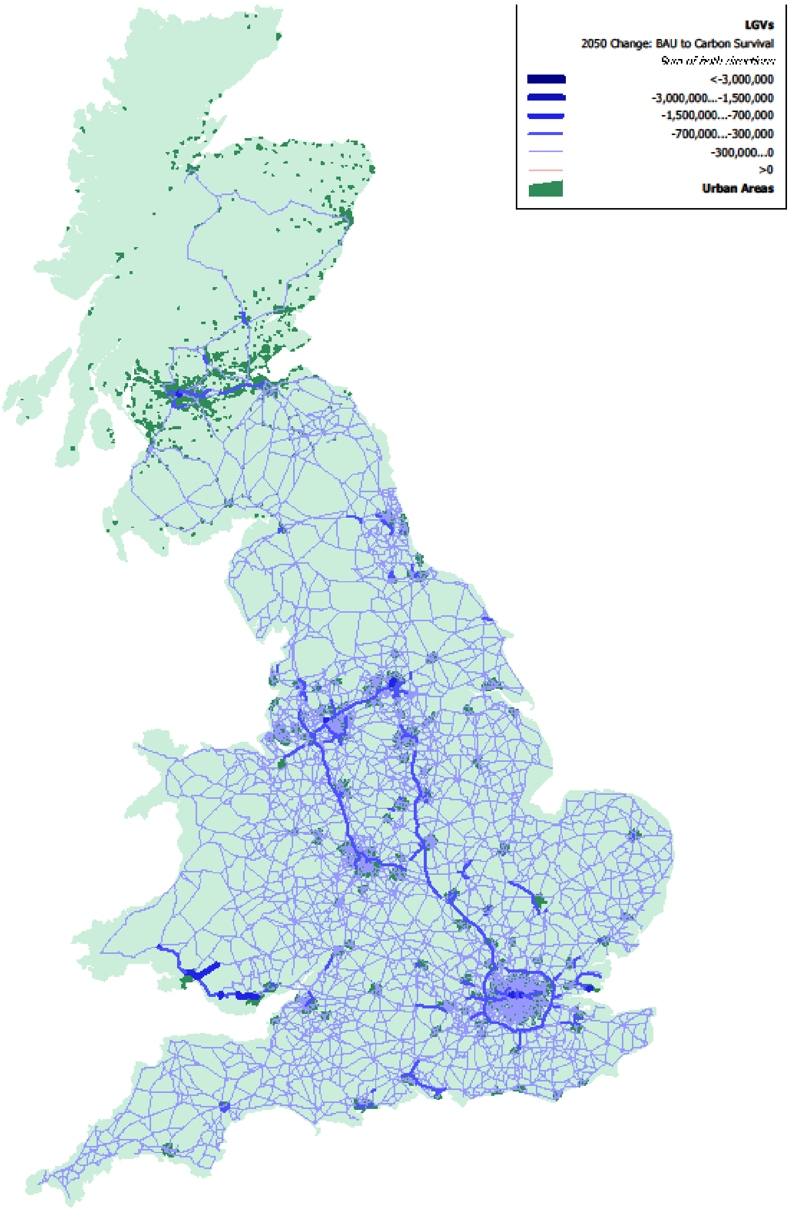
Figure 36: Absolute change in LGV flows in the 2050 Carbon Reduction Scenario vs the BAU

Source: MDS Transmodal



The smallest reductions in traffic are for the 2050 Carbon Survival Scenario (Figure 36) because of the higher penetration of the retail market by e-commerce that is assumed, so that a higher proportion of passenger trips to retail outlets are substituted by LGVs making parcel deliveries in this scenario compared to the 2050 Carbon Reduction Scenario.

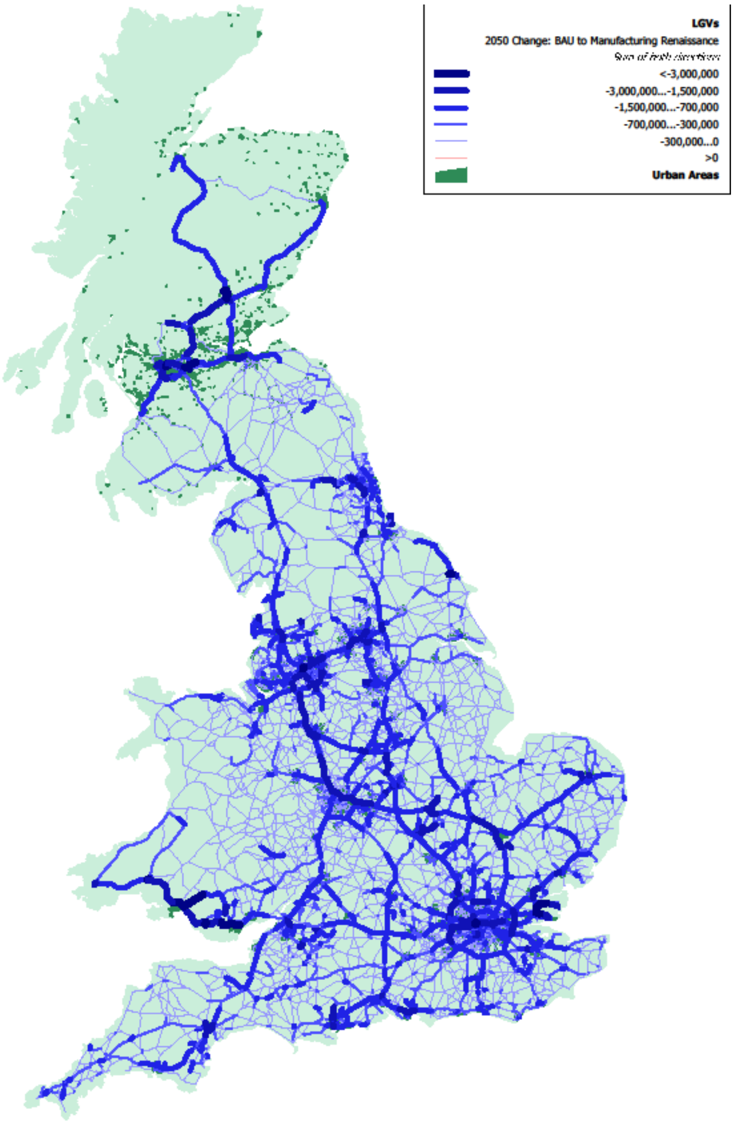
Figure 37: Absolute change in LGV flows in the 2050 Carbon Survival Scenario vs the BAU Scenario
Source: MDS Transmodal



A greater reduction in traffic is observed in the 2050 Manufacturing Renaissance Scenario (Figure 37) compared to the Carbon Survival Scenario because, although the penetration of the retail market by e-commerce is the same in both scenarios, the level of overall economic activity assumed in the Manufacturing Renaissance Scenario is lower than in the Carbon Survival Scenario.

Figure 38: Absolute change in LGV flows in the 2050 Manufacturing Renaissance Scenario vs the BAU Scenario

Source: MDS Transmodal



4.7 Change in user and non-user costs

The modelled change in road and rail freight user costs for 2050 between the BAU Scenario and the other scenarios are set out in Table 22 both in total and in terms of a change in cost per tonne lifted. User costs are those incurred directly by the freight industry in financial terms while using the road and rail networks. The modelled scenarios set out the potential impact of a range of assumptions related to the costs of the road, rail and short sea shipping modes that are incurred by the freight industry, including the (very uncertain) future costs of electric HGVs. The freight industry costs used for the modelling are summarised in Appendix 5.

Table 22: Modelled road, rail and maritime user costs in 2050 BAU Scenario and change with BAU for other 2050 scenarios

	Total user costs in 2050m BAU	Carbon Reduction 2050 (change compared to 2050 BAU)	Carbon Survival 2050 (change compared to 2050 BAU)	Manufacturing Renaissance 2050 (change compared to 2050 BAU)
Road user costs	£33.660bn	-£8.388bn	-£8.652bn	-£8.196bn
Rail user costs	£0.642bn	+£0.092bn	+£0.034bn	+£0.114bn
Maritime user costs	£2.299bn	-£0.426bn	-£0.962bn	-£0.533bn
User costs	£36.601bn	-£8.722bn	-£9.580bn	-£8.615bn
User cost/tonne	£12.80/tonne	-£3.35/tonne	-£3.65/tonne	-£3.46/tonne

Source: MDS Transmodal GB Freight Model

The results suggest that – subject to the caveats on CAVs set out above – the lower carbon scenarios for 2050 would lead to a reduction in the user costs incurred by the freight industry, principally due to the reduction of labour costs for road haulage and the greater use of more cost effective rail freight services and longer distance short sea shipping services. As the freight industry is intensely competitive these benefits would be passed on in the medium to long term as lower costs of production, lower prices for consumers and therefore increased gross value added.

The modelled change in non-user costs for 2050 between the BAU Scenario and the other scenarios are set out in Table 23 both in total and in terms of a change in cost per tonne lifted. Non-user costs in this context are those incurred by other users of the networks (mainly the impact of congestion on passengers) and the environment through the use of the road network by HGVs. These non-user costs have been calculated using the Modal Shift Benefit values[xvi] that the Department for Transport uses to calculate the environmental benefits that accrue from switching freight from the road to rail and waterborne freight transport.

Table 23: Modelled change in non-user costs compared to the Business as Usual Scenario in 2050

	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing & Global Trade Renaissance 2050
Change in total non-user costs	-£1.6bn	-£1.2bn	-£1.9bn
Change in non-user costs/tonne	-£0.62	-£0.47	-£0.75

Source: MDS Transmodal GB Freight Model

The results suggest that the lower carbon scenarios for 2050 would also lead to a reduction in non-user costs, principally due to the greater use of intermodal rail freight services to and from clusters of distribution centres on rail connected distribution parks and lower emissions from HGVs.

4.8 Local case studies

Introduction

The analysis for this study included examining the potential future demand for freight transport is some urban areas, which were selected in consultation with the client to be reasonably representative of important categories of urban areas. Case studies on the future of freight transport demand have therefore been completed for:

- Manchester and Glasgow (as examples of conurbations);
- Southampton (as an example of a port city);
- Bath (as an example of a heritage city), within the wider mainly rural local authority area (Bath and North East Somerset).

The scenarios shown are the same as those modelled for the whole of Great Britain. In the event that autonomous HGVs do not emerge as a practical technological solution by 2050, but the planning system leads to greater clustering of distribution centres on rail-connected distribution parks, major conurbations such as Manchester and Glasgow and cities with deep sea container ports such as Southampton would see a substantial increase in rail freight.

Manchester

The Greater Manchester Built up Area had a population of 2.55 million in 2011 and is the second most populous conurbation in the UK after Greater London; the city of Manchester alone had a population of 510,000 in 2011.

The city is located adjacent to the M6 corridor on a north-south axis and on the M62 Corridor on an east-west axis, with the M60 orbital motorway providing a route around the city for strategic traffic. The city is also located on the West Coast Main Line north-south rail route and has two active intermodal terminals at Trafford Park; the city is connected to Liverpool most directly via the Chat

Moss route and to Leeds and Sheffield by means of three trans-Pennine routes. Salford in Greater Manchester is connected to the Mersey estuary via the Manchester Ship Canal and there is an existing short sea container service along the canal to Irlam. There are major concentrations of distribution centres, serving both the North West region and, in some cases, a national hinterland, adjacent to the M62 and M6 corridors.

Total estimated freight delivered in Greater Manchester in 2015 was some 40.3m tonnes, while the conurbation was the origin of an estimated 35.9m tonnes of freight (Table 24). The balance in favour of net inbound freight traffic is typical of densely populated urban areas which have a greater propensity to consume, rather than generate, freight traffic.

Table 24: Summary freight data for Manchester, 2015

Million tonnes

	Origin of freight (million tonnes)	Destination of freight (million tonnes)
Road freight	34.4	37.8
Rail freight	1.5	2.5
Total	35.9	40.3

Source: MDS Transmodal GB Freight Model

Figure 39 shows the annual volume of HGVs in the 2015 base case; the major modelled flows of HGVs are concentrated on the M62 and M60 motorways around Manchester and on some of the major routes, mainly from the M60 to the west of the city into the city centre.

Forecast traffic for Manchester as a destination in 2050 is shown in Table 25 below.

Table 25: Modelled road and rail freight to Manchester

Million tonnes lifted

	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing Renaissance 2050
Road freight	37.8	61.2	54.5	54.5	52.2
Rail freight	2.5	4.8	4.0	5.3	6.2
Total	40.3	66.0	58.5	59.8	58.4

Source: MDS Transmodal GB Freight Model

Figure 40 shows the annual volume of HGVs in the 2050 BAU Scenario and Figure 41 shows the change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario (as an example of the change between one of the scenarios and the 2050 BAU Scenario).

The modelling suggests that the additional 62% road freight tonnes lifted in 2050 in the BAU scenario compared to 2015 adds more traffic to effectively the same links on the Strategic Road Network. Figure 41 suggests that the impact of a 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario would be to reduce the overall number of HGVs on the road network on many links. This reduction in HGV flows is partly due to the lower volumes of HGV movements as a result of lower levels of economic activity, but also due to an increase in intermodal rail freight services to and from rail-connected distribution parks in Greater Manchester as a result of the greater clustering of distribution centres on rail-connected sites. There are also some increases in HGVs flows in and around Greater Manchester due to more HGV movements being required for the distribution of more voluminous e-commerce parcels between regional distribution centres and urban areas and more local deliveries and collections from intermodal rail terminals.

Figure 39: Manchester – Annual HGV flows in 2015

Source: MDS Transmodal

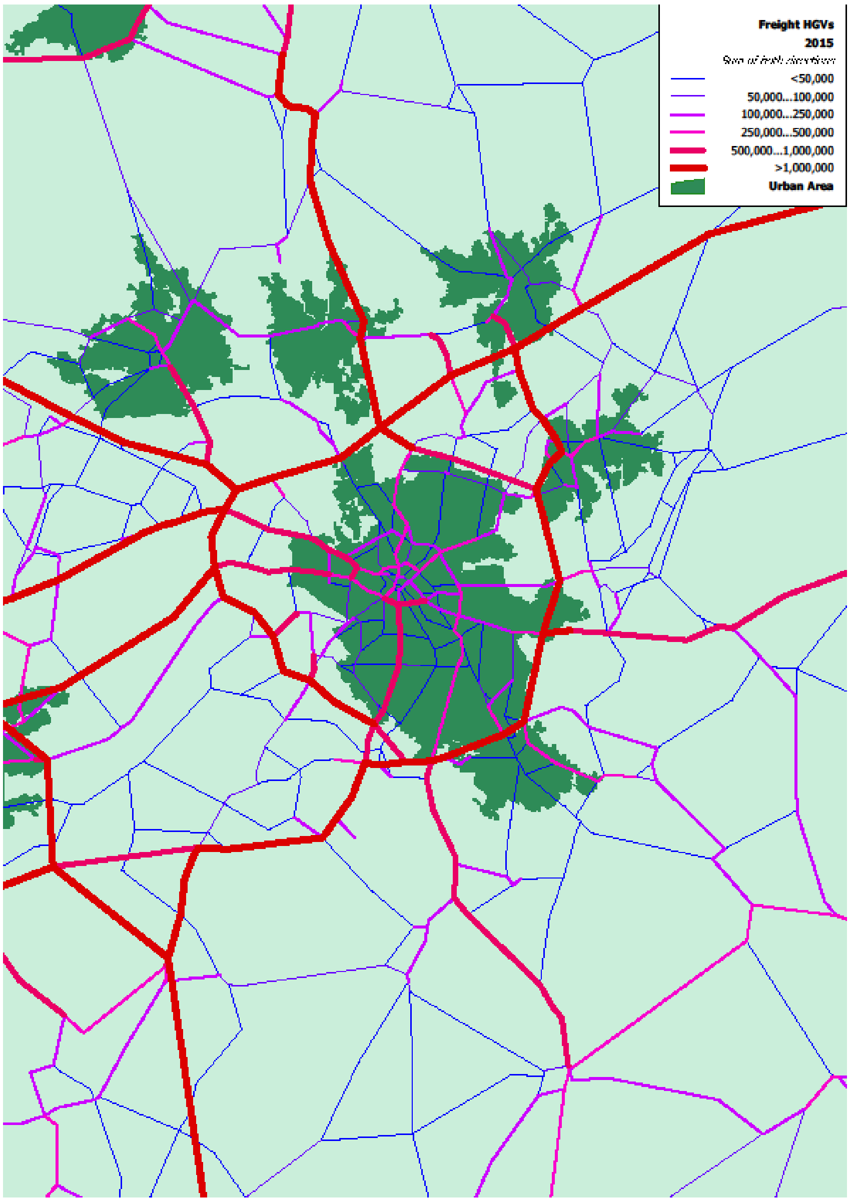


Figure 40: Manchester - Annual HGV flows in the BAU Scenario 2050

Source: MDS Transmodal

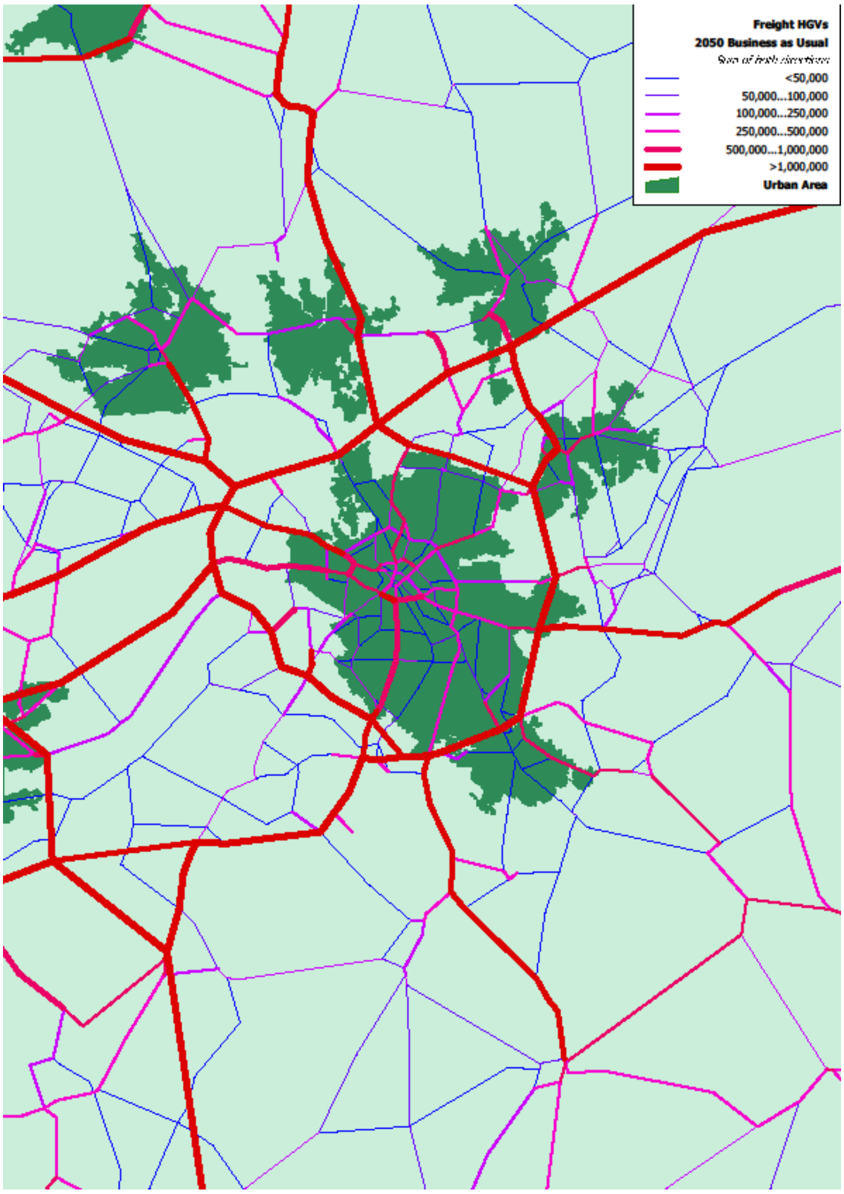


Figure 41: Manchester - Change in annual HGV flows in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal

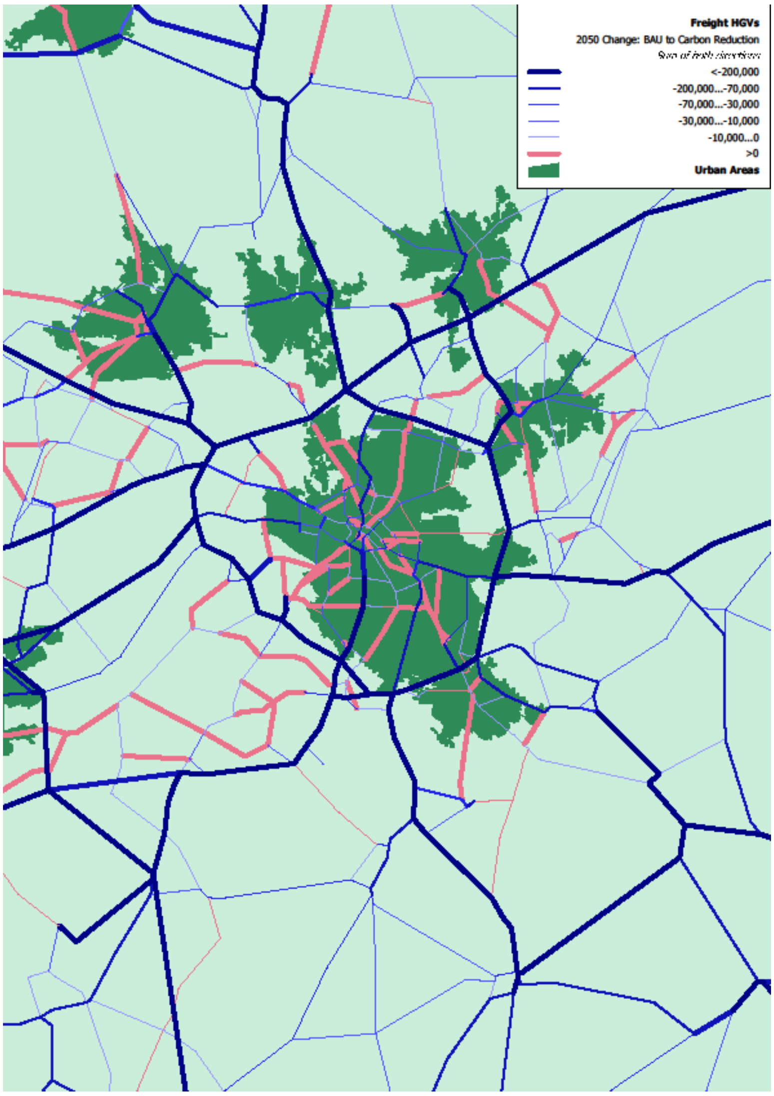


Figure 42 shows the daily train paths required for rail freight in the 2015 base case and that the major rail freight flows are between the West Coast Main Line and the Trafford Park intermodal terminals to the west of the city centre. Figure 43 shows the daily train paths required for rail freight in the 2050 BAU Scenario and Figures 44 shows the change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario.

Figure 43 suggest that there would be little change in the number of trains to and from Manchester in the 2050 BAU Scenario, but Figure 44 shows there would be an increase in intermodal rail freight services in the 2050 Carbon Reduction Scenario; this traffic would be to and from rail-connected distribution parks in Greater Manchester and the wider North West as a result of the greater clustering of distribution centres on rail-connected sites, as well as more traffic to and from the Port of Liverpool. This leads to additional transit rail traffic through the centre of Manchester.

In the event that autonomous HGVs do not emerge as a practical technological solution by 2050, but the planning system leads to greater clustering of distribution centres on rail-connected distribution parks, Manchester would see a substantial increase in rail freight in all the 2050 scenarios.

Figure 42: Manchester – Daily rail freight paths in 2015

Source: MDS Transmodal

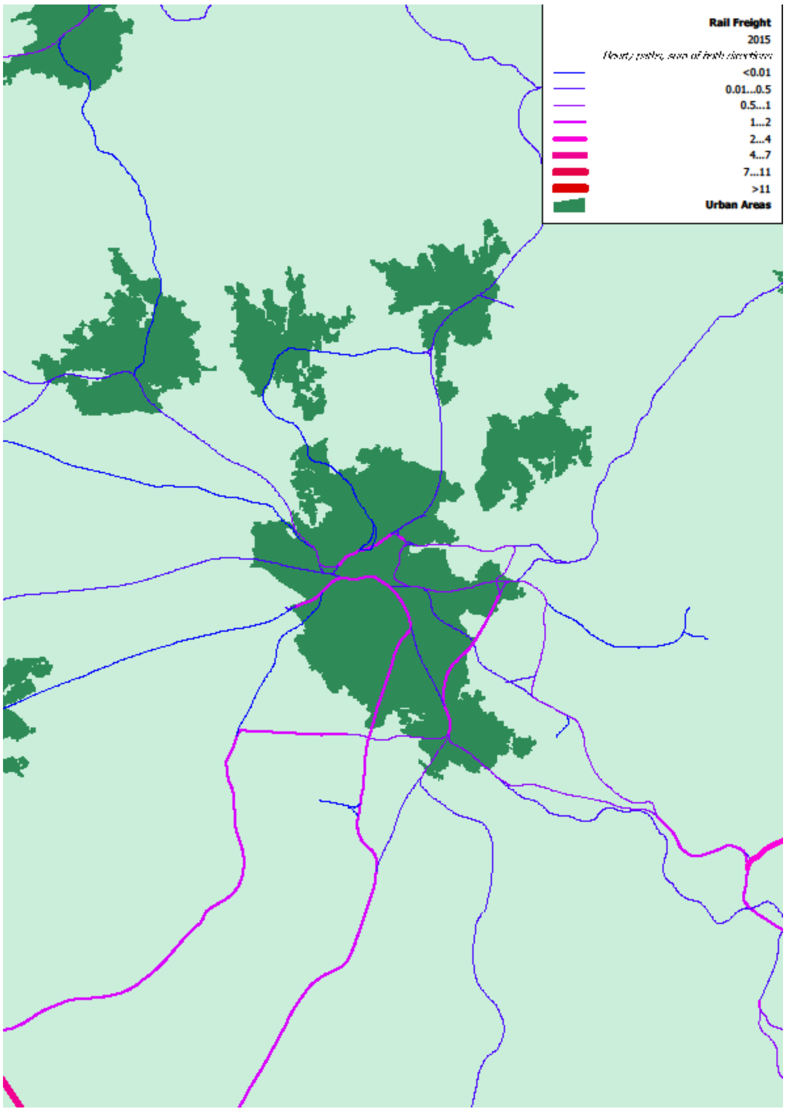


Figure 43: Manchester - Daily rail freight paths required in the 2050 BAU Scenario

Source: MDS Transmodal

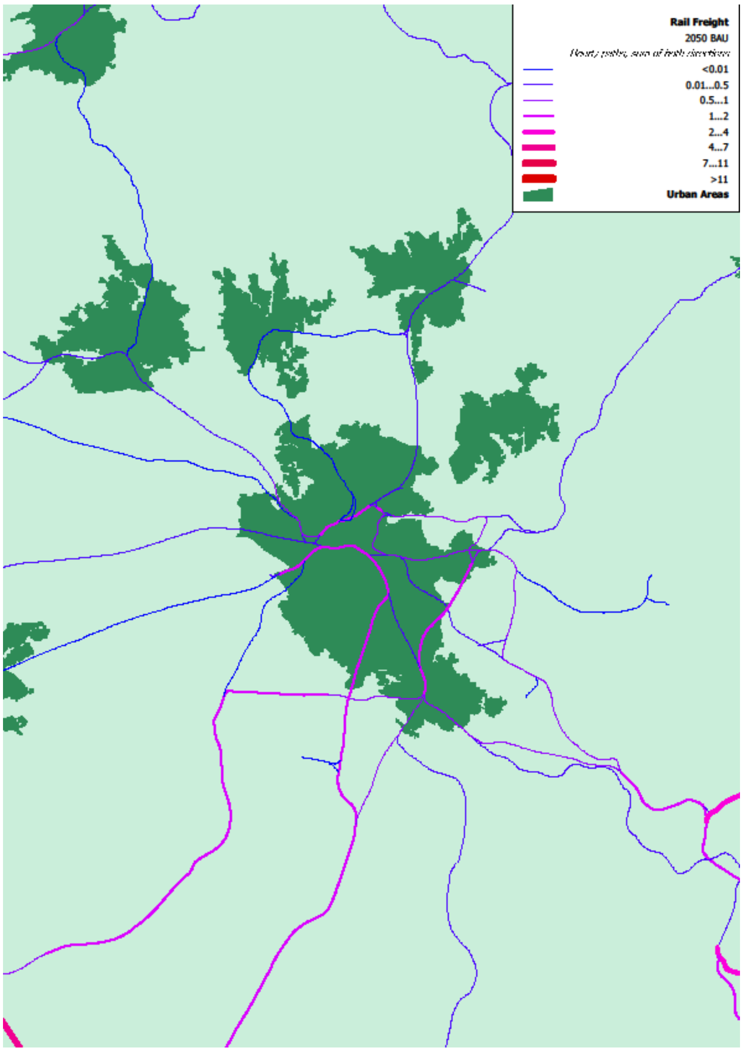


Figure 44: Manchester - Change in daily rail freight paths in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal

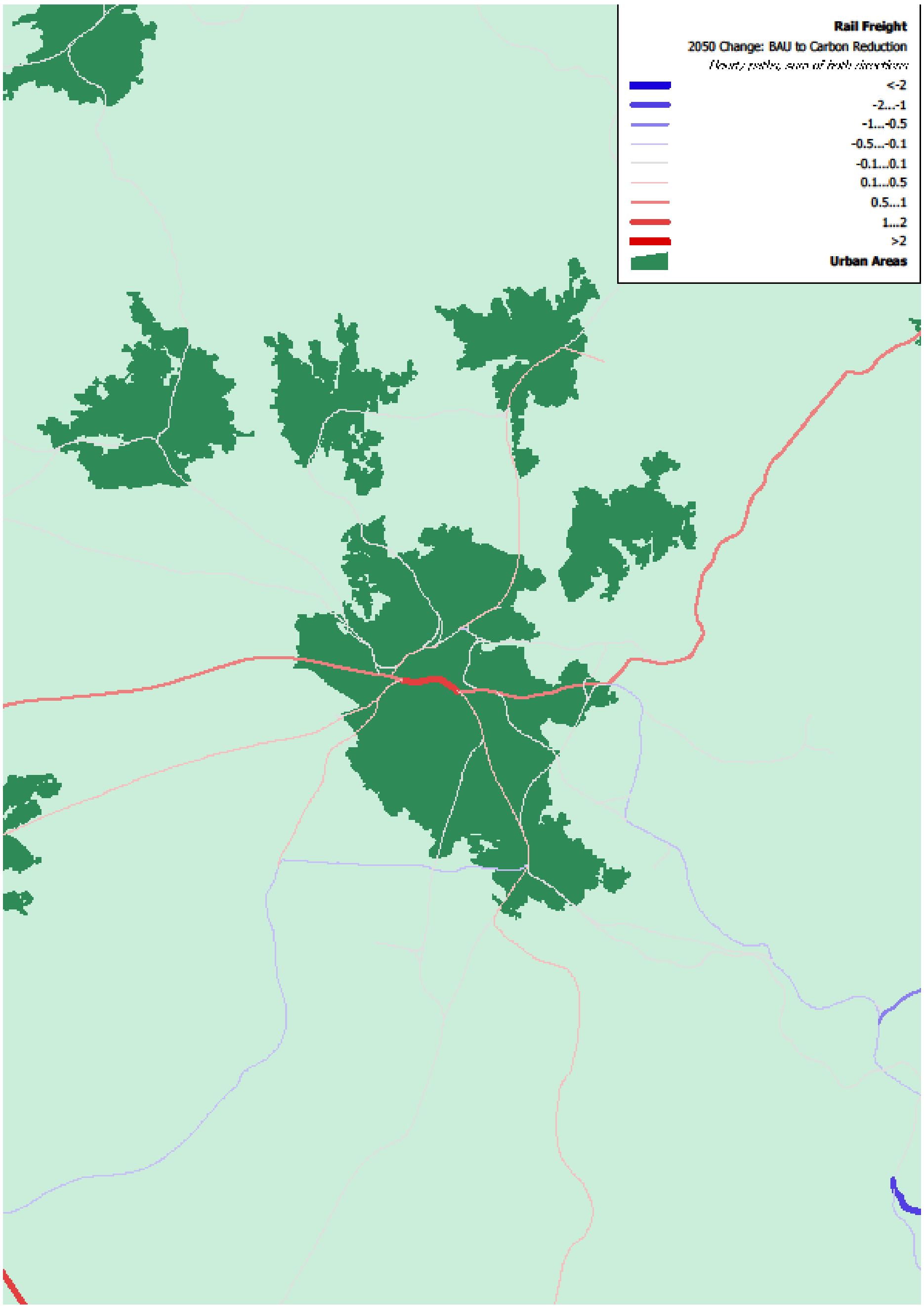


Figure 45 shows the annual LGV movements in the 2015 base case and that, although there are concentrations of traffic on the strategic road network there are also more dispersed movements on more regional and local roads.

Figure 46 shows the annual LGV movements in the 2050 BAU Scenario and Figure 47 shows the change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario. Figure 46 shows there would be significant increases in traffic volumes to be accommodated on the same network links in the 2050 BAU Scenario as in the 2015, mainly as a result of increased penetration of the retail market by e-commerce. Figure 47 shows the modelled reduction in LGV traffic in the 2050 Carbon Reduction Scenario due to the assumed lower penetration of the retail market by e-commerce, so that a lower proportion of passenger trips to retail outlets are substituted by LGVs making parcel deliveries.

Figure 45: Manchester – Annual LGV flows in 2015

Source: MDS Transmodal

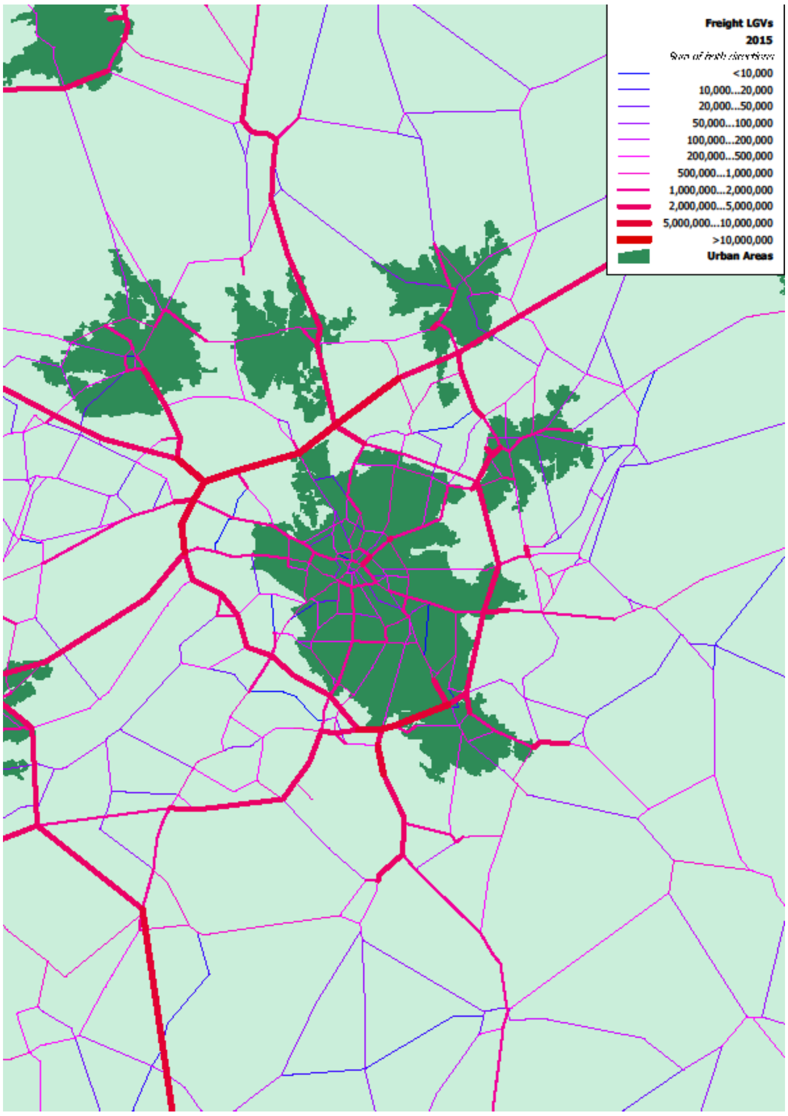


Figure 46: Manchester - Annual LGV flows in the 2050 BAU Scenario
Source: MDS Transmodal

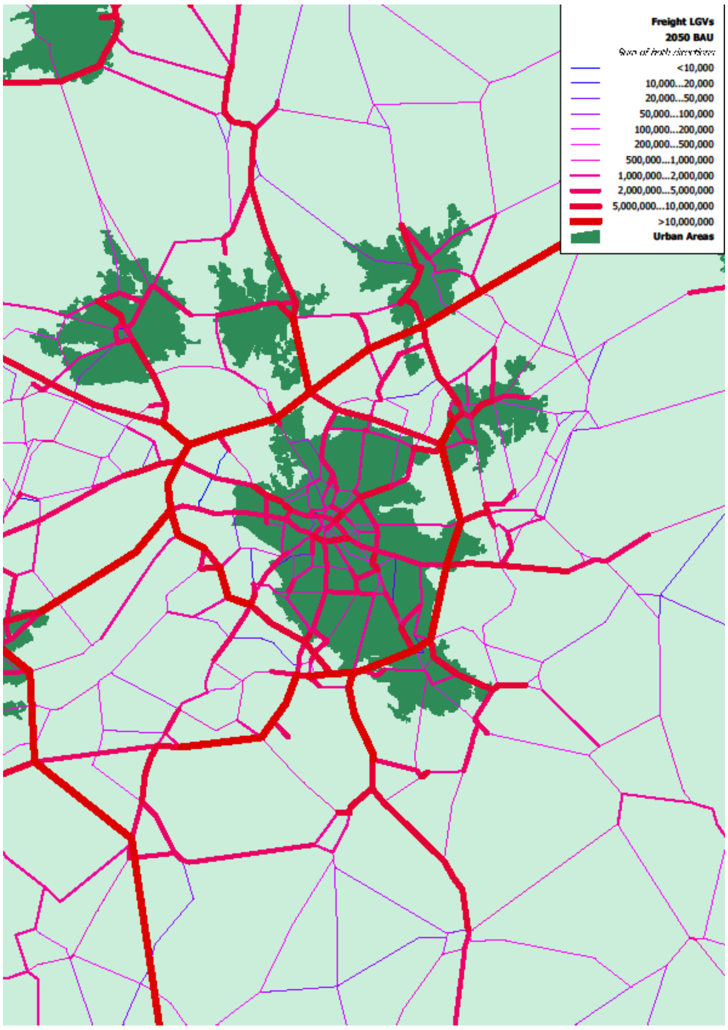
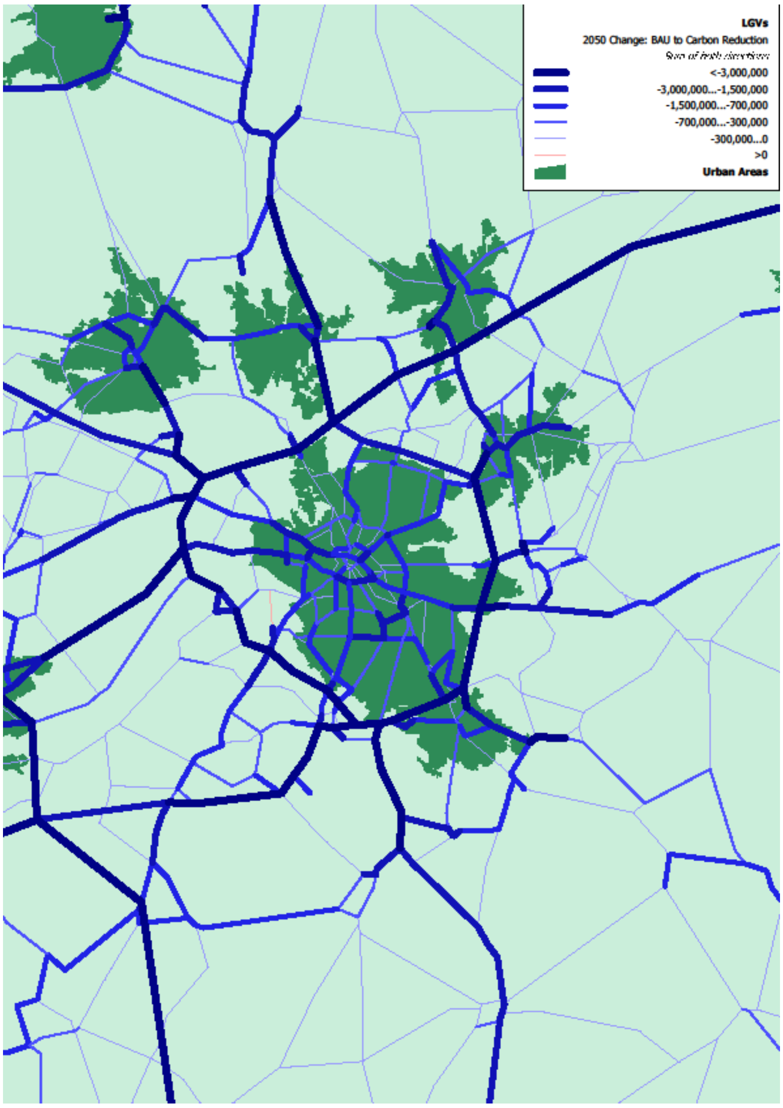


Figure 47: Manchester - Change in annual LGV flows in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal



Glasgow

Glasgow had an estimated population of 621,000 in 2017, making it the largest population centre in Scotland. The city is located on the M74/M9 corridor on the north-south axis, linking it to the English border to the south and to north east Scotland and the Highlands to the north. It is also located on the M8 motorway on the east-west axis across the Central Belt, connecting the city to Scotland's capital city and its largest container port at Grangemouth. The city is also located on the West Coast Main Line north-south route, with intermodal terminals/SRFIs located to the east of the city at Coatbridge and Mossend. Although the city is located on the Clyde, port facilities on the river are limited to accommodating relatively small coastal and short sea vessels; deeper water container port facilities are located at Greenock on the Clyde estuary. There are concentrations of distribution centres serving the whole Scottish market, mainly located to the east of the city.

Total estimated freight delivered in Glasgow in 2015 was some 15.4m tonnes, while the conurbation was the origin of an estimated 11.4m tonnes of freight.

Figure 48 shows the annual volume of HGVs in the 2015 base case; the major modelled flows of HGVs are concentrated on the motorway network and other strategic routes in and around Glasgow.

Table 26: Summary freight data for Glasgow, 2015

Million tonnes

	Origin of freight (million tonnes)	Destination of freight (million tonnes)
Road freight	11.4	15.4
Rail freight	-	-
Total	11.4	15.4

Source: MDS Transmodal GB Freight Model

Forecast traffic for Glasgow as a destination in 2050 is shown in Table 27 below.

Table 27: Modelled road freight to Glasgow

Million tonnes lifted

	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing Renaissance 2050
Road freight	15.4	18.0	17.4	16.9	17.0
Rail freight	-	-	-	-	-
Total	15.4	18.0	17.4	16.9	17.0

Source: MDS Transmodal GB Freight Model

Figure 49 shows the annual volume of HGVs in the 2050 BAU Scenario and Figure 50 shows the modelled change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario (as an example of the change between one of the scenarios and the 2050 BAU Scenario).

The modelling suggests that the additional 17% road freight tonnes lifted in 2050 in the BAU scenario compared to 2015 adds more traffic to effectively the same links on the Strategic Road Network. Figure 50 suggests that the impact of a 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario would be to reduce the overall number of HGVs on the road network on many links. This reduction in HGV flows is partly due to the lower volumes of HGV movements as a result of lower levels of economic activity, but also due to an increase in intermodal rail freight services to and from rail-connected distribution parks in the Central Belt as a result of the greater clustering of distribution centres on rail-connected sites. There are also some increases in HGVs flows in and around Glasgow due to more HGV movements being required for the distribution of more voluminous e-commerce parcels between regional distribution centres and urban areas and more local deliveries and collections from intermodal rail terminals.

Figure 48: Glasgow – Annual HGV flows in 2015

Source: MDS Transmodal

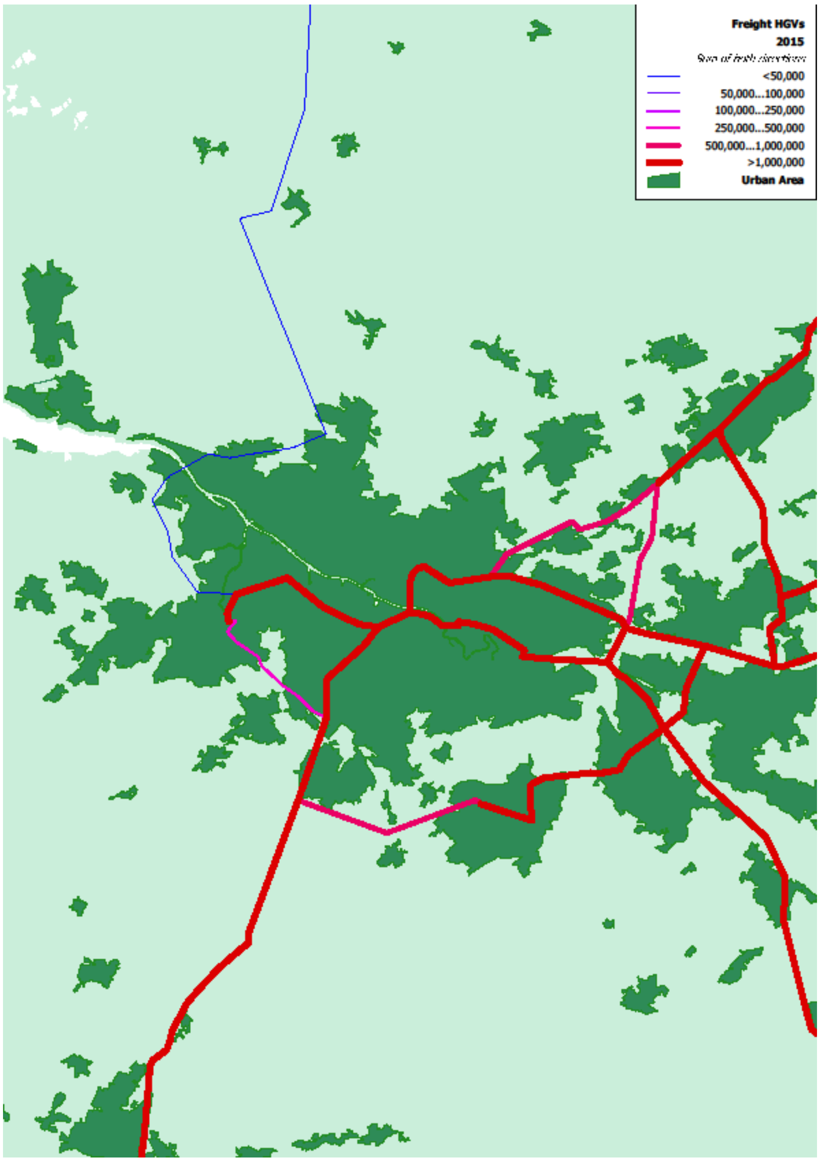


Figure 49: Glasgow - Annual HGV flows in the BAU Scenario 2050

Source: MDS Transmodal

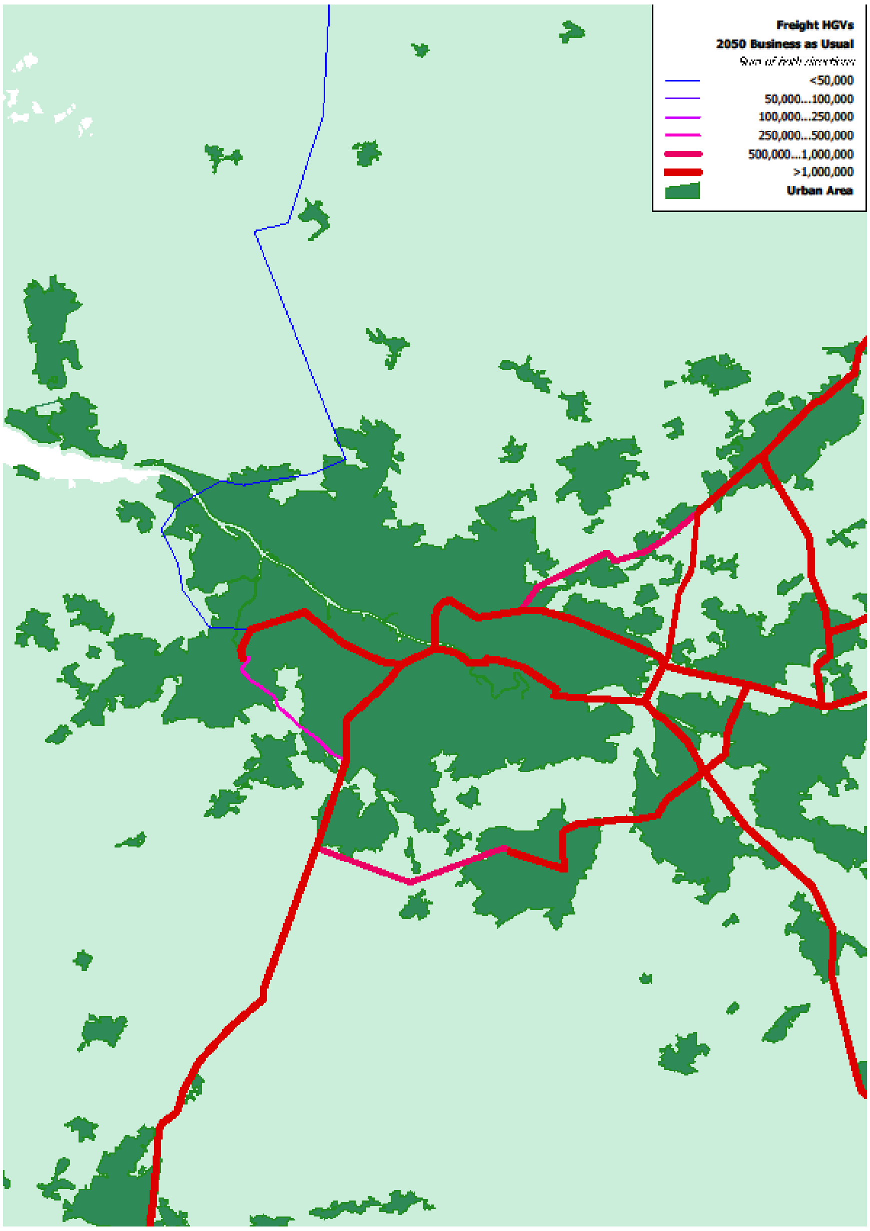


Figure 50: Glasgow - Change in annual HGV flows in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal

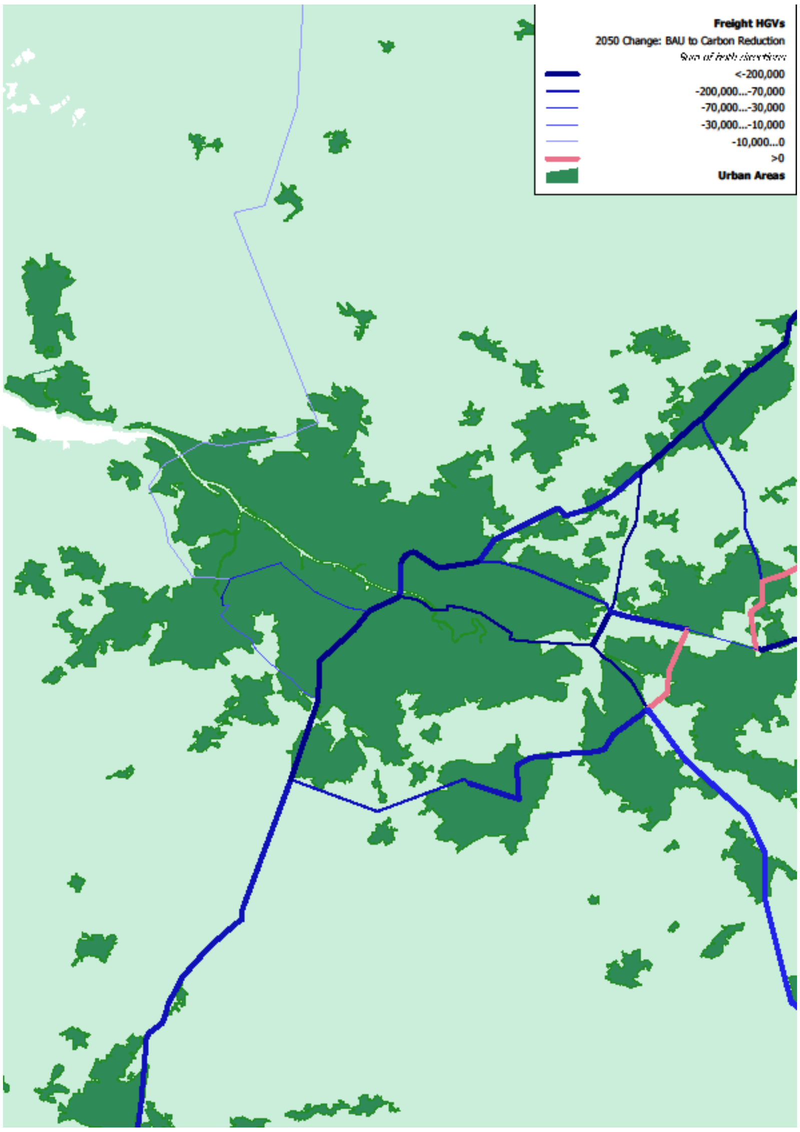


Figure 51 shows the daily train paths required for rail freight in the 2015 base case and that the major rail freight flows were to the west of Glasgow between the West Coast Main Line and the intermodal terminals at Mossend and Coatbridge and transit flows of bulk coal through Glasgow from Ayrshire.

Figure 52 shows the daily train paths required for rail freight in the 2050 BAU Scenario and Figures 53 shows the change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario. Figure 52 suggests there would be little change in the number of trains to and from the Glasgow area in the 2050 BAU Scenario, apart from the loss of the bulk coal traffic. However, Figure 53 shows there would be an increase in intermodal rail freight services in the 2050 Carbon Reduction Scenario; this traffic would be to and from rail-connected distribution parks in the Mossend area and the wider

Central Belt as a result of the greater clustering of distribution centres on rail-connected sites as short haul rail freight becomes viable. In the event that autonomous HGVs do not emerge as a practical technological solution by 2050, but the planning system leads to greater clustering of distribution centres on rail-connected distribution parks, Glasgow would see a substantial increase in rail freight.

Figure 51: Glasgow - Daily rail freight paths in 2015

Source: MDS Transmodal

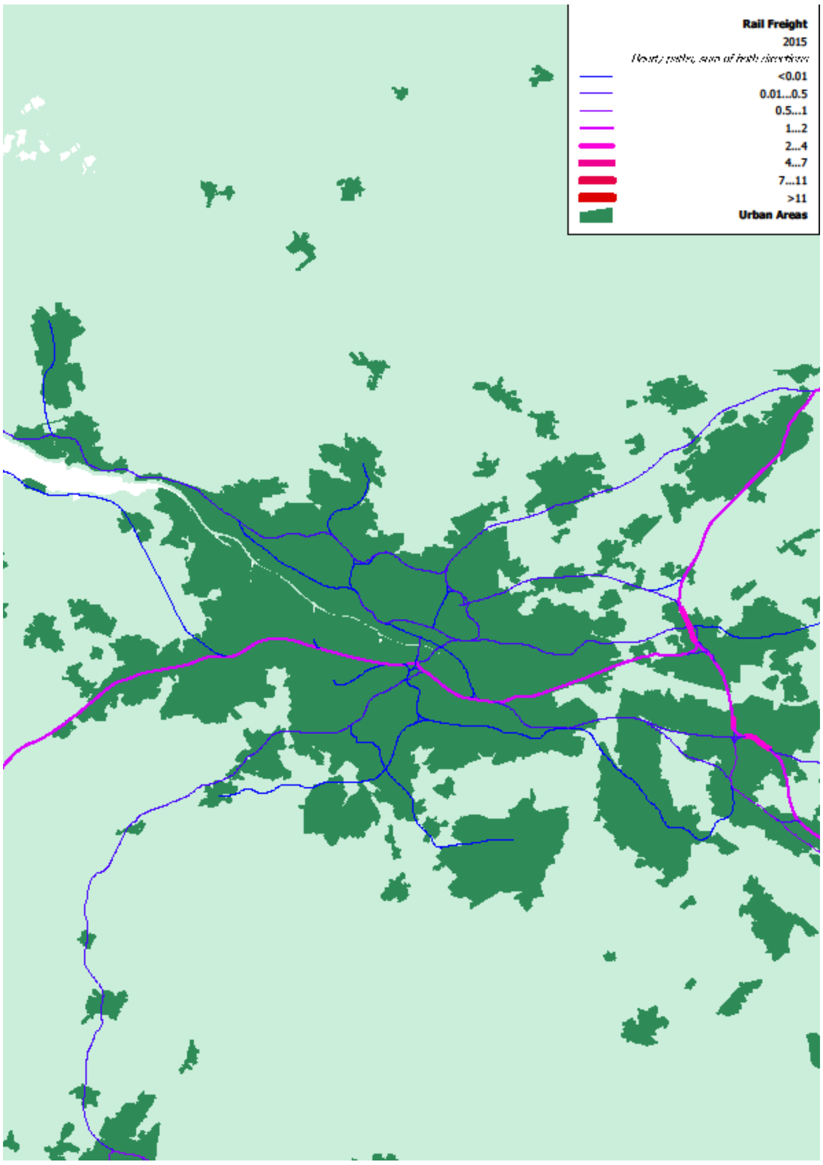


Figure 52: Glasgow - Daily rail freight paths required in the 2050 BAU Scenario

Source: MDS Transmodal

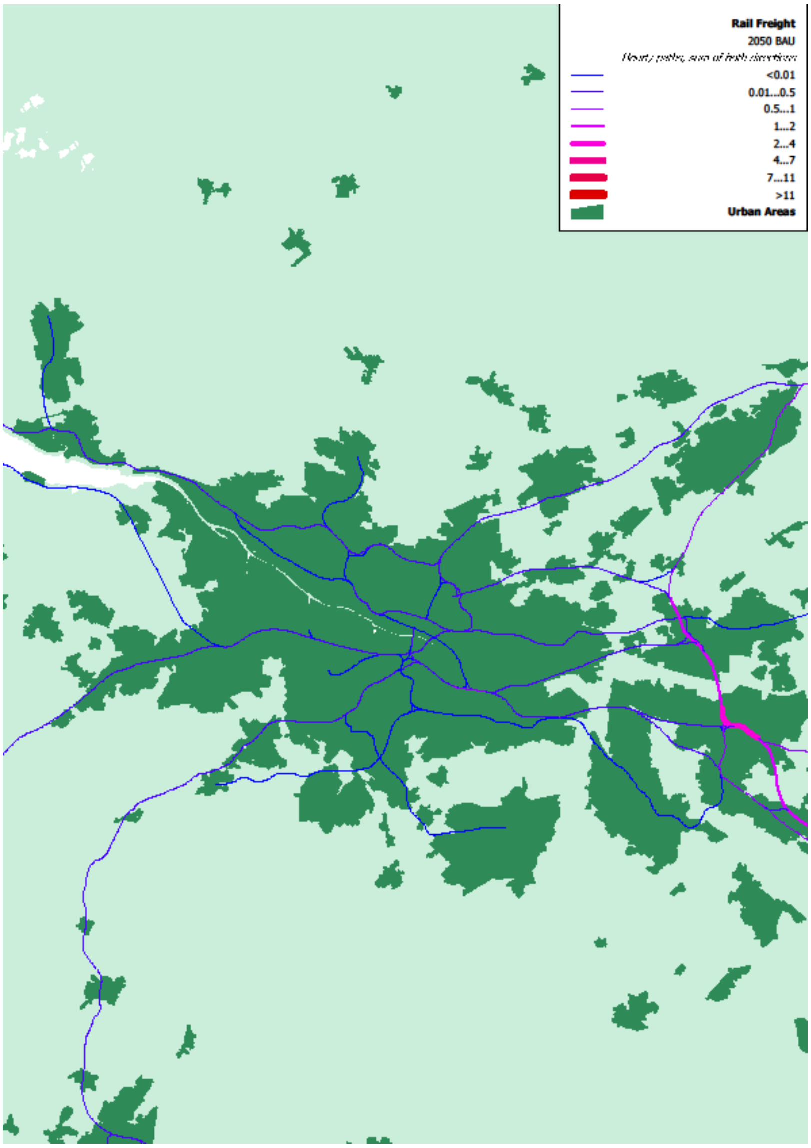


Figure 53: Glasgow - Change in daily rail freight paths in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal

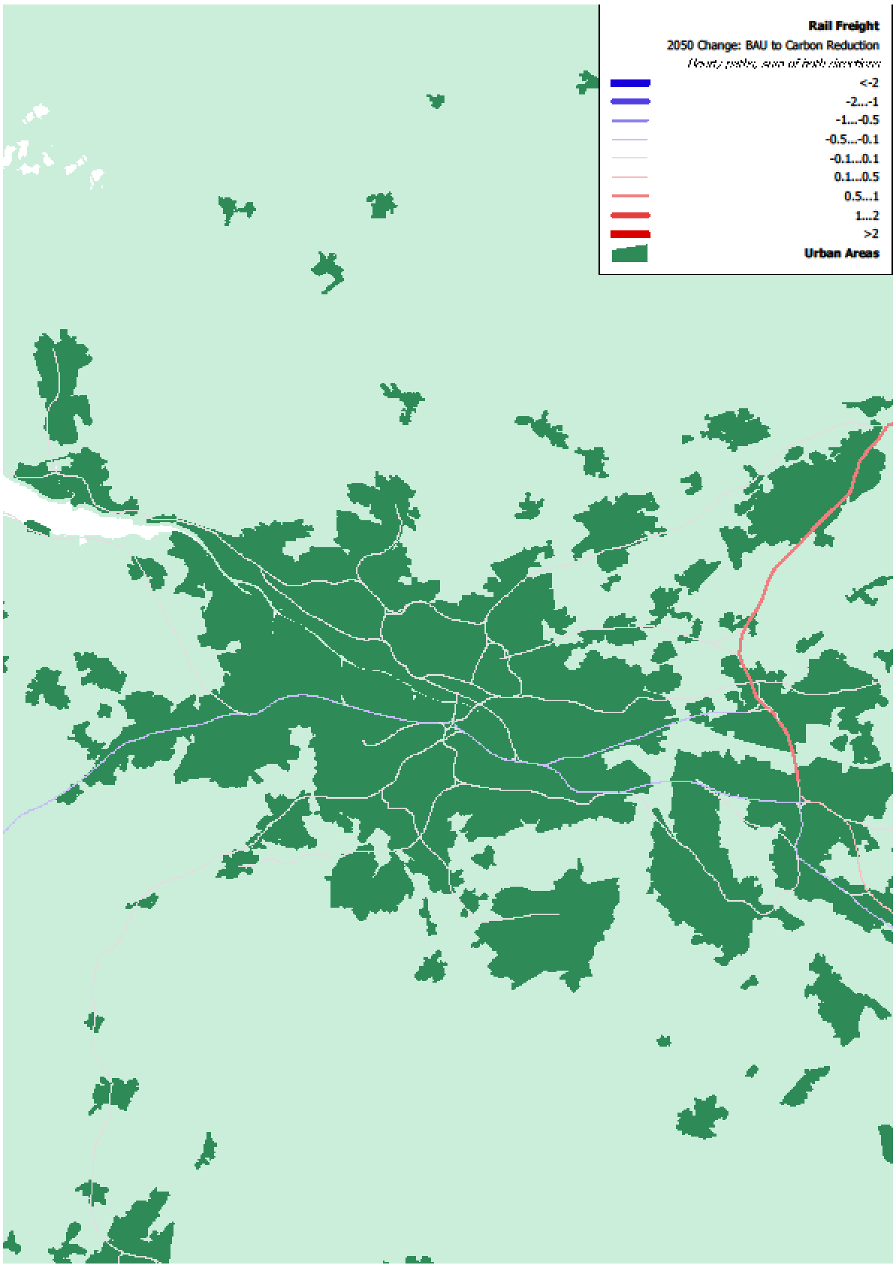


Figure 54 shows the annual LGV movements in the 2015 base case and that, although there are concentrations of traffic on the strategic road network there are also more dispersed movements on more regional and local roads.

Figure 55 shows the annual LGV movements in the 2050 BAU Scenario and Figure 56 shows the change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario. Figure 55 shows there would be significant increases in traffic volumes to be accommodated on the same network links in the 2050 BAU Scenario as in the 2015, mainly as a result of increased penetration of the retail market by e-commerce. Figure 56 shows the modelled reduction in LGV traffic in the 2050 Carbon Reduction Scenario due to the assumed lower penetration of the retail market by e-commerce, so that a lower proportion of passenger trips to retail outlets are substituted by LGVs making parcel deliveries.

Figure 54: Glasgow – Annual LGV flows in 2015

Source: MDS Transmodal

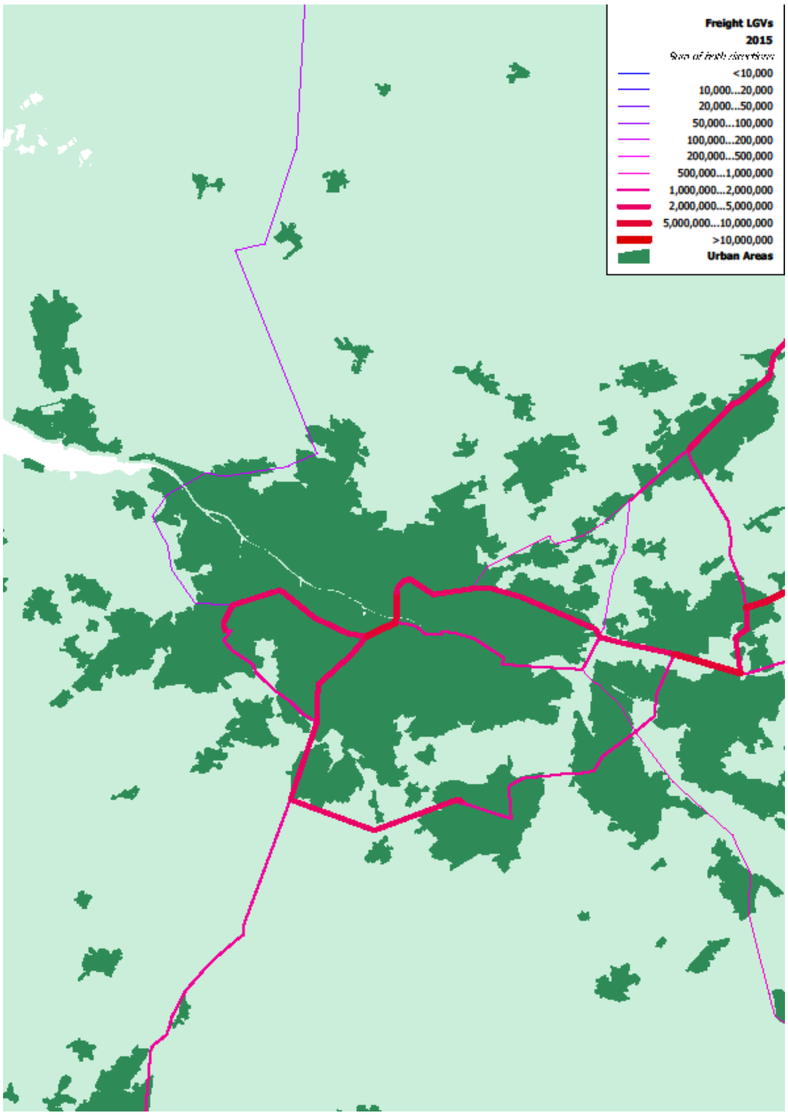


Figure 55: Glasgow - Annual LGV flows in the 2050 BAU Scenario
Source: MDS Transmodal

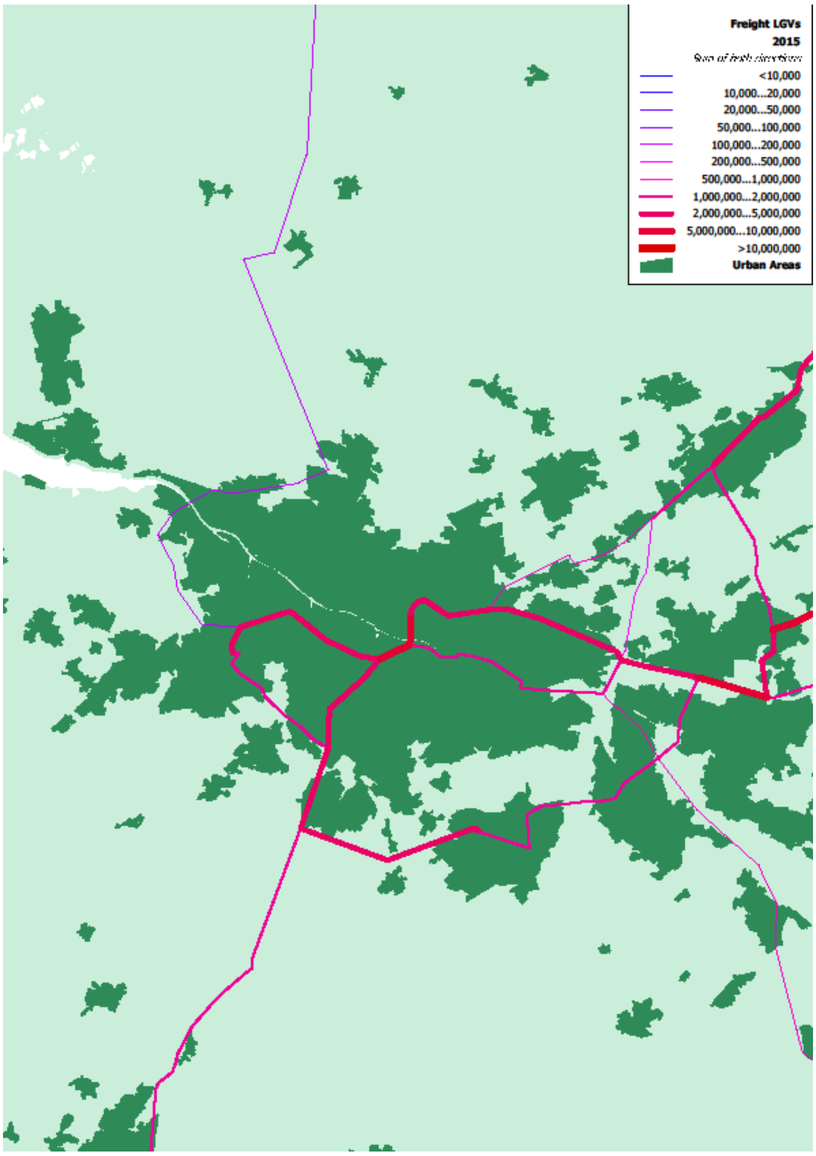
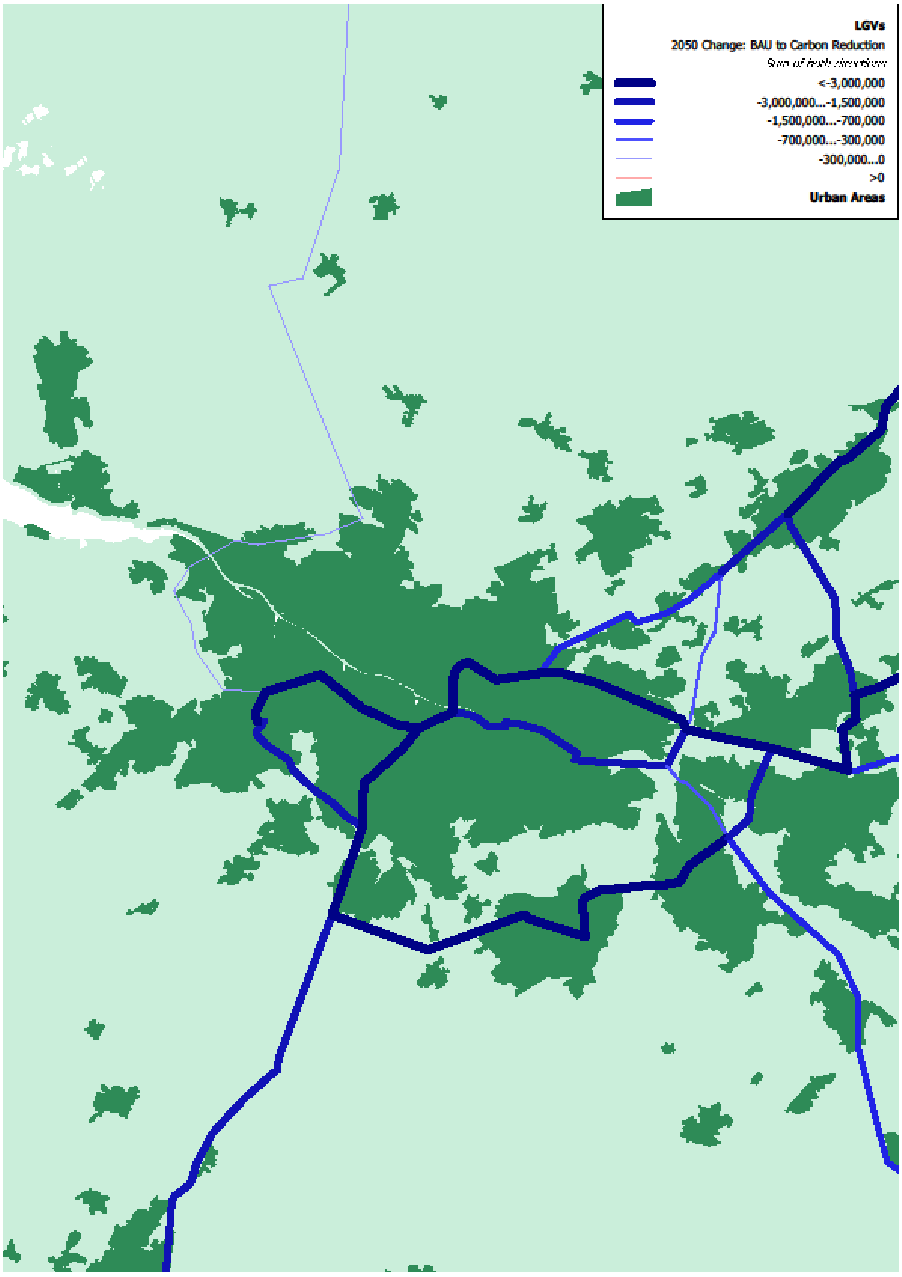


Figure 56: Glasgow - Change in annual LGV flows in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal



Southampton

Southampton has an estimated population of 254,000 and forms part of the South Hampshire built up area which includes Portsmouth and other population centres along Southampton Water and the Solent. The city is located on the M3/A34 corridor linking the city to London and on the Midlands and on the M27/A31 east-west corridor linking Southampton to Portsmouth to the east and Bournemouth to the west. The Port of Southampton is the second largest container port in the UK in terms of traffic volumes, with deep sea container services connecting the port to the Far East and the Americas; apart from crude oil and petroleum products to and from an oil refinery at Fawley, the port's other major cargo traffics are import/export vehicles (mainly deep sea exports) and a range of dry bulk cargoes. The port has a range of intermodal rail freight services linking it to Midlands and the West Coast Main Line.

Total estimated freight delivered in Southampton in 2015 was some 13.2m tonnes, while the city was the origin of an estimated 13.9m tonnes of freight. Figure 57 shows the annual volume of HGVs in the 2015 base case; the major modelled flows of HGVs are concentrated on the M3/A34 (including to a d from the port of Southampton) and the M27, the latter including freight traffic to and from Portsmouth with its cross-channel ferry links.

Table 28: Summary freight data for Southampton, 2015

Million tonnes

	Origin of freight (million tonnes)	Destination of freight (million tonnes)
Road freight	11.6	10.8
Rail freight	2.3	2.4
Total	13.9	13.2

Source: MDS Transmodal GB Freight Model

Forecast traffic for Southampton as a destination in 2050 is shown in Table 29 below.

Table 29: Modelled road and rail freight to Southampton

Million tonnes lifted

	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing Renaissance 2050
Road freight	10.8	6.8	6.8	6.5	10.8
Rail freight	2.4	3.4	2.6	3.3	5.6
Total	13.2	10.2	9.4	9.8	16.4

Source: MDS Transmodal GB Freight Model

Figure 58 shows the annual volume of HGVs in the 2050 BAU Scenario and Figure 59 shows the modelled change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario (as an example of the change between one of the scenarios and the 2050 BAU Scenario).

Figure 59 suggests that the impact of a 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario would be to reduce the overall number of HGVs on the road network on some links, particularly to and from the Port of Southampton. This reduction in HGV flows is partly due to the lower volumes of HGV movements as a result of lower levels of economic activity, but also due to an increase in intermodal rail freight services to and from the Port of Southampton as regional terminals are more likely to be located on rail-connected distribution parks. There are also some increases in HGVs flows in and around the Southampton which is likely to be due to more HGV movements being required for the distribution of more voluminous e-commerce parcels between regional distribution centres and urban areas and more accompanied roro traffic to and from Portsmouth; this neighbouring port would attract more accompanied trucks on its longer crossings of the English Channel at the expense of the shorter crossings of the Dover Straits.

Figure 57: Southampton – Annual HGV flows in 2015

Source: MDS Transmodal

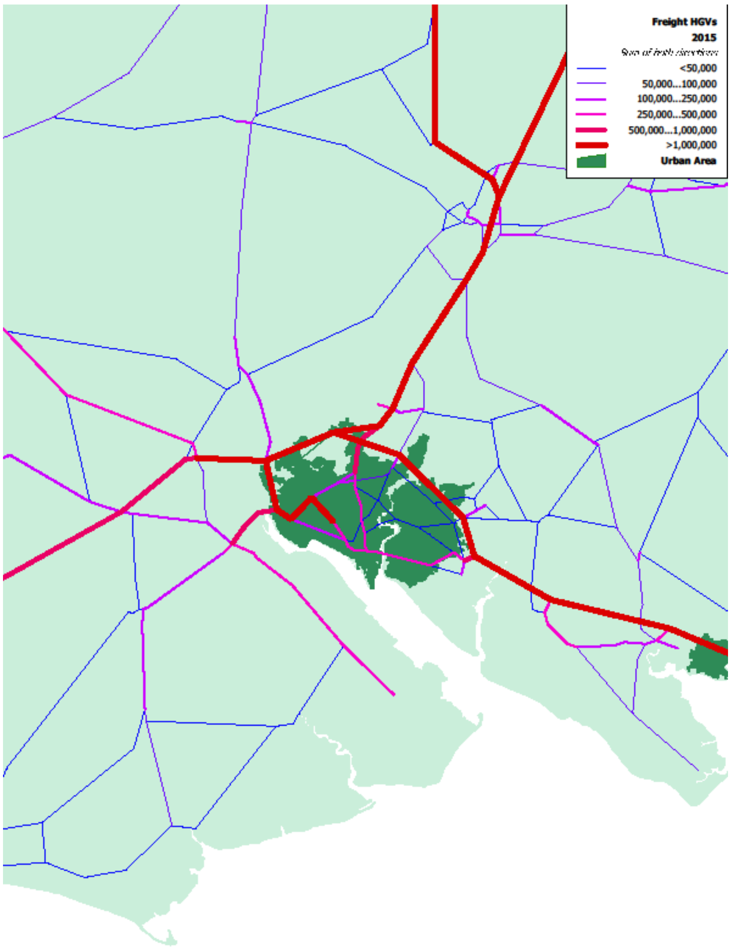


Figure 58: Southampton - Annual HGV flows in the BAU Scenario 2050

Source: MDS Transmodal

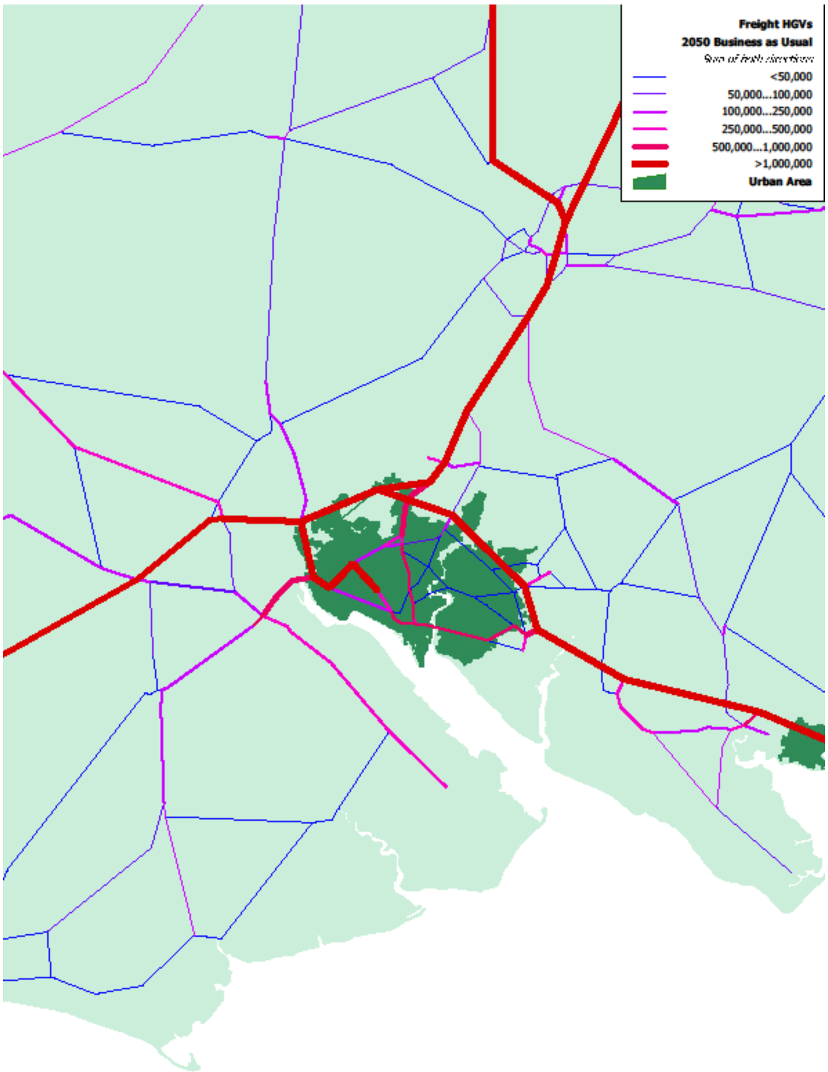


Figure 59: Southampton - Change in annual HGV flows in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal

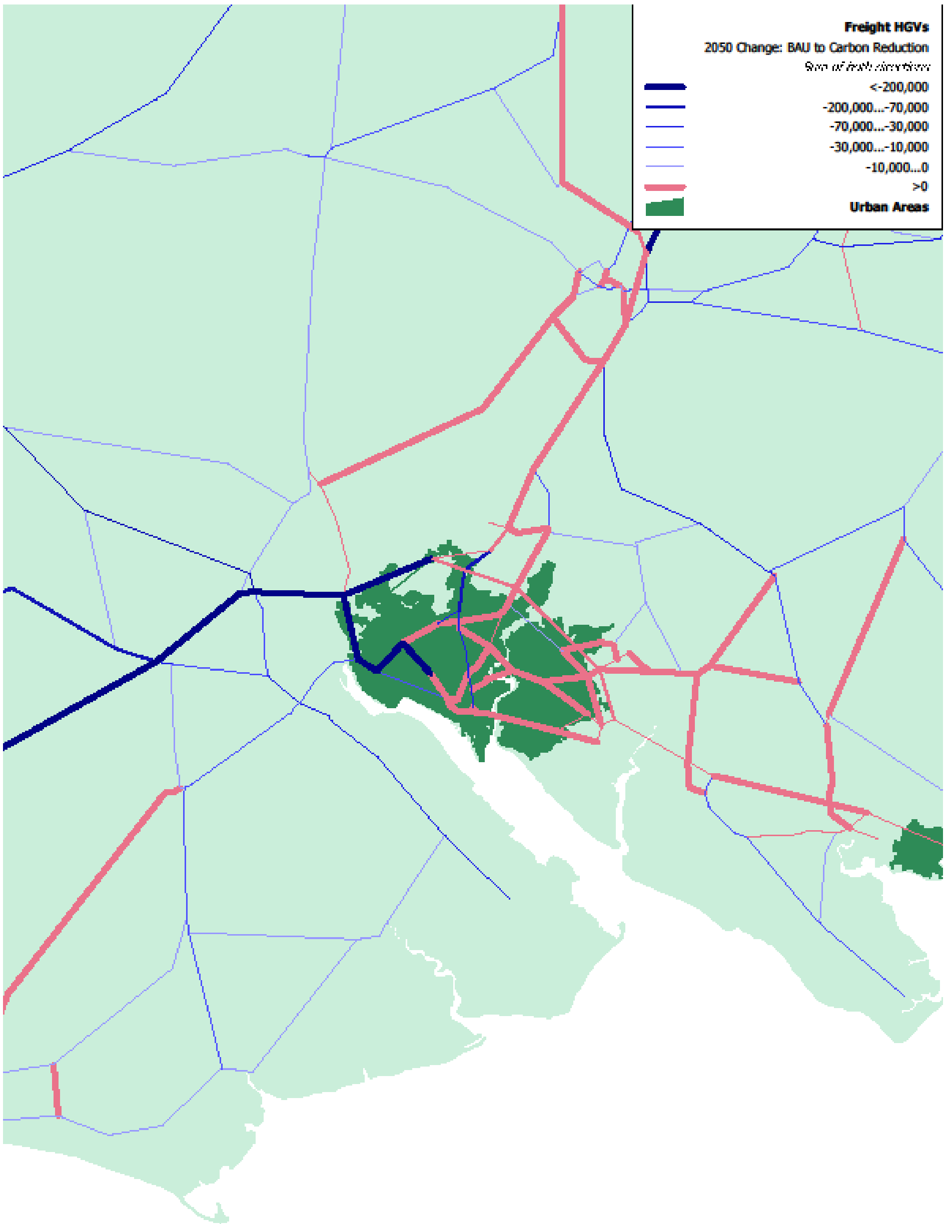


Figure 60 shows the daily train paths required for rail freight in the 2015 base case and that the major rail freight flows were intermodal rail freight services to and from the Port of Southampton.

Figure 61 shows the daily train paths required for rail freight in the 2050 BAU Scenario and Figures 62 shows the change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario. Figure 61 suggests there would be little change in the number of trains to and from the Southampton area in the 2050 BAU Scenario. However, Figure 62 shows there would be a small increase in intermodal rail freight services in the 2050 Carbon Reduction Scenario between the Port of Southampton and rail-connected distribution parks in the rest of Great Britain. In the event that autonomous HGVs do not emerge as a practical technological solution by 2050, but the planning system leads to greater clustering of distribution centres on rail-connected distribution parks, cities with deep sea container ports such as Southampton would see a substantial increase in rail freight.

Figure 60: Southampton - Daily rail freight paths in 2015

Source: MDS Transmodal

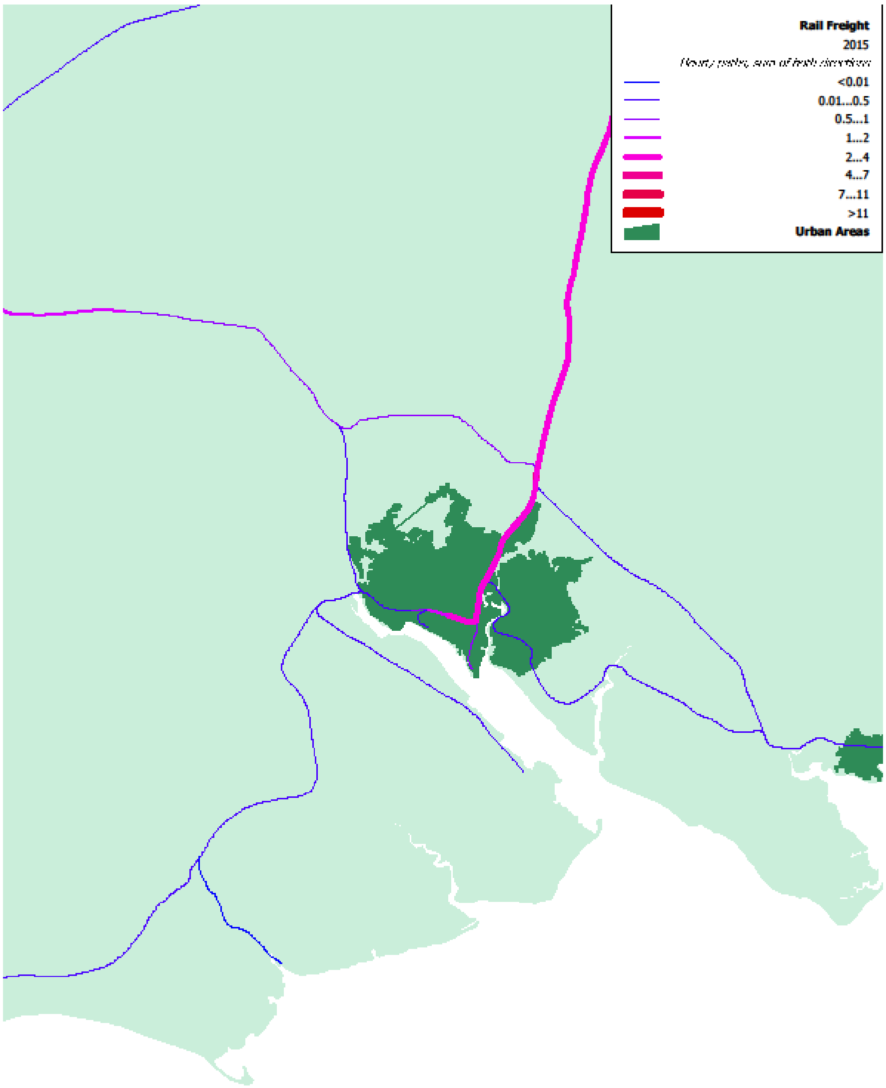


Figure 61: Southampton - Daily rail freight paths required in the 2050 BAU Scenario

Source: MDS Transmodal

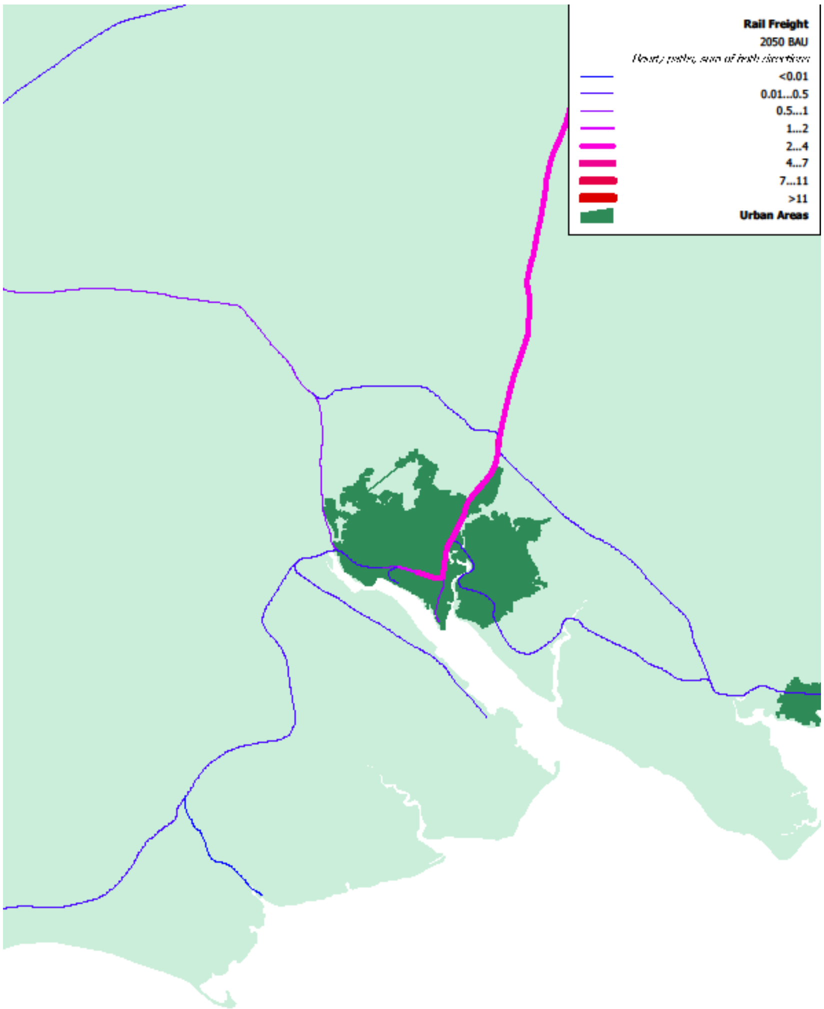


Figure 62: Southampton - Change in daily rail freight paths in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal

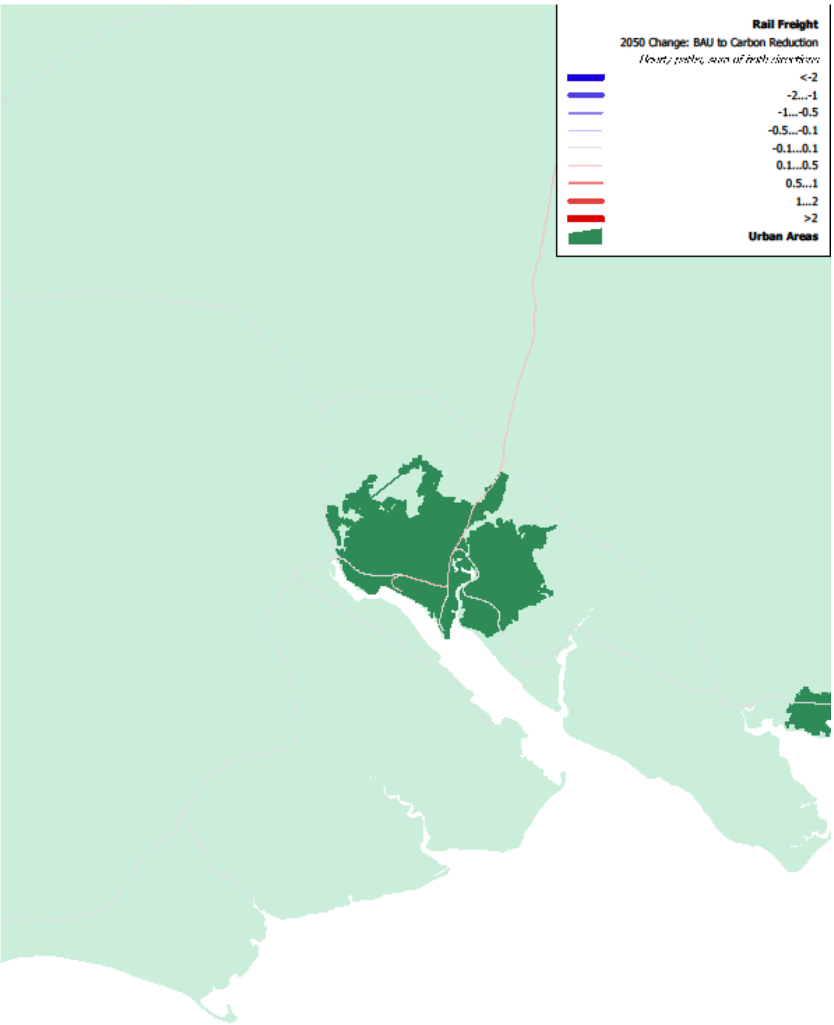


Figure 63 shows the annual LGV movements in the 2015 base case and that, although there are concentrations of traffic on the strategic road network there are also more dispersed movements on more regional and local roads.

Figure 64 shows the annual LGV movements in the 2050 BAU Scenario and Figure 65 shows the change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario. Figure 64 shows there would be significant increases in traffic volumes to be accommodated on the same network links in the 2050 BAU Scenario as in the 2015, mainly as a result of increased penetration of the retail market by e-commerce. Figure 65 shows the modelled reduction in LGV traffic in the 2050 Carbon Reduction Scenario due to the assumed lower penetration of the retail market by e-commerce, so that a lower proportion of passenger trips to retail outlets are substituted by LGVs making parcel deliveries.

Figure 63: Southampton – Annual LGV flows in 2015

Source: MDS Transmodal

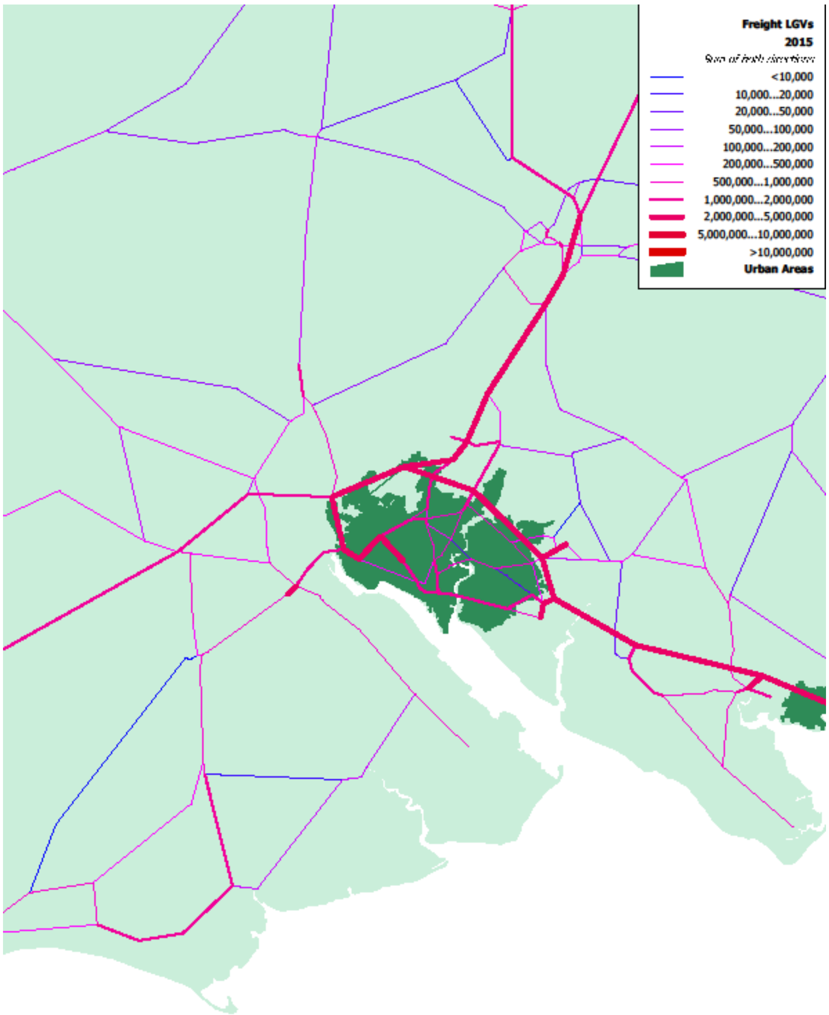


Figure 64: Southampton - Annual LGV flows in the 2050 BAU Scenario

Source: MDS Transmodal

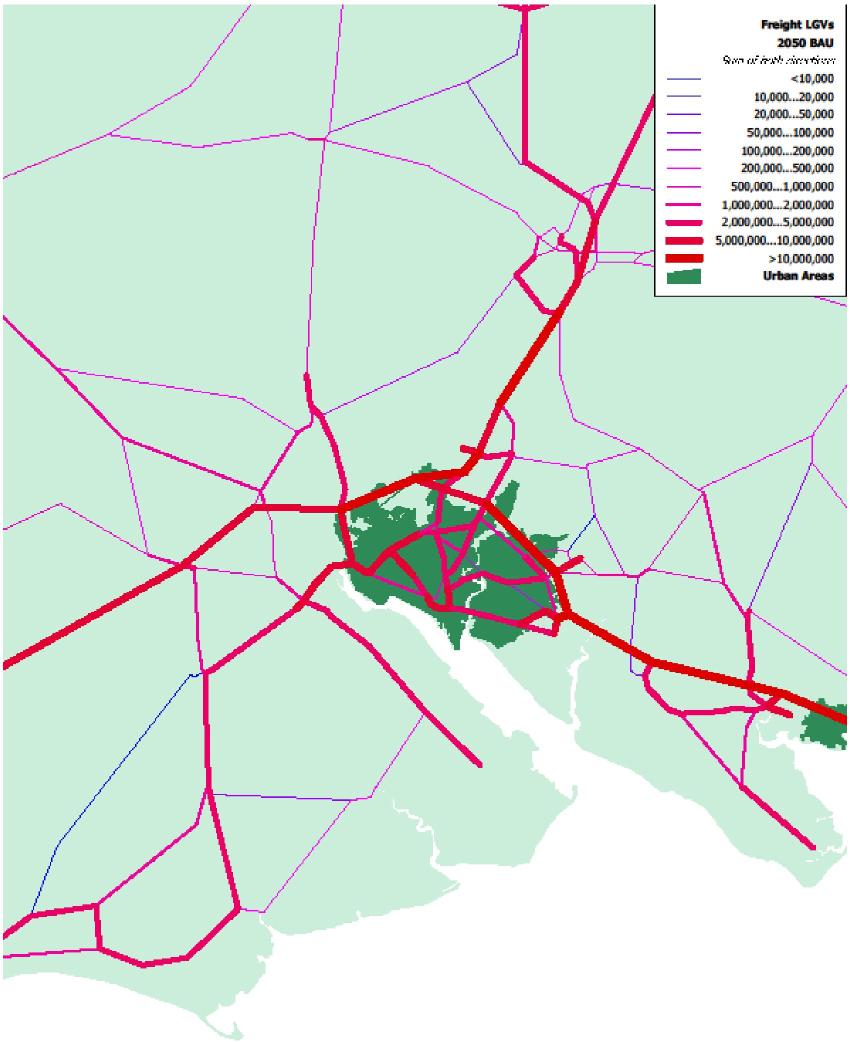
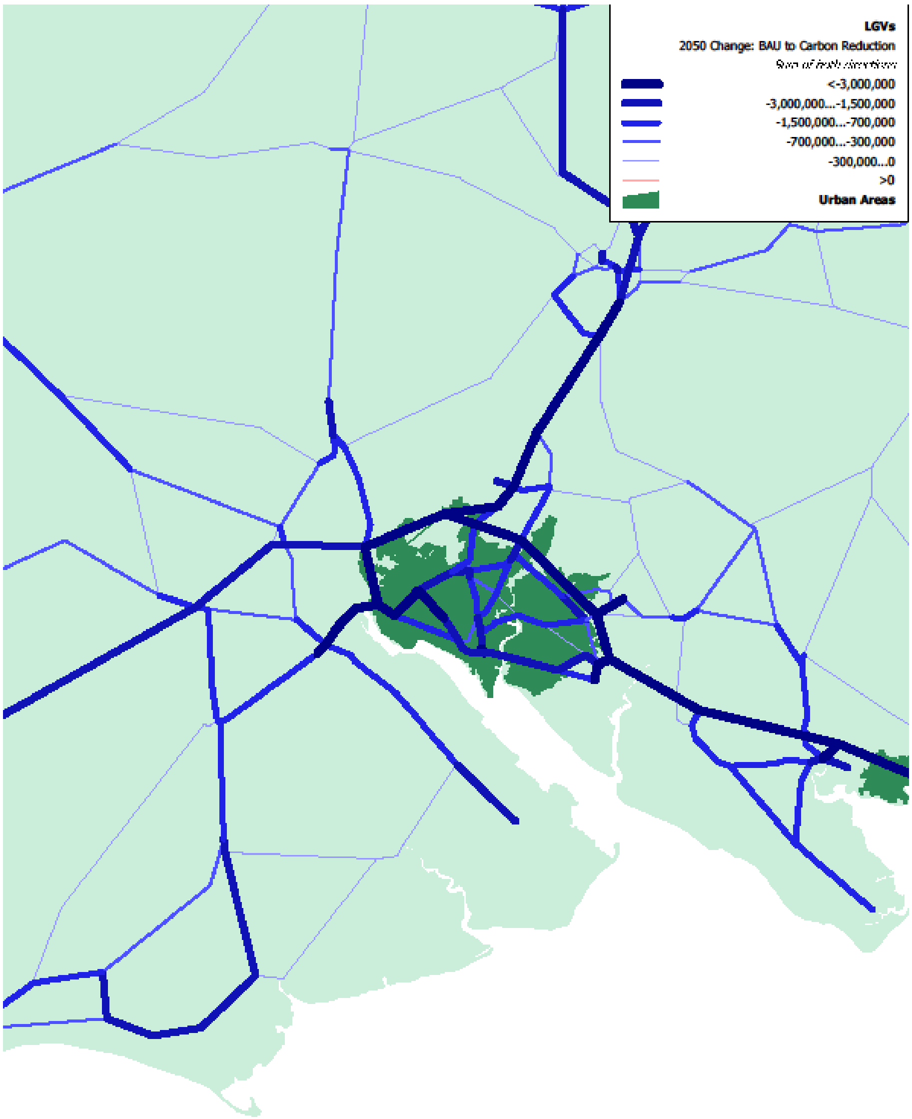


Figure 65: Southampton - Change in annual LGV flows in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal



Bath and North East Somerset

Bath and North East Somerset is a relatively rural and land-locked unitary authority to the south of Bristol with an estimated population of 0.15 million. The major population centre is Bath, which is a UNESCO World Heritage Site. The unitary authority's core road network consists mainly of single carriageway A roads, with the A4 linking Bath to Bristol to the north west and to the M4 via Chippenham to the North East. The A46 provides a more direct link to the M4 from Bath to the north of the city. Bath is located on the Great Western Main Line between London and the South West of England, but the nearest access to multimodal freight facilities is at Avonmouth.

Total estimated freight delivered in Bath and North East Somerset in 2015 was some 17.0m tonnes, while the area was the origin of an estimated 18.5m tonnes of freight. Figure 66 shows the annual volume of HGVs in the 2015 base case; the major modelled flows of HGVs are concentrated on the M4 and M5, rather than on routes to and from into Bath; Bath is likely to be served by distribution flows to and from regional distribution centres in the M4/M5 corridor.

Table 30: Summary freight data for Bath and North East Somerset, 2015

Million tonnes

	Origin of freight (million tonnes)	Destination of freight (million tonnes)
Road freight	16.7	15.7
Rail freight	1.8	1.3
Total	18.5	17.0

Source: MDS Transmodal GB Freight Model

Forecast traffic for Bath and North East Somerset as a destination in 2050 is shown in Table 31 below.

Table 31: Modelled road and rail freight to Bath and North East Somerset

Million tonnes lifted

	2015	Business as Usual 2050	Carbon Reduction 2050	Carbon Survival 2050	Manufacturing Renaissance 2050
Road freight	15.7	27.0	22.8	23.1	21.5
Rail freight	1.3	2.9	1.1	1.9	1.1
Total	17.0	29.9	23.9	25.0	22.6

Source: MDS Transmodal GB Freight Model

Figure 67 shows the annual volume of HGVs in the 2050 BAU Scenario and Figure 68 shows the modelled change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario (as an example of the change between one of the scenarios and the 2050 BAU Scenario).

The modelling suggests that the additional 72% road freight tonnes lifted in 2050 in the BAU scenario compared to 2015 adds more traffic to effectively the same links on the Strategic Road Network. Figure 68 suggests that the impact of a 2050 Carbon Reduction Scenario compared to the 2050 BAU

Scenario would be to reduce the overall number of HGVs on the road network on most links, including on the A4 into the city of Bath. This reduction in HGV flows is mainly due to the lower levels of economic activity that rea assumed in this scenario.

Figure 66: Bath & NE Somerset – Annual HGV flows in 2015

Source: MDS Transmodal

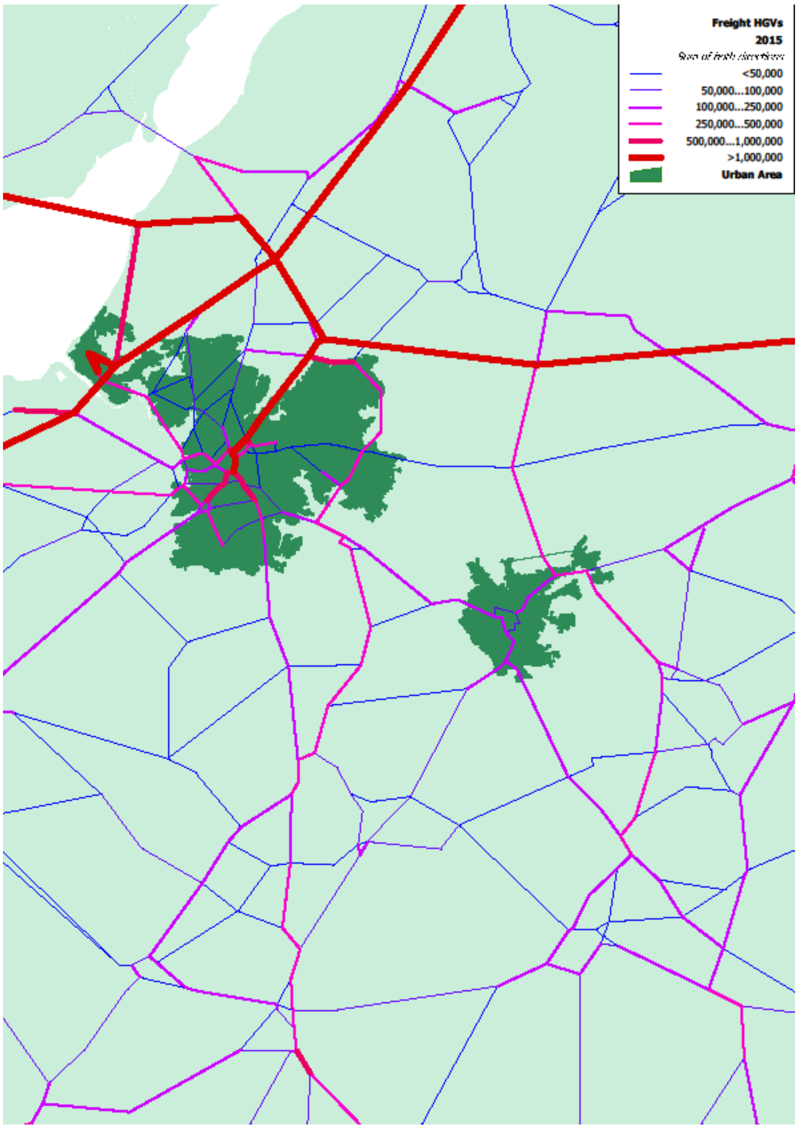


Figure 67: Bath & NE Somerset - Annual HGV flows in the BAU Scenario 2050

Source: MDS Transmodal

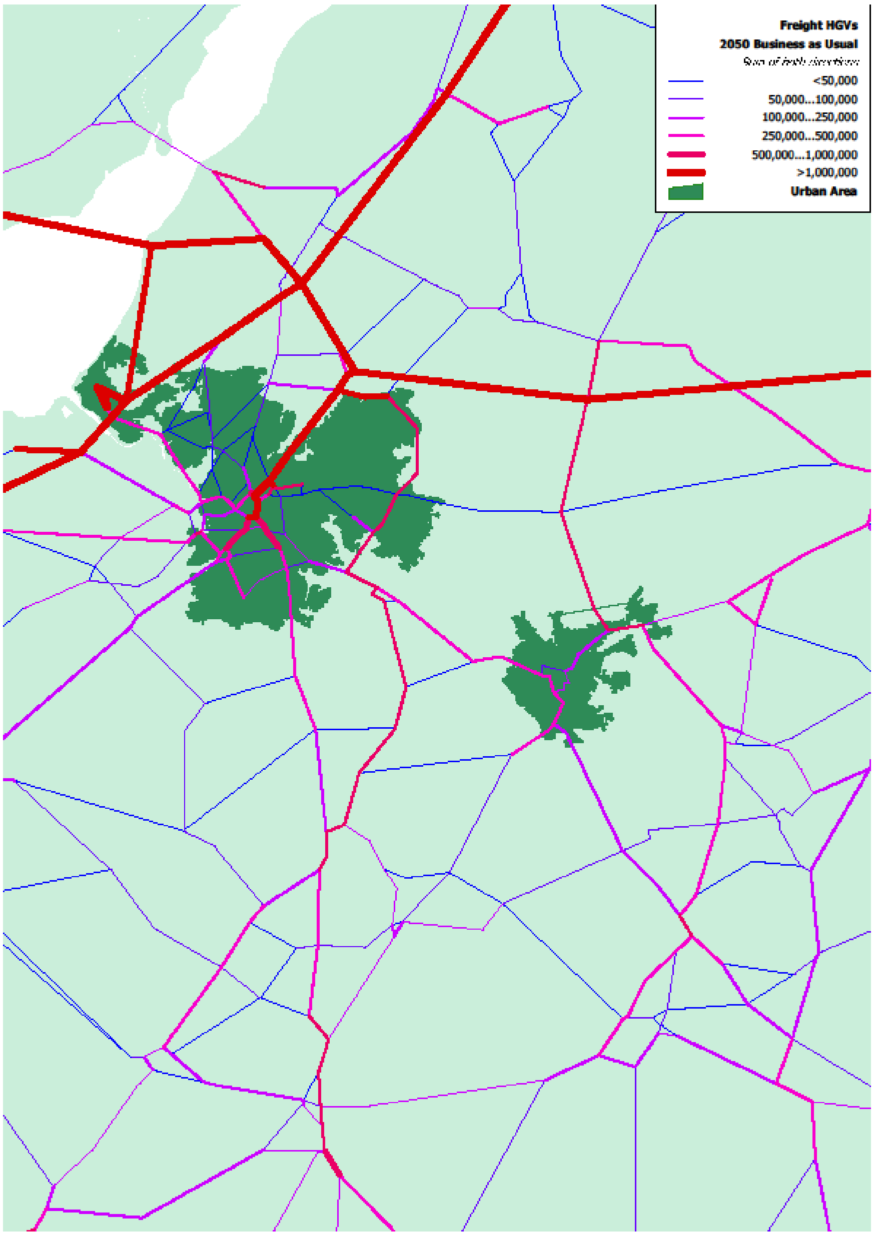


Figure 68: Bath & NE Somerset - Change in annual HGV flows in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal

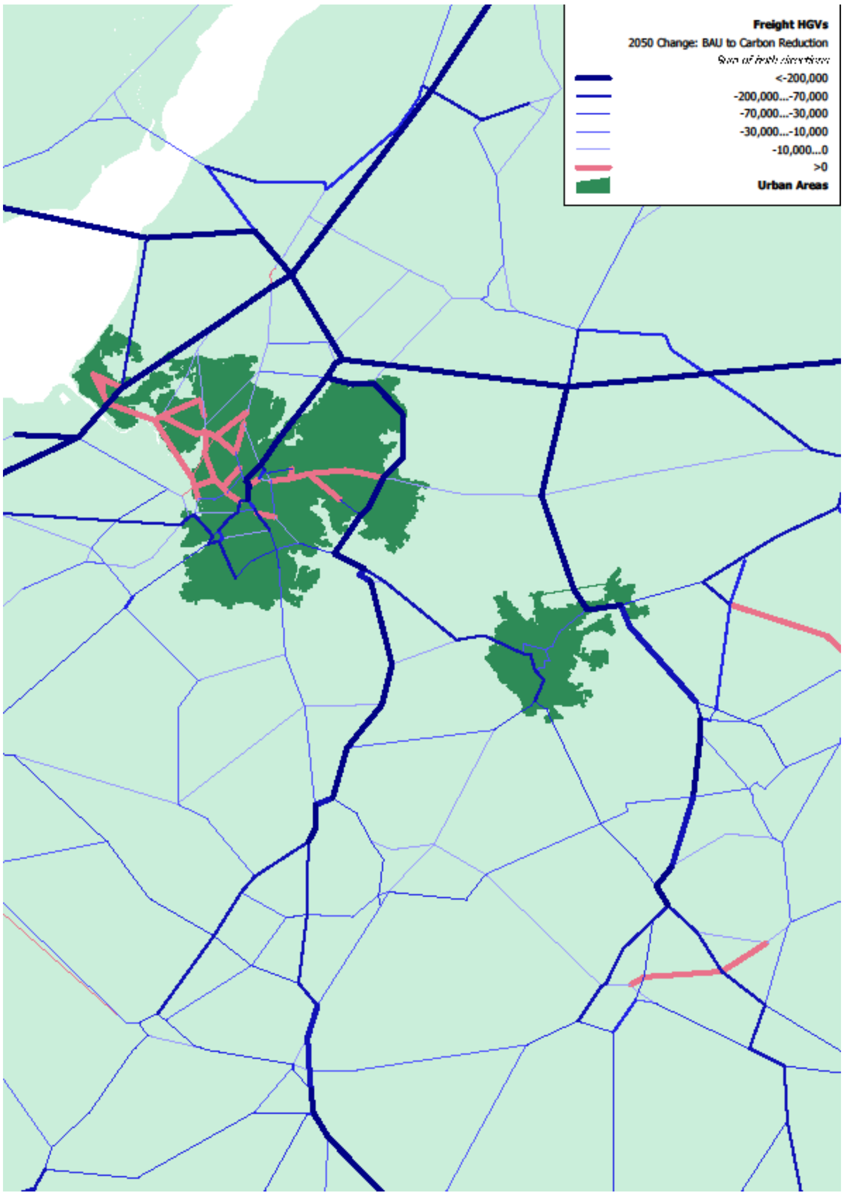


Figure 69 shows the daily train paths required for rail freight in the 2015 base case and that the only rail freight flows relevant to Bath is a transit flow. The main rail freight flows and from quarries in the Mendips to the south of the city of Bath and on the Great Western Mainline to and from South Wales.

Figure 70 shows the daily train paths required for rail freight in the 2050 BAU Scenario and Figure 71 shows the change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario. Figure 70 suggests there would be little change in the number of trains to and from the Bath and North East Somerset area in the 2050 BAU Scenario, apart from some additional transit traffic to and from South

Wales. However, Figure 71 shows there would be a small increase in intermodal rail freight services in the 2050 Carbon Reduction Scenario to and from Avonmouth.

Figure 69: Bath & NE Somerset - Daily rail freight paths in 2015

Source: MDS Transmodal

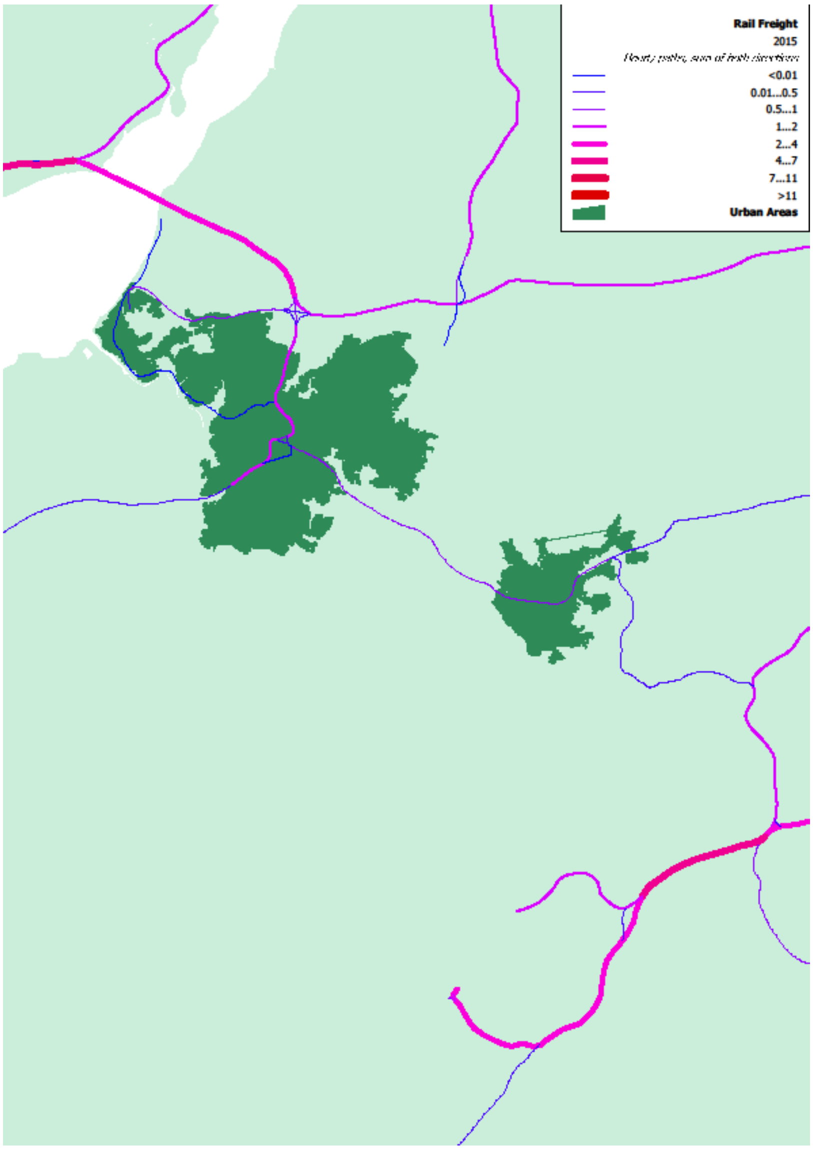


Figure 70: Bath & NE Somerset - Daily rail freight paths required in the 2050 BAU Scenario

Source: MDS Transmodal

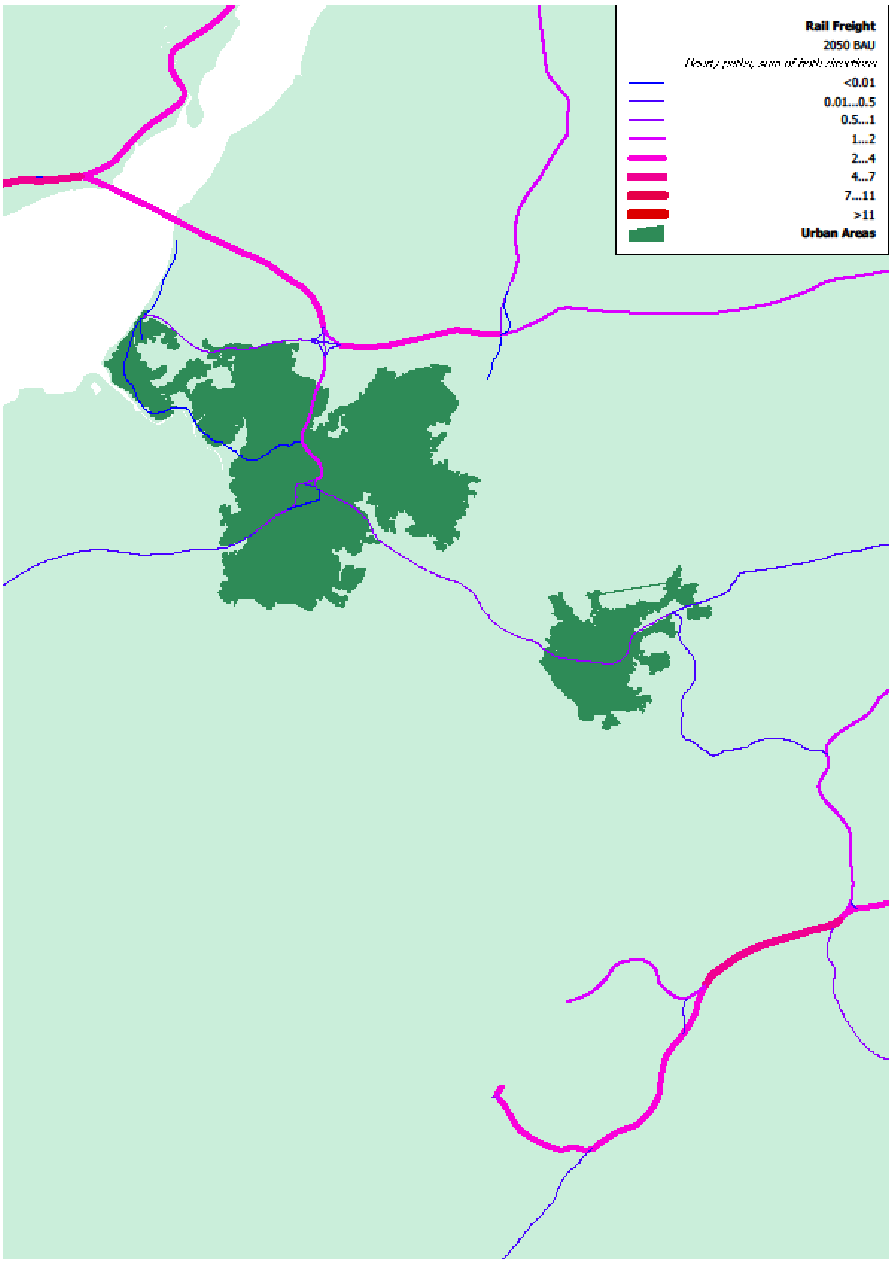


Figure 71: Bath & NE Somerset - Change in daily rail freight paths in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal

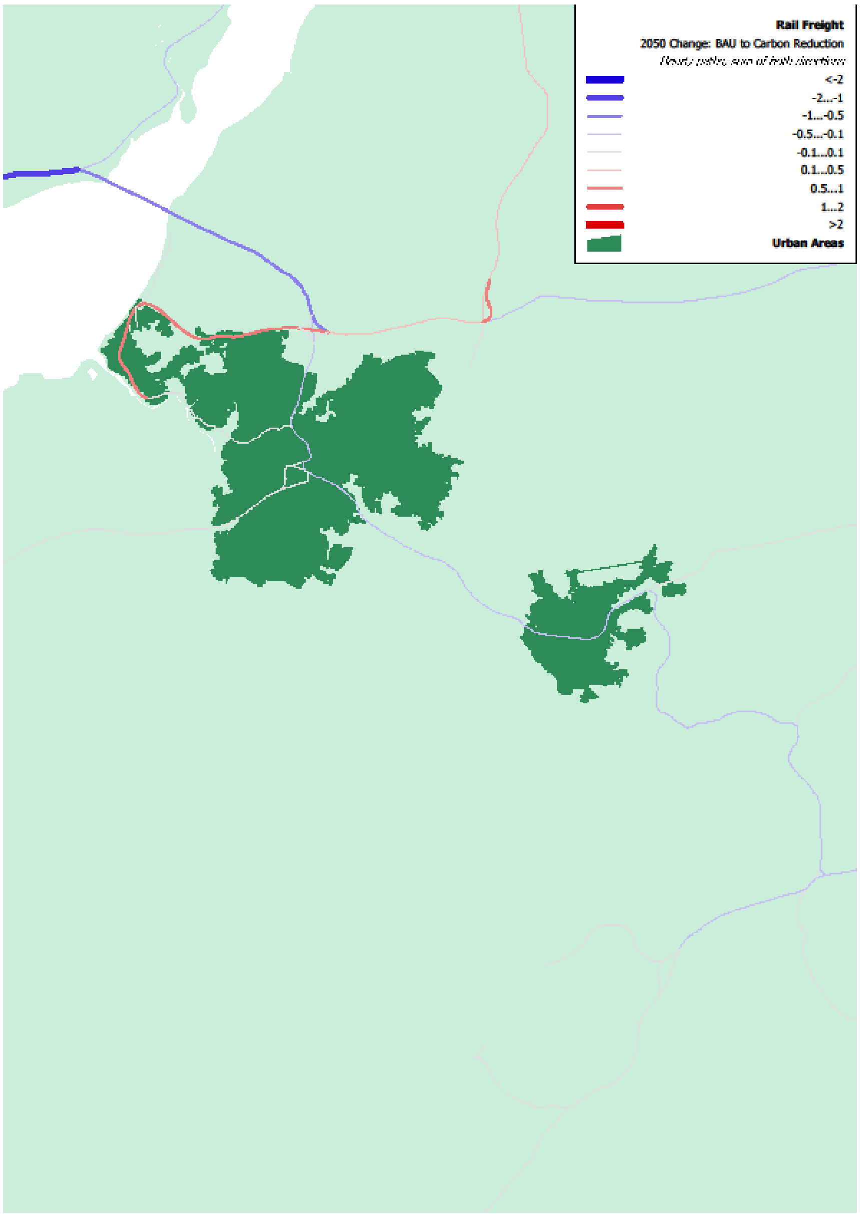


Figure 72 shows the annual LGV movements in the 2015 base case and that, although there are concentrations of traffic on the strategic road network there are also more dispersed movements on more regional and local roads.

Figure 73 shows the annual LGV movements in the 2050 BAU Scenario and Figure 74 shows the change between the 2050 Carbon Reduction Scenario and the 2050 BAU Scenario. Figure 73 shows there would be significant increases in traffic volumes to be accommodated on the same network links in the 2050 BAU Scenario as in the 2015, mainly as a result of increased penetration of the retail market by e-commerce. Figure 74 shows the modelled reduction in LGV traffic in the 2050 Carbon

Reduction Scenario due to the assumed lower penetration of the retail market by e-commerce, so that a lower proportion of passenger trips to retail outlets are substituted by LGVs making parcel deliveries.

Figure 72: Bath & NE Somerset – Annual LGV flows in 2015

Source: MDS Transmodal

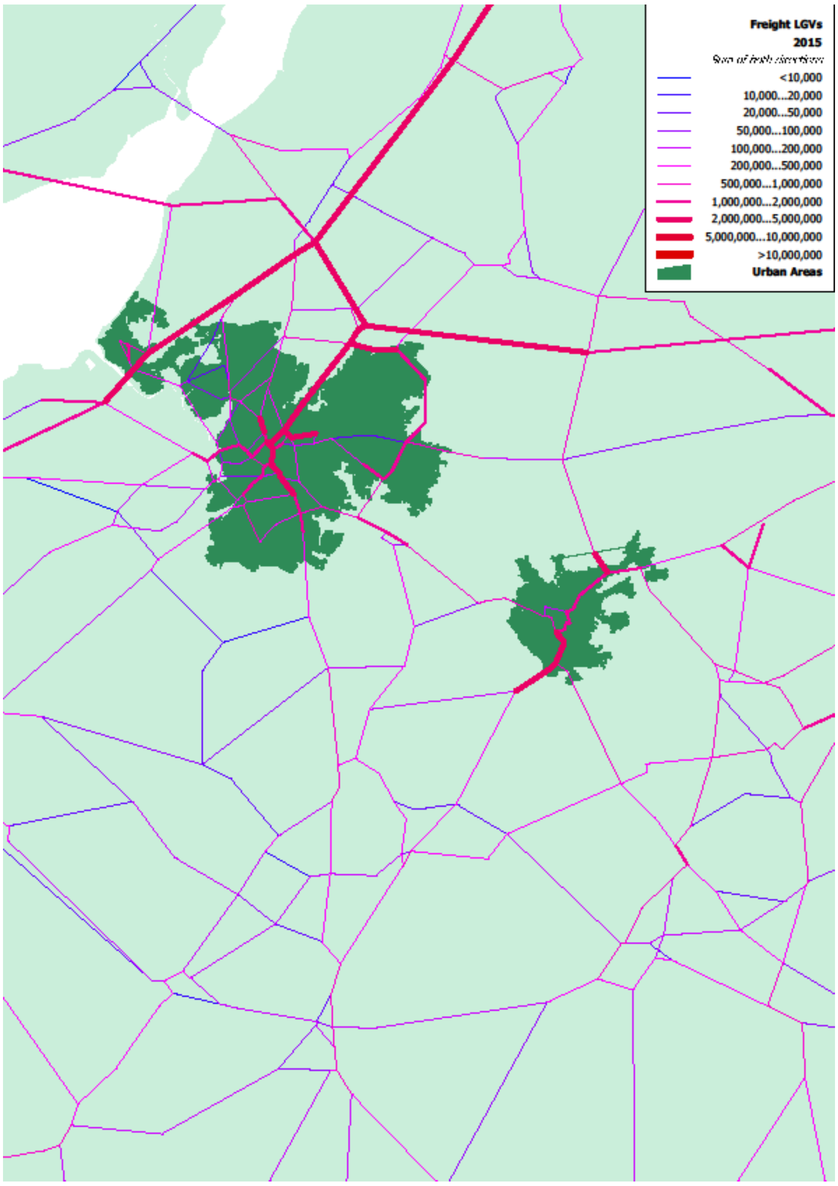


Figure 73: Bath & NE Somerset - Annual LGV flows in the 2050 BAU Scenario

Source: MDS Transmodal

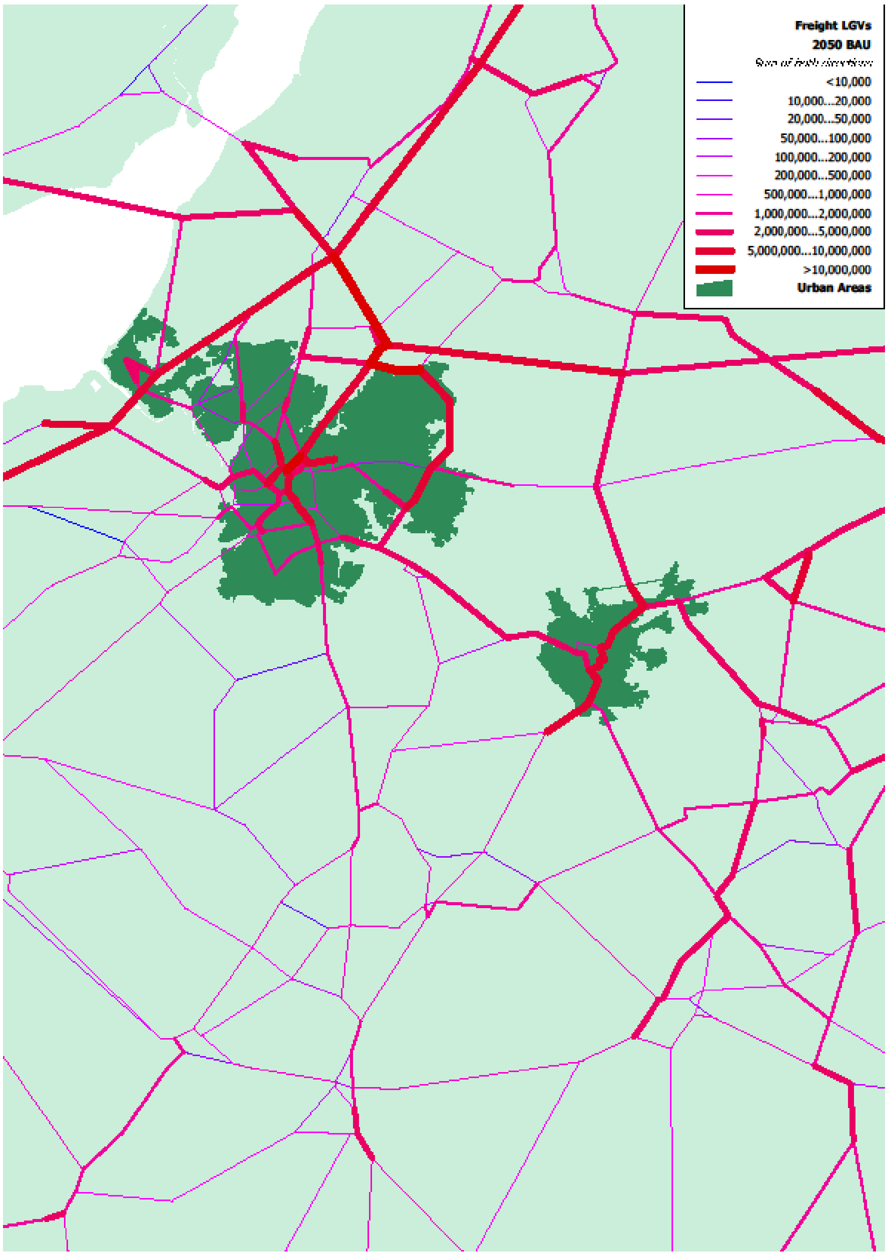
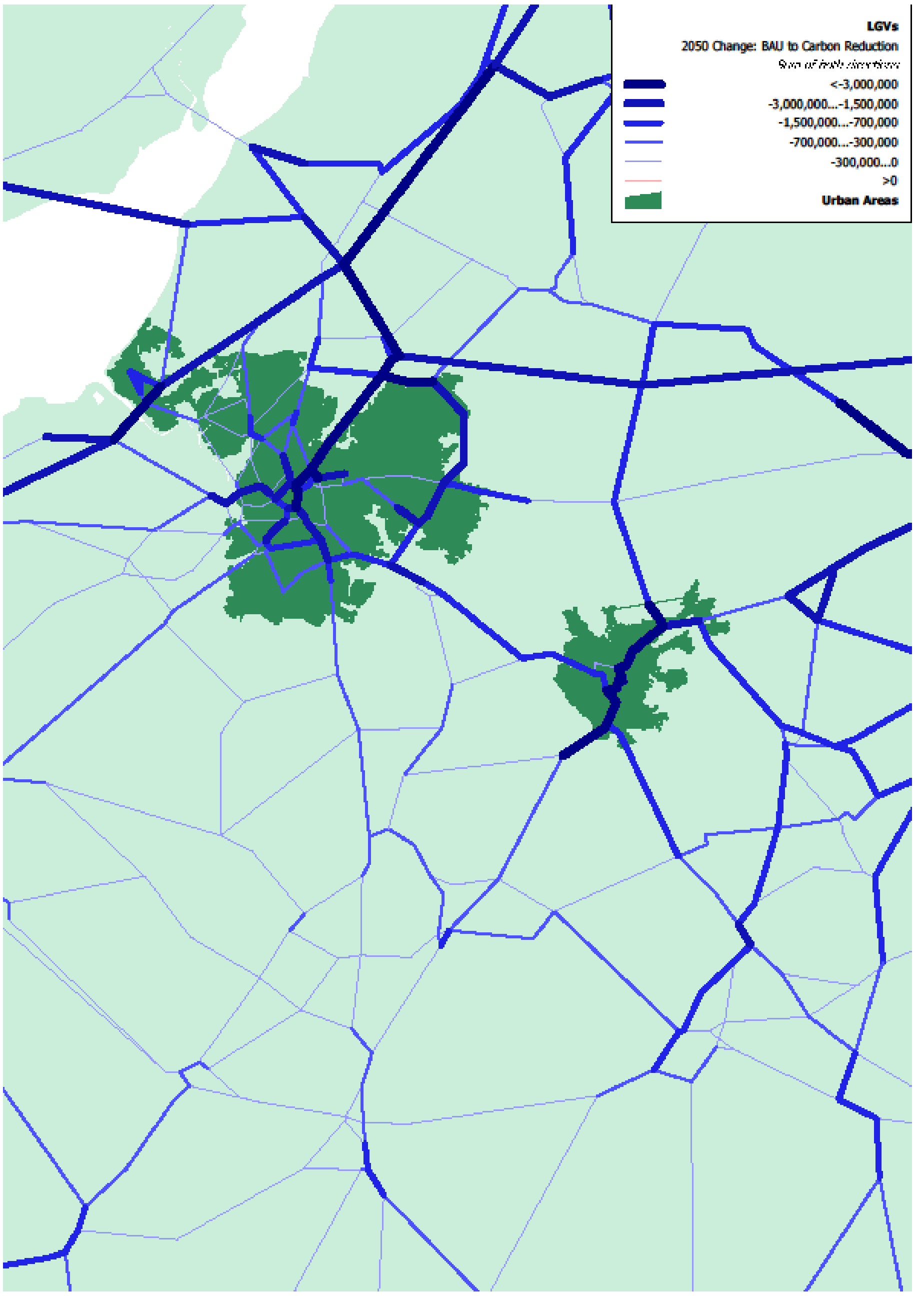


Figure 74: Bath & NE Somerset - Change in annual LGV flows in the 2050 Carbon Reduction Scenario compared to the 2050 BAU Scenario

Source: MDS Transmodal



The wider implications of the results of the modelling and the study as a whole are provided in section 5.

5 CONCLUSIONS

5.1 Implications for policy and infrastructure development

The quantitative modelling carried out for this study sought to address the inherent uncertainty in forecasting freight transport over more than 30 years into the future by developing and then modelling some quite different scenarios. These scenarios also sought to take into account potential different scenarios following the UK's departure from the EU and the nature of the UK's potential trading relationship with the EU and the rest of the world.

The quantitative modelling of future scenarios in section 4 should be viewed therefore as providing some quantified potential outcomes for what the future may hold for freight transport in 2050, taking into account different scenarios with respect to how the economy, consumer behaviour, technology and policy may develop. The results cannot be used for detailed analysis of the potential impact of individual policy options without developing and modelling each of the major options separately and then examining the incremental impact. Having said that, based on our experience of carrying out freight modelling using the GB Freight Model, the following conclusions can be reached.

Aggregate growth in freight tonnes and freight tonne kilometres in each scenario is related to the increase in forecast GVA provided by the E3ME macro-economic model (with some deflation as described above). The aggregate demand is therefore highest for the 2050 BAU scenario, but marginally lower for the other three scenarios as these reflect the UK's potential changing trading relationship with the EU.

Connected and Autonomous Vehicles (CAVs) have a significant impact in reducing the fixed operating costs of electric HGVs as we assumed that only one-third of existing labour would on average be required in 2050. Compared to the 2050 BAU Scenario this has the effect of encouraging a switch to the use of HGVs rather than rail for domestic freight and also a switch towards accompanied RORO services for trade between GB and the rest of Europe as the fixed cost of trucks on a ferry falls compared to unaccompanied roro services.

Clustering of warehousing on sites that are linked to rail has the opposite effect as rail-based transport chains can start or end at the origins and destinations of the freight movements (the distribution centres) rather than requiring the additional cost of road transport to take the freight between the rail terminals and the distribution centres. This helps to limit the switch from rail to road as a result of the use of CAVs and, if CAVs do not develop as set out above, then this clustering would allow overall tonnages by rail to rise to around 160 million tonnes of traffic per annum by 2050.

The complete **loss of Electricity Supply Industry (ESI) coal** to the rail freight industry by 2050 compared to 2015 (when there was 23 million tonnes of this traffic on rail) due to Government energy policy has the effect of reducing the overall rail market share as compared with the level in 2015 and if autonomous vehicles are implemented by 2050. When ESI coal is taken out of the calculation of the change in modal shift, rail is securing significant growth and would secure even more growth if autonomous trucks were not, in practice, widely implemented.

The modelling is **unconstrained by capacity** and future freight demand would need to be accommodated by, in particular, road, rail and port infrastructure networks along with demand for passenger transport.

The potential **policy implications** of the modelling are that:

- The introduction of CAVs and electric HGVs in isolation is likely to lead to a switch of freight from rail to road and, based on the assumptions made, appears to outweigh many of the other measures;
- Road pricing (based on the need to reduce road congestion levels) would lead to a switch to rail and also help to maintain Government taxation revenues;
- Planning policies to locate distribution centres on rail- and water-connected distribution parks – rather than just next to motorway junctions - would encourage the development of non-road freight services to help reduce road congestion on medium and long distance flows on strategic links and therefore also free up capacity for road freight that needs to use those links;
- Improved economies of scale available from all modes of transport (e.g. longer HGVs and longer trains) provide efficiency benefits for the freight transport operators and the wider economy;
- Without reductions in passenger demand, additional infrastructure network capacity is likely to be required to accommodate the growth, particularly on the core road and rail networks and also at some unitload ports.
- Again, without reductions in passenger demand, significant growth in LGVs transporting freight is forecast, which will have implications for, in particular, the capacity of urban road infrastructure.

5.2 Overall conclusions

Despite the inherent uncertainty involved in forecasting over a period of more than 30 years, and particularly so given the importance of the UK's future trading relationships for the freight transport sector, we have sought to set out below some views on how the future of freight demand may develop by 2050.

Aggregate growth in freight demand is unlikely to be sensitive to foreseeable changes in the cost of freight transport up to 2050 because, for all but building materials, the value of goods being transported is so much higher than the cost of door-to-door freight transport. The amount of freight transport required in 2050 will therefore be determined mainly by the growth and future structure of the UK economy and its future trading relationships. As the UK has gradually developed since the 1980s into an essentially service-based economy, future growth in freight is likely to be at a lower rate than growth in overall GVA and closer to forecast growth in population as it reflects consumption.

The structure of this service-based economy is such that the UK is likely to continue to have a propensity to import consumer goods rather than produce them within the domestic economy and so international gateways will retain their key role in the UK’s freight transport system. Having said that, high value manufacturing is likely to retain a role in the economy and, in some scenarios, could increase its role; such manufacturing may not increase the volume of HGVs, trains or containers moving to and from ports as the traffic will provide backloads for otherwise empty units.

Future significant growth in e-commerce is likely because of its convenience for consumers and this would lead to a significant increase in traffic making deliveries in urban areas instead of generating passenger trips to retail outlets. The extent of this growth is likely to be determined partly by consumer requirements and habits and where people live, but also by the extent to which the full cost of deliveries is incorporated transparently into the pricing of e-commerce purchases.

The UK’s future trading relationship with the EU and the rest of the world is likely to have a major impact on international gateways, with a possible re-focusing of trade to the rest of the world and away from the EU likely to lead to a greater market share of high value unitload traffic being handled through deep sea container ports and major international airports rather than through short sea ferry ports.

Whatever the nature of the UK’s trading relationships in 2050, international gateways (major ports, the Channel Tunnel and major international airports such as London Heathrow) are likely to retain their importance in the freight transport system, both for the handling of imports and exports of high value manufactured goods and foodstuffs, parts for assembly lines and materials for activities such as construction. The handling of energy products at major ports, on the other hand, will have ended as the UK economy decarbonises and North Sea oil production ceases.

Road and rail freight services are likely to retain their major role for the domestic distribution of ‘heavy’ freight and for the inland distribution of goods to and from international gateways. Inland waterway transport and coastal shipping would also play a role in some transport chains, particularly where relatively large consignments of non-time sensitive goods are being transported. The successful and widespread implementation of autonomous vehicles in the road haulage sector by 2050 could radically improve the economics of road haulage in competition with other modes because it could, in theory, remove a significant proportion of the mode’s fixed costs. This would, in the absence of any other changes, lead to a switch of traffic away from rail and other inland modes because the introduction of autonomy for other modes has a much less significant impact on the cost of moving a tonne of cargo. This is because road haulage is otherwise highly labour intensive.

The assumed widespread introduction of electric LGVs and HGVs by 2050 would cut dramatically the emissions from road freight transport as long as the required electricity can be generated from renewable sources. It would also have the effect of reducing the variable costs per kilometre due to the assumed lower cost of energy and lower maintenance costs, unless a system of road pricing was introduced by the Government both to manage road congestion and also to maintain tax revenue following the loss of Fuel Duty currently levied on diesel.

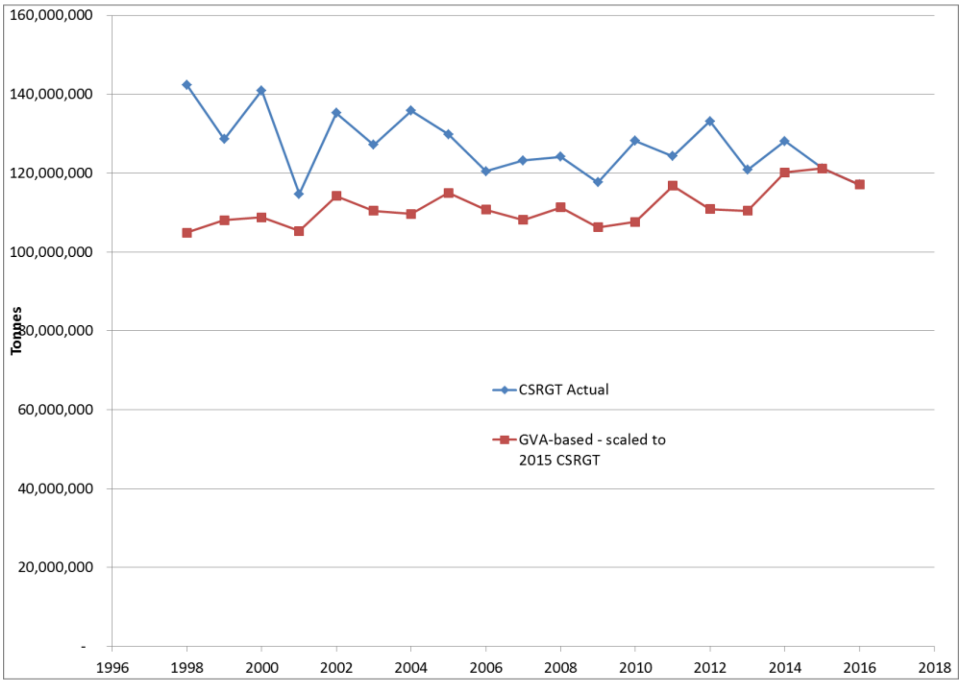
The land use planning system is likely to have a key role to play in facilitating the greater use of rail, inland waterways and shipping up to 2050 and encourage the greater use of non-road modes to relieve pressure on the strategic road network. The planning system would need to encourage the clustering of distribution centres on sites which are rail and/or water-connected, so there would be no additional fixed cost of road haulage required to distribute the freight between the rail and/or water-connected terminal and off-site distribution centres. In the event that autonomous HGVs do not emerge as a practical technological solution by 2050, but the planning system leads to greater clustering of distribution centres on rail-connected distribution parks, there would be a substantial net switch of traffic from road to rail.

Urban freight movements are likely to increase up to 2050 as a result of an assumed increased penetration of the retail market by e-commerce. These additional freight movements, mainly in LGVs, would replace some existing passenger trips to retail outlets and would be completed using electric vehicles and so minimise emissions; nevertheless, there may be political pressure to re-organise urban logistics chains to reduce the potential congestion impacts of these movements. The clustering of distribution centres on rail- and water-connected sites on the edge of major conurbations may provide an opportunity for greater use of non-road modes for trunk hauls of e-commerce goods and consolidation of loads in electric LGVs for final deliveries in the urban areas.

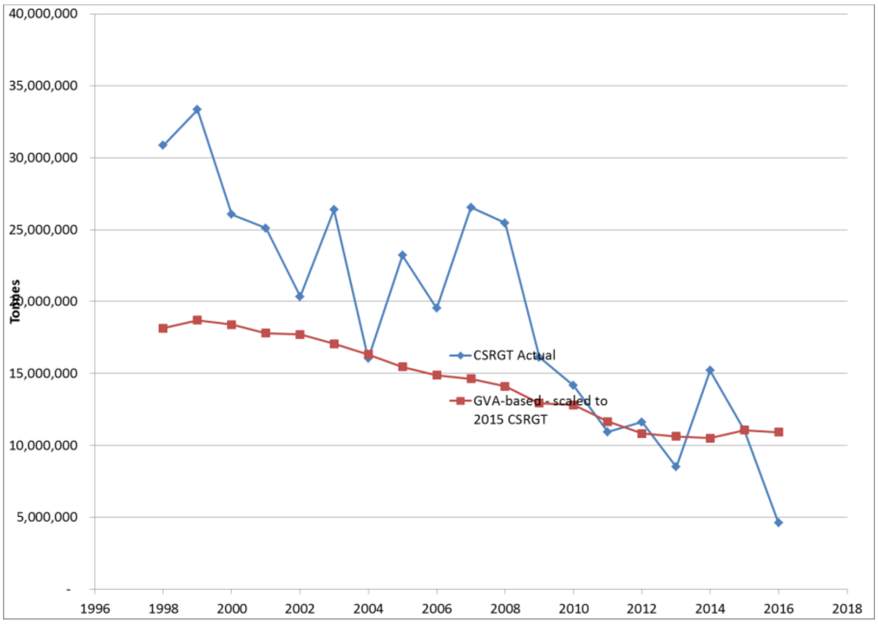
The freight transport system may not be so radically different from that in 2018 in that the same modes are likely to be required for the transport of the vast majority of freight tonne kilometres – with ‘alternative’ modes such as drones securing a limited market share in niche markets. The major changes may be in the reduction in emissions and the reduction in costs in real terms as a result of the introduction of electric and more autonomous vehicles. New logistics models may have been successfully implemented to reduce the impact of greater demand for e-commerce deliveries in urban areas.

APPENDIX 1: COMPARISON BETWEEN HISTORIC GVA & ROAD FREIGHT TONNES BY SECTOR

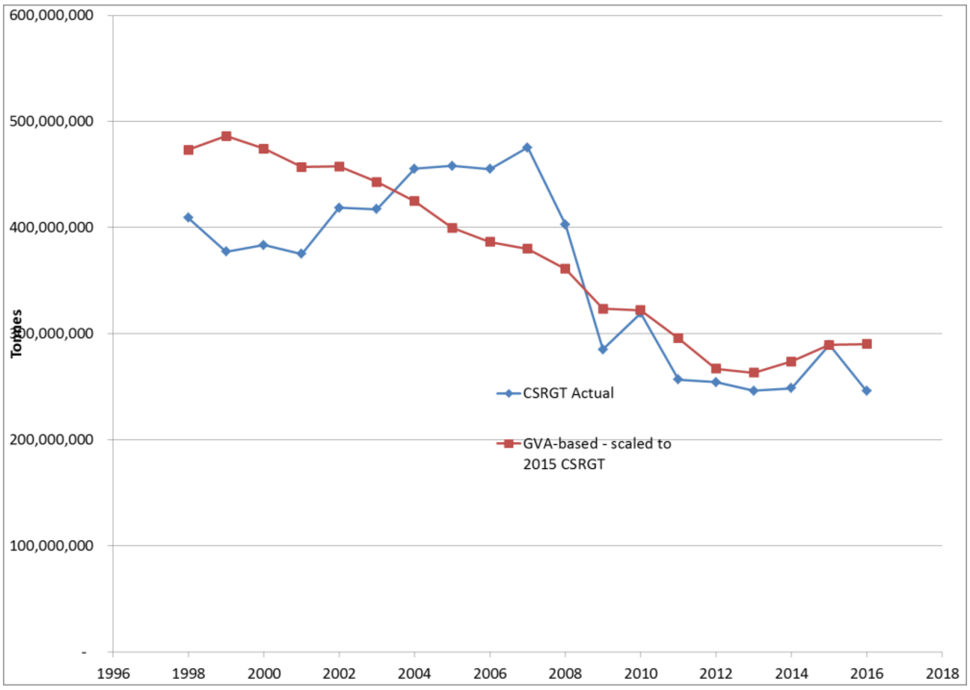
1: Products of agriculture, hunting, and forestry; fish and other fishing products



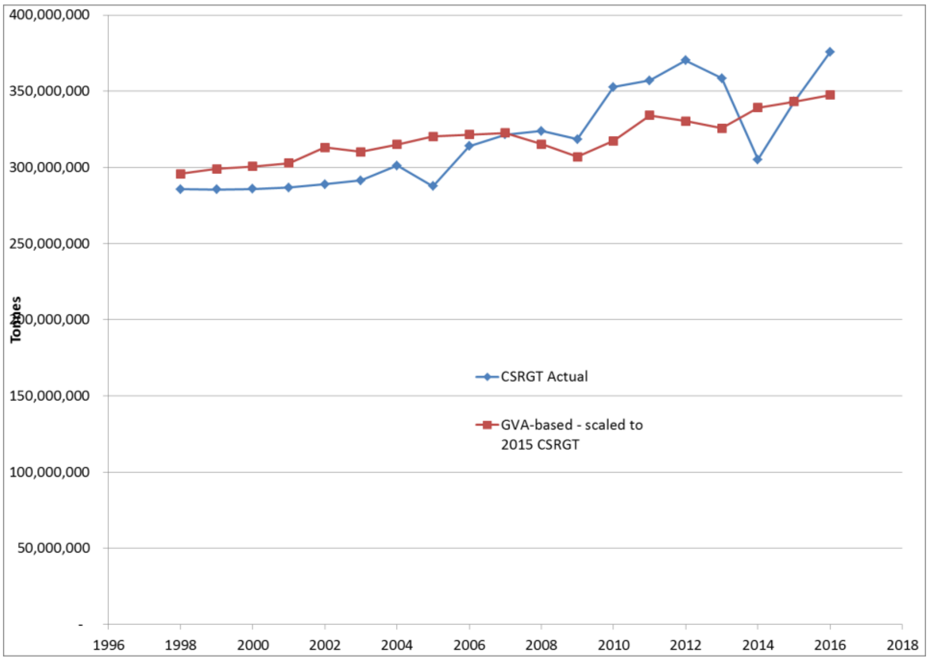
2: Coal and lignite; crude petroleum, natural gas



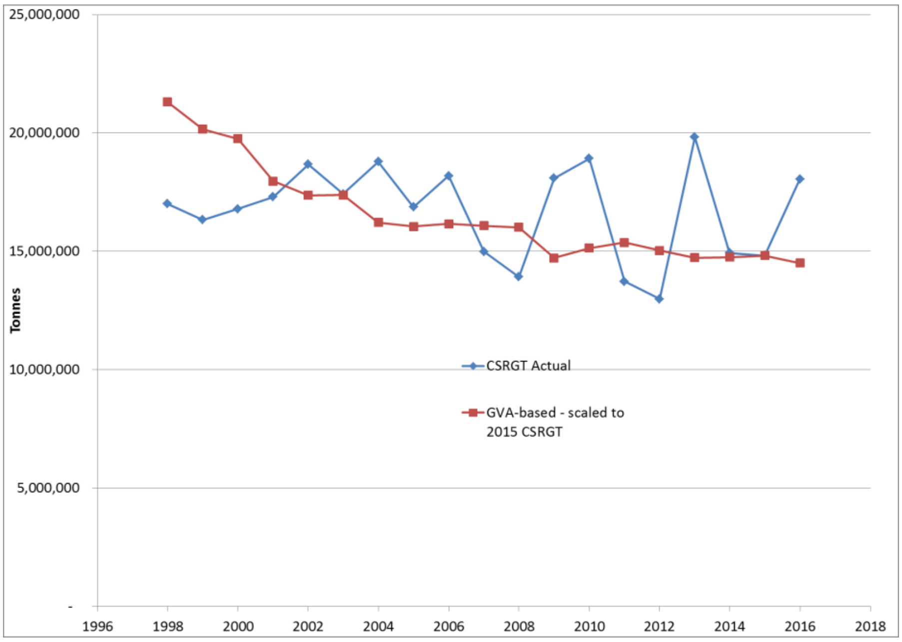
3: Metal ores and other mining and quarrying products; peat; uranium and thorium ores



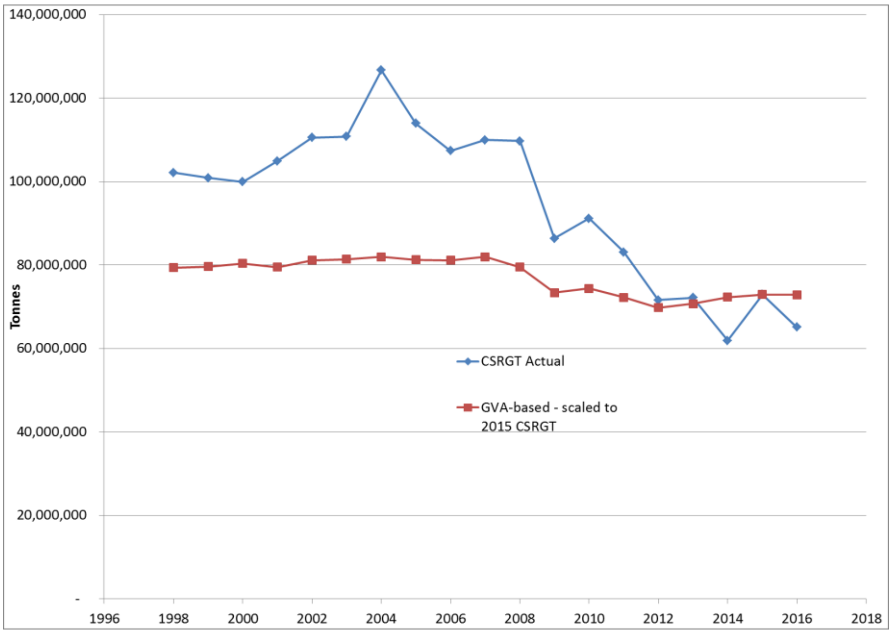
4: Food products, beverages and tobacco



5: Textiles and textile products; leather and leather products

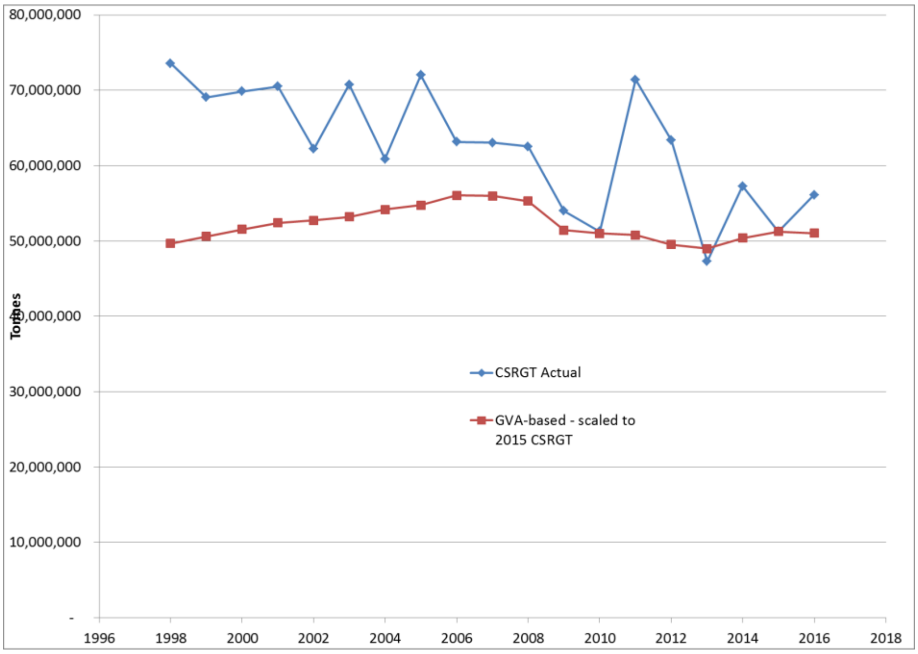


6: Wood and products of wood and cork (except furniture); articles of straw and plaiting materials; pulp, paper and paper products; printed matter and recorded media

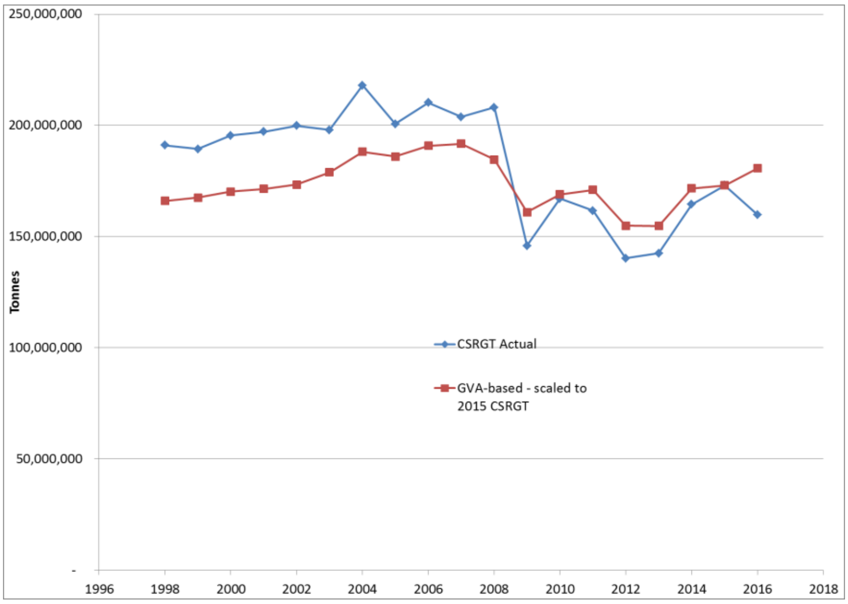


7: Coke and refined petroleum products

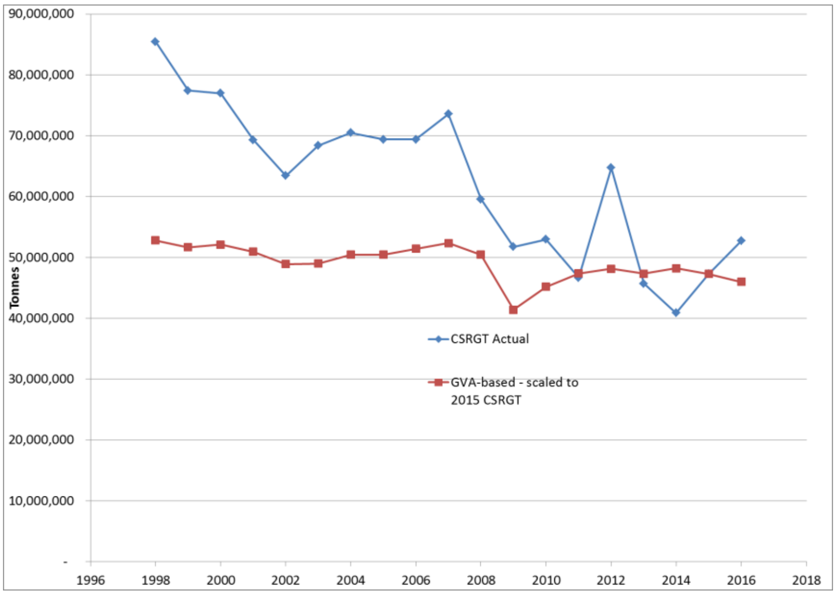
8: Chemicals, chemical products, and man-made fibres; rubber and plastic products; nuclear fuel



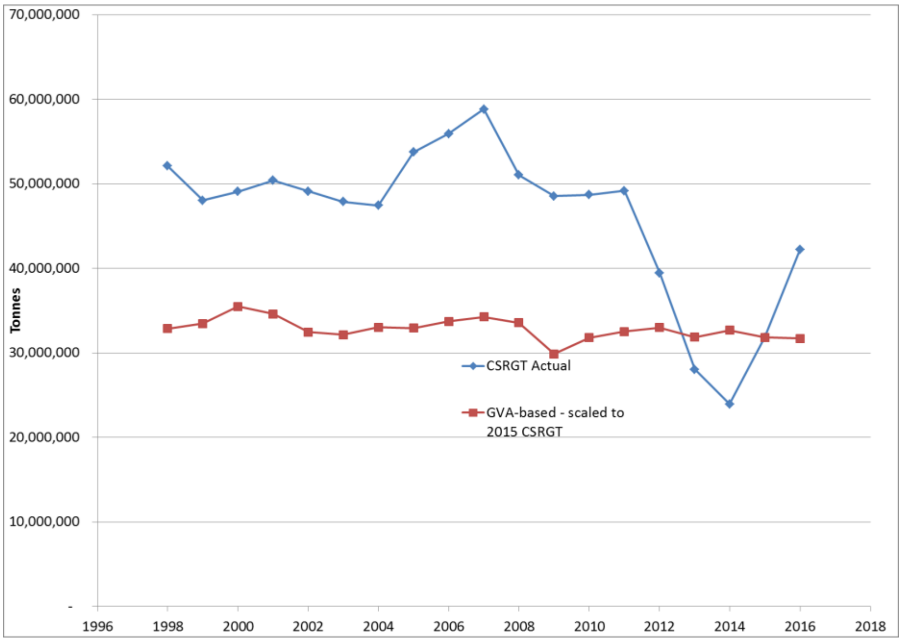
9: Other non-metallic mineral products



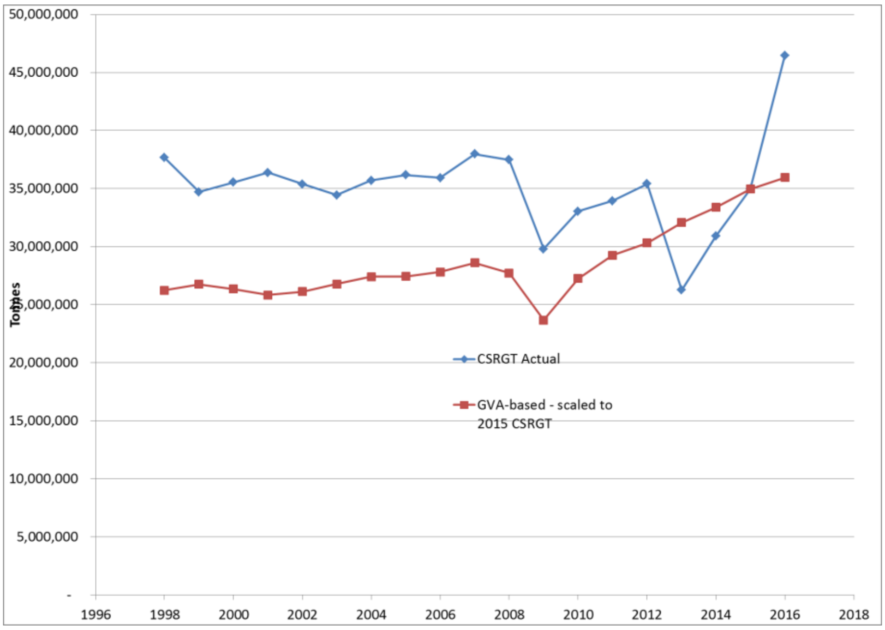
10: Basic metals; fabricated metal products, except machinery and equipment



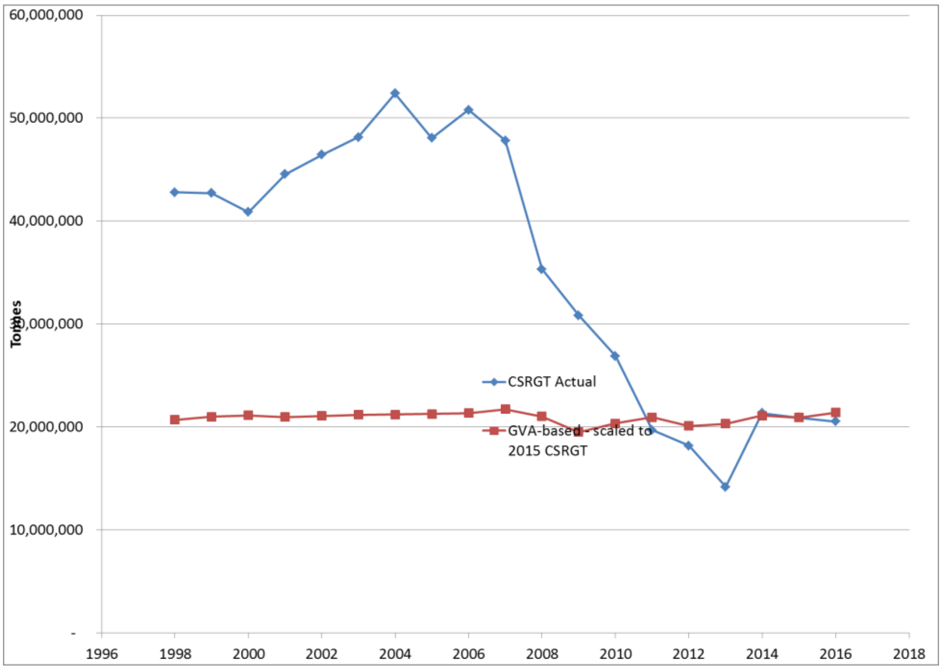
11: Machinery & equipment



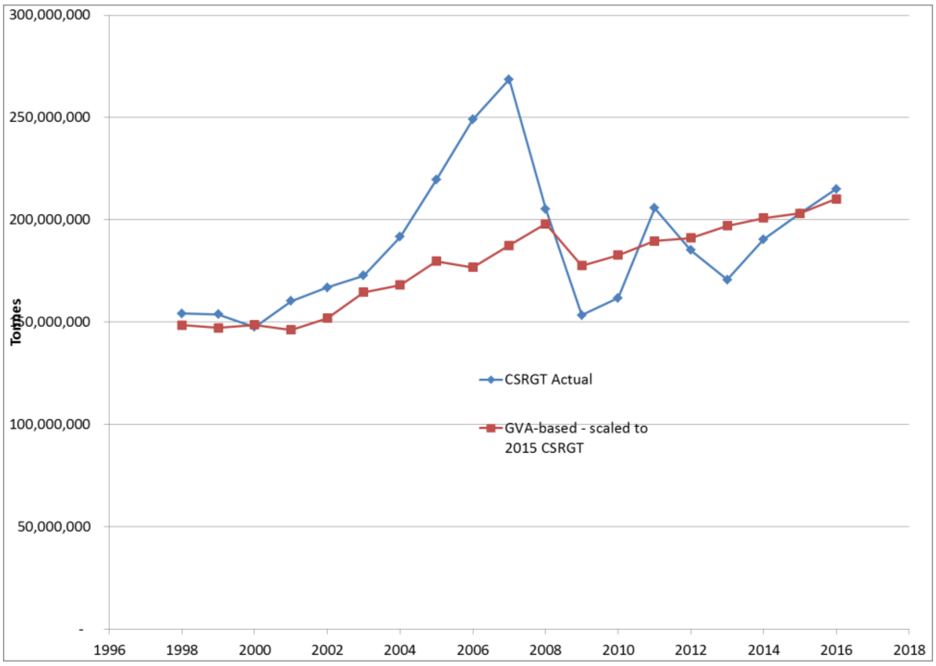
12: Transport equipment



13: Furniture; other manufactured goods n.e.c.



14: Secondary raw materials; municipal wastes and other wastes



APPENDIX 2: REVIEW OF FREIGHT FORECASTING

1 Rail Freight Forecasts

Background

The Railways Act 1993 restructured the rail industry, with the ownership/management of the track infrastructure separated from the operation of train services. A new track infrastructure company was created (Railtrack, but subsequently reformed as Network Rail in 2001), and the former British Rail freight sectors sold to private sector investors. The commercial environment subsequently created for freight was based on the concept of 'on-rail' competition, where private operators (both privatised BR sectors and new entrants) would invest in new equipment and terminals, and compete for traffic on an open competitive basis. An independent regulator (the Office of Rail Regulation) was established to ensure open competition and fair access to Railtrack's network. This included a regulatory condition on Railtrack to provide for the freight operators' 'reasonable requirements' over the long-term.

The newly elected Labour Government in 1997 broadly accepted the new commercial structure of the railways. However, it concluded that there was a lack of 'strategic oversight' for the railways industry, and a Strategic Rail Authority (SRA) was subsequently created by the Transport Act 2000. The SRA was charged with developing strategies for both passengers and freight, with a particular emphasis on delivering the new Government's policy of increasing the amount of freight moved by rail. The SRA subsequently published its Freight Strategy in 2001. This document reiterated that the private sector was best placed to develop the necessary services, and that the SRA would facilitate this by providing, amongst other initiatives, long term capital investment in the national track infrastructure to improve its capacity, reliability and capability. This policy, alongside the 'reasonable requirements' condition, necessitated the production of long term demand forecasts for the rail freight sector in order to better understand the market, including identifying the key sectors where investment should be targeted.

Consequently, the SRA's 2001 Freight Strategy included a set of long term demand forecasts for the rail freight sector. Following the SRA's abolition in 2006, long-term strategic planning passed to Network Rail. The funding of infrastructure enhancements for freight subsequently became part of Network Rail's five-yearly periodic review (Control Period) process. Further iterations of rail freight demand forecasts have therefore been necessary to inform Network Rail's 'reasonable requirements' condition, its long-term planning obligations and the periodic review process. These are described below. Note in each case the forecasts produced are for Great Britain.

Therefore, in just under a decade the commercial and regulatory environment changed from one which was essentially managing decline (under BR) to one where private operators were investing to grow rail freight traffics, supported by public sector interventions to enhance the capacity and capability of the infrastructure. Rail freight demand forecasts have become an important part of this process.

SRA Freight Strategy Forecasts (2001)

As explained above, the SRA published its Freight Strategy in 2001. Designed to deliver the Government's policy of increasing the amount of freight moved by rail, it included a series of infrastructure interventions to enhance the capacity, reliability and capability of the network alongside other policy measures designed to remove barriers to growth. In order to better understand the market and to 'test' the emerging strategy, two sets of forecasts were commissioned by the SRA.

The first set of forecasts was produced by MDS Transmodal using an early version of the GB Freight Model. Eight commodity sectors in total were modelled, including coal, metals, construction, maritime containers and Channel Tunnel. The year 2000 was adopted as the base year, with forecast outputs produced for 2010. In addition to a baseline forecast, two further scenarios were produced to reflect actions that could be taken by Government or the rail industry to improve the rail offer. Outputs were produced on an unconstrained basis. The second set of forecasts was produced by consultants Sinclair Knight Merz (SKM), derived from a custom-built rail forecasting model commissioned by the SRA. As per the MDST forecasts, the same base year was adopted (2000), three scenarios were modelled and the outputs were produced on an unconstrained basis.

While the three scenarios modelled in each case were different and were therefore are not directly comparable, both sets of forecasts adopted broadly similar methodologies. Base year tonnages by commodity were quantified and then projected forwards to 2010. In the case of the MDST forecasts, total freight flows were initially forecast based on historical growth rates. Modal split was then estimated based on end-end transport costs. The SKM forecasts adopted a 'break-even distance' approach, whereas the MDST forecasts sought to assign flows to rail where this provided the lowest 'generalised cost'. A summary of the base scenarios is shown in Table 1.

Table 1: 2001 SRA Freight Strategy Forecasts to 2010

	2000	MDST Baseline	SKM Baseline
Total (tonne-km, bn)	18.4	21.2	18.9
Growth v 2000		15%	3%
CAGR		1.4%	0.3%

Source: MDS Transmodal

Freight Transport Association and Rail Freight Group Forecasts (2008)

As noted above, the SRA was abolished in 2006 with responsibilities for long-term strategic planning transferred to Network Rail. In the absence of the SRA, the Freight Transport Association (FTA) and the Rail Freight Group (RFG) jointly commissioned MDS Transmodal to produce an updated set of rail freight demand forecasts on behalf of the freight sector. In addition to providing Network Rail with the industry's 'reasonable requirements' over the long-term, the forecasts would also inform the 2009 High Level Output Statement (HLOS) and the subsequent Control Period 4 (2009-2014) periodic review process. The forecasts were produced using a significantly updated version of the GB Freight Model.

By way of background, the key starting component of the GB Freight Model is a multi-dimensional base matrix, built up from several sources, which describes freight flows within Great Britain and to/from Great Britain by origin/destination and commodity. Sources include the Continuing Survey of Road Goods Transport (CSRGT), Network Rail billing data and Port Statistics. Freight flows in the base matrix are subsequently disaggregated down to Post Code District (PCD) level. The base matrix therefore describes the current distribution of cargo nationally (between each of the PCD origins/destinations) by commodity on a mode-neutral basis.

The model's mode-choice assignment component subsequently assigns the base matrix flows between each of the PCD origins/destinations to transport modes (road or rail for inland). This is based on a lowest 'generalised cost' approach, which takes into account transport costs (from industry validated cost models internal to the GB Freight Model) alongside other factors such as speed, flexibility and reliability. A calibration process is undertaken which ensures that the outputs replicate current mode shares.

For future freight forecasts, growth rates are applied to the base matrix. For GB-domestic freight flows, trend based forecasting is adopted, with growth rates subsequently applied to the GB-domestic elements of the base matrix. For GB-international freight flows, growth rates by commodity, sector and country are derived from external trade forecasting models developed and operated by MDS Transmodal. These are then applied to the GB-international elements of the base matrix. Effectively, a 'new' matrix of origin/destination freight flows (on a mode-neutral basis) is generated based on the respective growth rates as described applied to the base matrix.

Once future freight flows are forecast, the mode-choice assignment component subsequently assigns the forecast flows between each of the PCD origins/destinations to transport modes (road and rail). This is also based on the 'generalised cost' approach. By adjusting the internal cost models, user-defined scenarios or assumptions can be 'tested' in terms of their potential impact on mode share/shift. This could include higher fuel costs (due to oil price rises or taxation), increased HGV fuel efficiency rates, distance based road user charging, higher driver wages and enhanced road or railway infrastructure (including SRFIs). The assignment is undertaken on an unconstrained basis i.e.

it assumes rail network capacity is available and does not account for changes in congestion on the wider highway network. Note also that, even if the primary purpose of the exercise is to produce rail forecasts (as in this case), the nature of the GB Freight Model means that road forecasts are also produced alongside (though not necessarily published in every case).

The model also includes a 'land-use' element, which allows the development of new rail-served warehouse capacity to be tested in terms of its impact on future rail freight demand. The GB Freight Model also includes a rail and road assignment module. This allows existing and forecast rail freight flows to be 'converted' into daily train numbers and then assigned onto specific routes on the national railway network (and likewise road outputs to be equated as daily HGVs and assigned to particular roads).

For these forecasts, the base year selected was 2006 (actual rail freight moved/lifted derived from Network Rail data). Forecasts were produced for 2015 and 2030, with future freight traffics forecast and modal assignment undertaken by the GB Freight Model as described above. A single scenario was developed, with the key assumption being the development of an additional 9 million square metres of rail-served warehouse capacity alongside generally accepted changes going forward to fuel prices, wage rates etc. over time. As per the 2001 SRA forecasts, the outputs were produced on an unconstrained basis. Table 2 below summarises the forecasts.

Table 2: 2008 FTA/RFG Forecasts – 2015 and 2030 with base year 2006

	2006 Base	2015	2030
Total (tonne-km, bn)	23.5	31.0	50.4
Growth v 2006		31.9%	114%
CAGR		3.1%	3.2%

Source: MDS Transmodal

It should be noted that the forecasts:

- Sought and received 'buy in' from the DfT – they effectively replaced national rail freight projections previously produced by SRA and represented 'industry's' reasonable expectations for future growth; They subsequently informed Network Rail's Freight Route Utilisation Strategy (RUS) and the DfT's case for the Strategic Freight Network (SFN); and
- They informed the review of track access charges for Control Period 4 (2009-2014).

Rail Freight Group and Rail Freight Operators Association forecasts (2011)

It was generally accepted by the rail freight sector in 2011 that an updated set of rail freight demand forecasts were required, for reasons including:

- To confirm the case for continuing network upgrades given the success of a number of infrastructure enhancement schemes specific to the freight sector in the late 2000s e.g. Southampton to Midlands and Felixstowe to Midlands gauge enhancement;
- To establish the impact of the global financial crisis (and subsequent 2008-9 economic recession) on future rail freight demand;
- To establish the impact of measures, either being implemented or planned, which were designed to improve rail freight productivity e.g. longer trains, six-day working etc.; and
- To update the position with respect to land use, in particular accounting for those developments which have been granted planning consent or denied planning consent, and new proposals which have emerged since 2008.

The RFG and the Rail Freight Operators Association subsequently commissioned MDS Transmodal to produce an updated set of demand forecasts for 2020 and 2030. The GB Freight Model was again utilised as the forecasting tool and broadly the same methodology used for the 2008 FTA/RFG forecasts adopted. This included long-run trend based forecasting for domestic freight flows and different growth rates for international traffics derived from external trade forecasting models, with modal assignment also undertaken by the GB Freight Model.

The key change in the methodology when compared with the 2008 forecasts concerned coal for electricity generation. In this case, specific assumptions were made with respect to expected coal-fired power station closures, due to stricter emissions regulations, and the subsequent impact on coal volumes estimated i.e. growth rates effectively forecast separately 'outside' the GB Freight Model as described above.

The other key drivers included an additional 7.2 million square metres of rail-served warehouse capacity alongside generally accepted changes going forward to fuel prices, wage rates etc.. over time. The base year selected was the 12-month period July 2010 to June 2011 (actual rail freight moved/lifted derived from Network Rail data).

Two forecast scenarios were tested, namely:

- Base assumptions with respect to freight growth, rail-served warehousing, agreed changes to fuel and wage costs etc. plus current (2011) levels of rail freight productivity; and
- The same base assumptions with respect to freight growth etc. plus improved levels of intermodal service productivity through a 20% increase in trailing length and a move to 6 day per week working.

The results are summarised in Table 3.

Table 3: 2011 RFG/RFOA Forecasts – 2020 and 2030 with base year 12 months to June 2012

	Base (2012)	2020		2030	
		Low	High	Low	High
Total (tonne-km, bn)	21.0	33.0	34.0	40.0	43.0
Growth v 2012		57%	62%	90%	105%
CAGR		5.2%	5.5%	3.4%	3.8%

Source: MDS Transmodal

Network Rail forecasts (2013)

One of Network Rail's licence conditions is that it is required to establish strategies to inform the long term development of the network. Its current methodology for undertaking this task is called the Long Term Planning Process or LTPP. The LTPP consists of a number of different elements, which when taken together, seek to define the future capability of the network. The individual elements are market studies, route studies and cross-boundary analysis. Together they provide a key part of the evidence base for future updates of the network. Four market studies to inform the LTPP were published in October 2013, including a Freight Market Study (FMS).

The FMS was published by Network Rail on behalf of a cross-industry working group. To inform the market study, a set of national rail freight demand forecasts over a 10, 20 and 30 year planning horizon were produced by MDS Transmodal for the working group (financial years 2023/4, 2033/4 and 2043/4). A base year of 12 months to the end of September 2012 was used as the basis of the forecasting. Forecasts for 13 commodity groups were undertaken, including intermodal rail from the ports, Channel Tunnel and domestic sources, which were then subsequently combined to form forecasts for all rail freight traffics. In a change to the previous iterations described above, the forecasting methodology and assumptions varied for each commodity grouping. In broad terms, forecasting by commodity 'outside' the GB Freight Model was undertaken using an appropriate approach, with the mode assignment and routing then undertaken by the model. These are summarised below.

International unit load traffics:

- Growth rates from base year traffics (all modes) derived from the MDS Transmodal World Cargo Database (in-house trade forecasting software);
- Modal assignment using the GB Freight Model;
- An additional 10 million square metres of rail-served floor space;
- Productivity improvements – including 20% longer trains and 20% more operating days by 2023 and lower lift charges at terminals;
- Lower Channel Tunnel charges; and

- Assignment to rail network using GB Freight Model.

Domestic unit load traffics:

- Growth rates from base year traffics (all modes) based on long-term trends;
- Modal assignment using the GB Freight Model;
- An additional 10 million square metres of rail-served floor space;
- Productivity improvements – including 20% longer trains and 20% more operating days by 2023 and lower lift charges at terminals; and
- Assignment to rail network using GB Freight Model

Power station coal:

- A fall from 40 million tonnes (actual in 2011) to 3.9 million tonnes by 2030, derived from Department for Energy and Climate Change forecasts, which were based on projected power station closures from 2016 onwards; and
- Assignment to network using GB Freight Model based on the fixed location of remaining power stations and existing train productivity.

Biomass:

- Remaining coal-fired power stations switch 30% of their generating capacity to biomass by 2023;
- Assignment to network using GB Freight Model based on the fixed location of remaining power stations and existing train productivity.

Waste:

- Existing waste flows by rail remain constant;
- A limited number of new EfW plants (in 2013);
- Assignment to network using GB Freight Model based on known EfW locations and existing train productivity.

Construction (aggregates):

- Growth in volumes nationally in proportion to population increases (sourced from WebTag);
- Modal assignment using the GB Freight Model;
- Base year origins, destinations and routes assumed to continue into the future; and
- Assignment to rail network using GB Freight Model.

Other commodities, including Petroleum, Chemicals, Industrial Minerals, Metals and Automotive:

- No significant change in the overall markets for these sectors was forecast;
- Modal assignment using the GB Freight Model; and
- Assignment to rail network using GB Freight Model.

All the scenarios assumed the following:

- Real-terms increases on labour (drivers wages) and fuel (diesel) costs as per WebTag; and
- No real-terms changes to Network Rail track access charges.

Again, the outputs were produced on an unconstrained basis. Table 4 below summarises the outputs.

Table 4: Network Rail FMS Forecasts 2013 – to 2023/4, 2033/4 and 2043/4 with base year 12 month to September 2012

	Base (2012)	2023/4	2033/4	2043/4
Total (tonne-km, bn)	23.0	36.8	48.1	62.4
Growth v 2012		60%	109%	171%
CAGR		3.99%	3.4%	3.2%

Source: MDS Transmodal

These forecasts were subsequently incorporated into the National Policy Statement (NPS) for National Networks. The NPS notes that the forecasts, and the methodology used to produce them, are 'robust' and 'that the Government has accepted them for planning purposes'. The NPS concluded that they confirm the need for an expanded network of large Strategic Rail Freight Interchanges (SRFIs) across the regions to accommodate the long-term growth in rail freight.

Network Rail forecasts for CP6 (2017)

These forecasts were commissioned by Network Rail in 2017; they effectively formed an update of the FMS forecasts described above and were intended to inform Network Rail's Strategic Business Plan for Control Period 6 (2019 to 2024). As for the FMS forecasts, they were produced by MDS Transmodal. The need for an updated set of forecasts was driven by a sharp fall in the volume of cargo lifted by the rail freight sector since the FMS forecasts were originally produced. As a result, the FMS growth projections (in total) were not being realised (though some commodity sectors, principally construction, were ahead of projections). The reasons for the decline in traffic were taken to be:

- Government energy policy changes, resulting in a significantly faster reduction in the role of coal fired power stations and a lower take-up of biomass than expected because of cuts in the level of financial support available;
- Lower fuel price growth and wage growth than expected. Fuel prices declined in real terms between 2013 and 2017. The assumptions in the FMS forecasts had been based on the then WebTag projections being made by the DfT.
- A lower rate of build-out of rail served warehousing sites than expected, consequent on the 'lost years' of the financial crisis which delayed many projects.

The revised rail freight forecasts were for the financial year 2023/24, with the base year being the financial year 2016/17. The modelling methodology was broadly the same as that adopted in the

2013 FMS forecasts. However, unlike the FMS there was not one central scenario. Four separate scenarios were modelled, spanning factors favouring rail to factors disfavouring rail, and low market growth to high market growth. The scenarios were:

- 2023/24 scenario A2: Factors which favour rail relative to road, with low market growth;
- 2023/24 scenario B2: Factors which favour rail relative to road, with high market growth;
- 2023/24 scenario C2: Factors which disfavour rail relative to road, with low market growth; and
- 2023/24 scenario D2: Factors which disfavour rail relative to road, with high market growth

Effectively, for B2 and D2 the underlying forecast total freight by commodity is the same; the scenarios merely reflect the rail industry's ability to attract traffic based on its competitive position versus road haulage (and likewise for A2 and C2). The general assumptions applied to each of the scenarios are shown in Table 5 below. The scenarios favouring rail assumed an additional 1.1 million square metres of rail-served floor space would be delivered by 2023/4. The other scenarios assumed a lower level of rail-served development by the same year (additional 0.4 million square metres).

Table 5: General assumptions by scenario

Assumption for 2023/24 relative to 2016/17	Sc: A2	Sc: B2	Sc: C2	Sc: D2
Labour (drivers' wages for road and rail)	+16% for road +8% for rail		+8%	
Source: Work value-of-time, WebTAG, March 2017 gives +12% as a central forecast *				
HGV fuel costs (including duty)	+22%		+2%	
Source: BEIS, March 2017: Data tables 1-19: supporting the toolkit and the guidance (table 8), low and high				
Fuel duty for road and rail	+5%			
Source: Fuel and Electricity Prices and Components, WebTAG table A.1.3.7, March 2017.				
Derived rail fuel costs (including duty)	+43%		-1%***	
Operational days per week	No change			
Train length (and tonnes of cargo per train)**	All commodities +5%		No change	

*The hypothetical scenarios (A2 & B2) that favour rail in terms of reducing rail costs vs road include a higher HGV wage increase vs rail wages. Two explanations for such a possible outcome are as follows:

- A possible Brexit impact whereby it is more difficult to take advantage of low Eastern European HGV wages. This will have little impact on train drivers.
- Currently there is a relatively free market for HGV drivers, with reasonably easy access for new drivers. This is less true for train drivers. In a rail-market-favouring scenario, we are assuming that the train driver market becomes more flexible with a lower cost of employing drivers. This may be brought about by the short-term impact of reduced demand in sectors such as coal

** We assume that there is no increase in HGV length and weight under any of the scenarios

*** Note that because the HGV fuel costs (including duty) only increase by 2% but the duty increases by 5%, this means there is a slight reduction in the resource cost of fuel.

Commodity specific assumptions are listed in the table below.

Table 6: Commodity Specific Assumptions by Scenario

Assumption for 2023/24 relative to 2016/17	Sc: A2	Sc: B2	Sc: C2	Sc: D2
Variable Usage Charges by commodity	Already committed for 2018/19:		Already committed 2018/19 + 25% for all commodities. This may in reality be forms of track charges other than VUC	
Construction	+16%			
Chemicals	-15%			
Domestic Automotive	-11%			
Domestic Intermodal	-5%			
Metals	+7%			
Industrial Minerals	+11%			
Maritime containers deep-sea trade growth	+10%	+25%	+10%	+25%
Domestic non-bulk traffic market growth	+4.7%	+14.2%	+4.7%	+14.2%
Channel Tunnel containers trade growth	+10%	+20%	+10%	+20%
Channel Tunnel bulks growth	-5%	+5%	-5%	+5%
Biomass: % increase for traffic to Drax	+20%	+80%	+20%	+80%
Lynemouth	0.7m t	1.4m t	0.7m t	1.4m t
Power station (ESI) coal: No rail traffic.				
Source: BEIS 2016 Updated Energy & Emissions Projections Annex J (v1.0 26-Jan-2017) projects that there will be zero electricity generation by coal in 2024				
Petroleum, Chemicals, Industrial Minerals, Metals and Automotive				
No major changes forecast in the overall markets, but fuel prices and drivers' wages will impact on rail's mode share.				
Overall market: Low market growth: -5%. High market growth: +5% + specific automotive flows identified as highly likely to happen by 2023/4 due to new rail connections: finished vehicles from Solihull to Southampton.				

The outputs from the forecasts are shown in Table 7 below.

Table 7: Network Rail CP6 Forecasts 2017 – to 2023/4, with base year FY2016/17

	Base (2016/17)	2023/4 A2	2023/4 B2	2023/4 C2	2023/4 D2
Total (tonne-km, bn)	19.0	23.9	28.5	17.5	21.2
Growth v 2012		25.8%	50%	-7.9%	11.6%
CAGR		3.3%	6.0%	-1.2%	1.6%

Source: MDS Transmodal

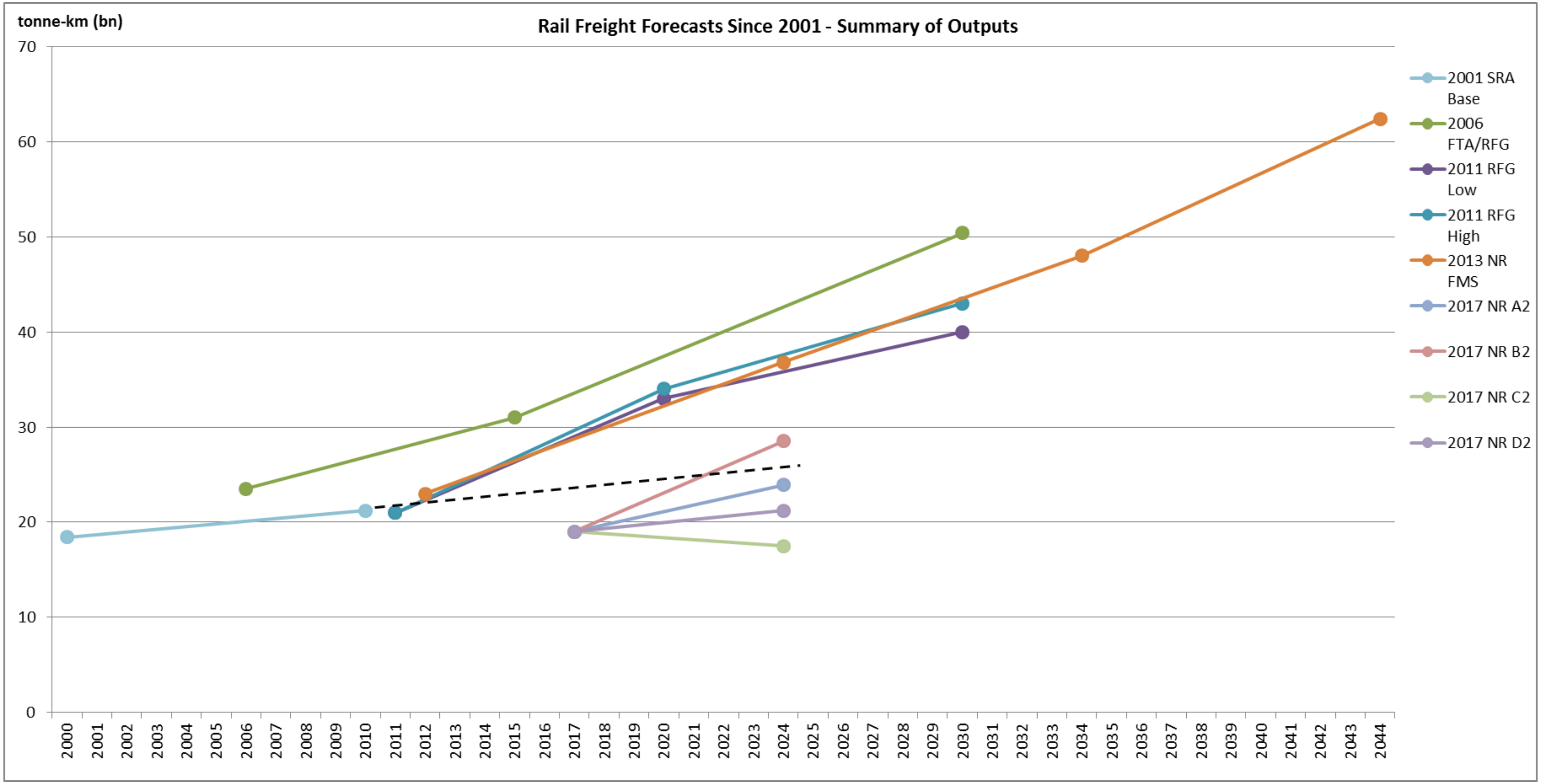
Summary of rail freight forecasts 2001-2017

Figure 1 below illustrates a summary of the rail freight demand forecast iterations described above. The key points are:

- The baseline year (actual) tonne-km value for the 2008 FTA/RFG forecasts was actually ahead of the projected forecast in the SRA's 2001 Freight Strategy forecasts;
- The baseline year (actual) tonne-km value for the 2011 RFG/RFOA forecasts and the FMS forecasts was broadly in line with the projected forecast for the previous year in the SRA's 2001Freight Strategy forecasts; and

- A forward projection of the SRA's Freight Strategy forecasts from 2010 onwards (on a straight line basis – see black dotted line) would see it more or less fall mid-point between Scenarios A2 and B2 from the 2017 Network Rail forecasts in 2023/4.

Figure 1: Summary of rail freight demand forecasts



It is apparent from the above that the baseline (actual) value in each of the forecasts from 2011 onwards is below the baseline from the previous iteration. This could suggest that each iteration was over-optimistic in its approach. As part of the 2017 CP6 forecasts, Network Rail asked MDS Transmodal initially to rerun the FMS forecasts but using the values for the economic drivers which were actually experienced (rather than forecast in 2013). The results are shown in Figure 2 below along with the actual FMS forecasts, actual tonnes-lifted 2012-2016 and the 2017 forecasts to 2023/4. Had the significant fall on coal volumes, lower fuel prices and fewer rail-served warehousing new-builds been known in 2013 (when the FMS forecasts were completed), the forecast volumes subsequently produced would have been broadly in line with actual performance up to 2016.

Figure 3 removes coal volumes from the FMS forecasts and the actual rail traffics tonnes-lifted 2012-2016. In this case, the FMS forecasts are broadly in-line with the actual performance 2012-2015, with a small dip in 2016 below the FMS forecast line. It also shows that the FMS forecasts (minus coal) would by 2023/4 fall mid-point between Scenarios B2 and A2 from the 2017 iteration.

Figure 2: Re-Run FMS Forecasts, Actual Traffics and 2017 Forecasts

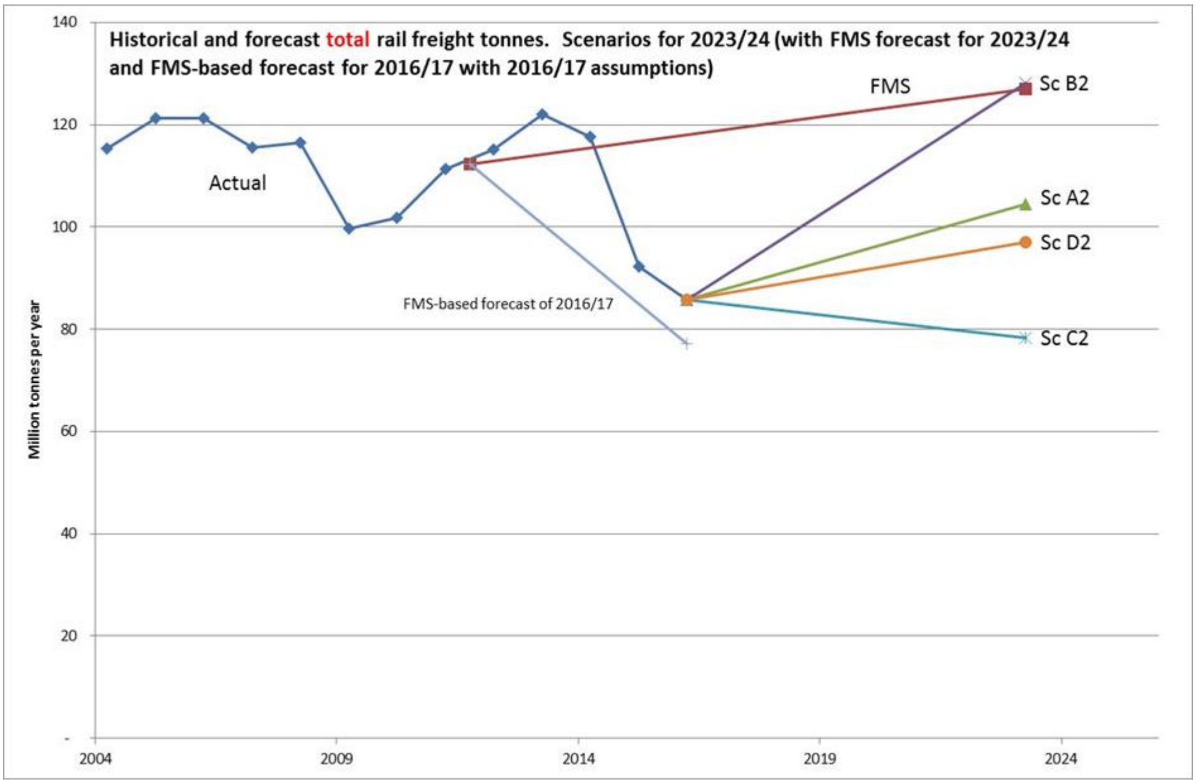
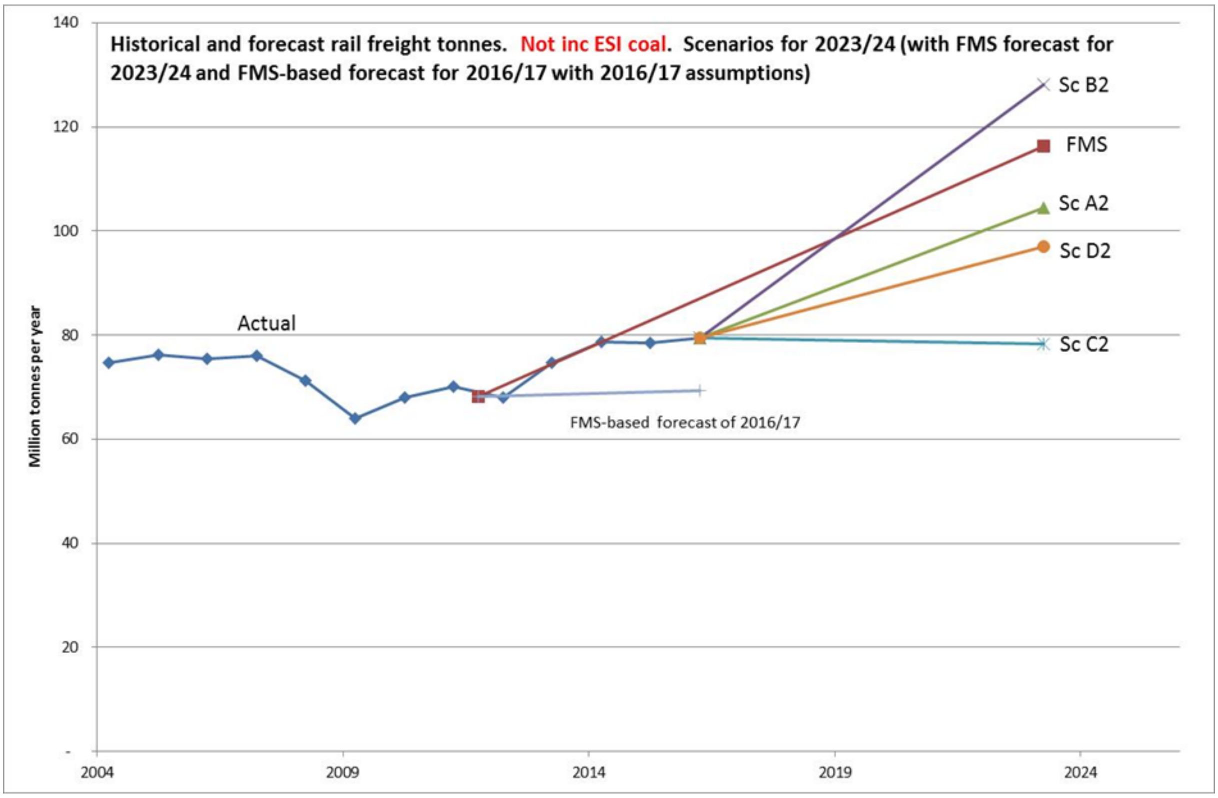


Figure 3: FMS Forecasts Minus Coal Actual Traffics and 2017 Forecasts



Rail freight growth and mode shift study 2016

This report was commissioned by the DfT from consultants AECOM, ARUP and SNC-Lavalin. It was intended to inform the preparation of a rail freight strategy, which was also published by the DfT in 2016, by helping the DfT better understand the rail freight market and the potential for growth. The strategy itself set out a vision both for how rail freight in its traditional sense can continue to grow – even if some of its traditional core markets, such as coal, are now in decline – and for the potential opportunities for the broader logistics sector and rail industry to collaborate in order to help relieve the pressure on our road network.

Overall, the report considered the following:

- It assessed the market and the potential for rail freight growth across a range of sectors. It concluded that there is a need to move away from traditional coal and ore movements to alternative sectors. The analysis identified Port Intermodal/Domestic Intermodal, Construction, Channel Tunnel traffic, express parcels and automotive as the most promising areas for expansion;
- A review of rail network capacity around infrastructure pinch points, route capacity, terminal location and resource availability;

- A set of Rail Freight Forecasts developed by the study team, providing a high level forecast for fourteen key commodities, taking into account the identified key constraints on the network; and
- A range of different interventions that could encourage modal shift.

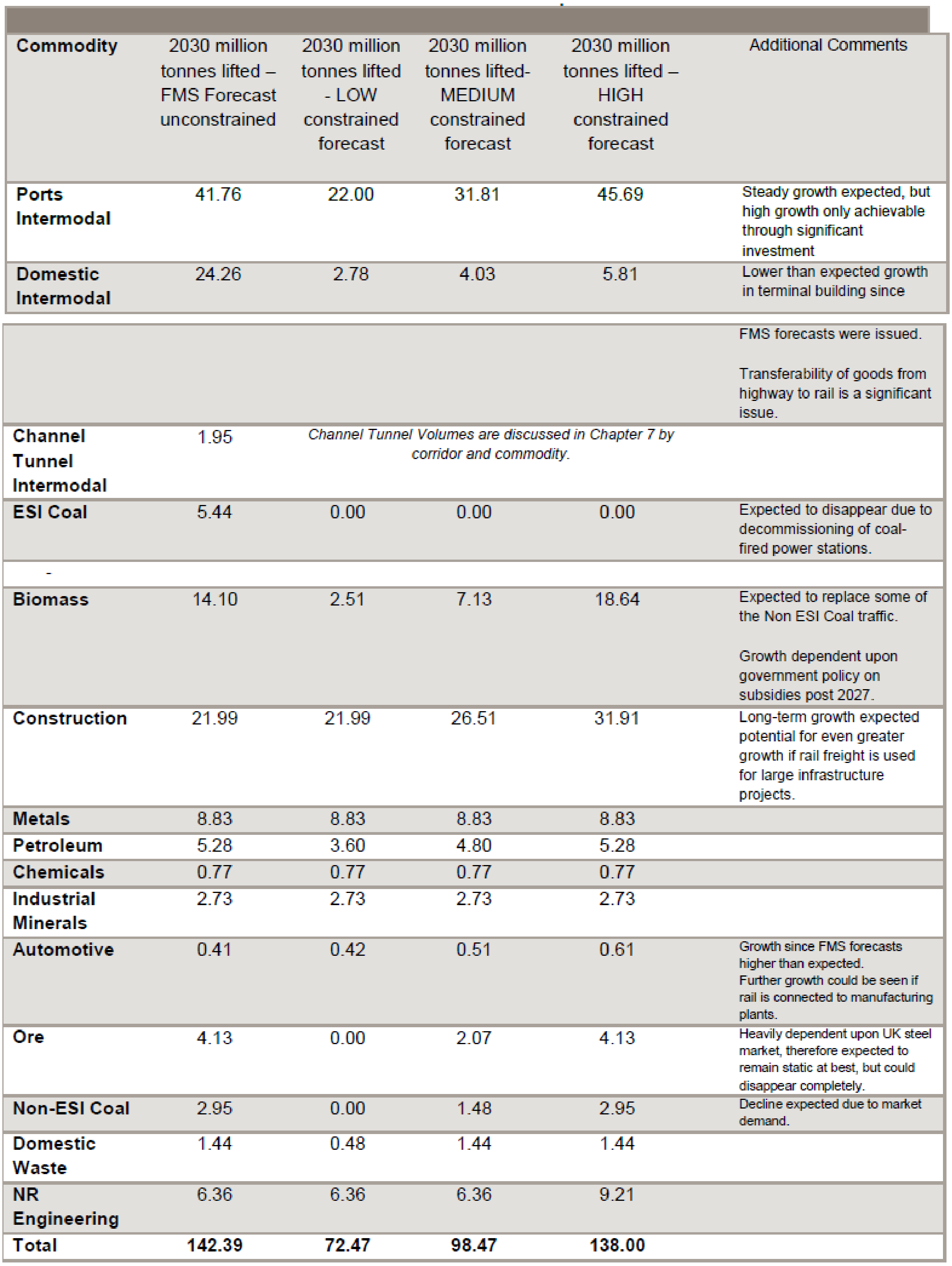
The document prepared by the consultants and published alongside the DfT's Rail Freight Strategy reports on the production of a set of rail freight forecasts. The report states that these were produced by "a model that had been developed for the study", to the forecast year 2030 and split by commodities and routes. Importantly, the report notes that "This model is separate to, and does not replace, the 2013 Network Rail Freight Market Study, and should instead be viewed as a complementary forecast to the FMS approach".

Instead, the report notes that the DfT asked and aimed to answer a different question to the Network Rail FMS. Rather, this study looked to understand the potential growth markets in rail considering the constraints (such as network capacity and otherwise) which impact this. It also sought to understand the potential for mode shift and the greenhouse gas emission savings that could be achieved, whereas the Network Rail FMS looked at what could be achieved in an unconstrained environment (as alluded to above). Accordingly, it states that the forecast outputs therefore may not necessarily always correspond with the FMS forecasts outlined above.

The report summarises the forecast methodology. It states that the starting point was the Network Rail 2013 FMS forecasts and DfT data regarding HGV movements. The 2033 FMS forecasts were adjusted to the year 2030 based on annual growth rates. The equivalent road forecasts were mapped to the rail commodities. The FMS rail forecasts were then revised based on "market conditions and industry knowledge of expected constraints".

Low, medium and high forecasts were undertaken, based upon varying assumptions on government policy, market conditions and network constraints through to 2030. The latest available rail volumes (2015-16), both lifted and moved, were used to inform current market trends. These trends in addition to industry consultation, recent trade reports and industry knowledge were used by the consultants in their review of a number of variables considered, which included GDP growth forecasts. The report notes the lower oil price since 2014 which has had an effect on transport costs. It concludes that the net effect of this was to reduce pressure on road costs and hence less inclination for shippers to consider modal switch. It also notes that the low/medium forecasts reflect coal's more rapid than anticipated (as per FMS/2017 forecasts above). The outputs from the study are presented in Table 8 below (extracted from the report).

Table 8: AEOCOM/ARUP/LCN-Lavalin Rail Forecasts to 2030 (Comparison with FMS)



Commodity	2030 million tonnes lifted – FMS Forecast unconstrained	2030 million tonnes lifted - LOW constrained forecast	2030 million tonnes lifted- MEDIUM constrained forecast	2030 million tonnes lifted – HIGH constrained forecast	Additional Comments
Ports Intermodal	41.76	22.00	31.81	45.69	Steady growth expected, but high growth only achievable through significant investment
Domestic Intermodal	24.26	2.78	4.03	5.81	Lower than expected growth in terminal building since FMS forecasts were issued. Transferability of goods from highway to rail is a significant issue.
Channel Tunnel Intermodal	1.95	*Channel Tunnel Volumes are discussed in Chapter 7 by corridor and commodity.*			
ESI Coal	5.44	0.00	0.00	0.00	Expected to disappear due to decommissioning of coal-fired power stations.
-					
Biomass	14.10	2.51	7.13	18.64	Expected to replace some of the Non ESI Coal traffic. Growth dependent upon government policy on subsidies post 2027.
Construction	21.99	21.99	26.51	31.91	Long-term growth expected potential for even greater growth if rail freight is used for large infrastructure projects.
Metals	8.83	8.83	8.83	8.83	
Petroleum	5.28	3.60	4.80	5.28	
Chemicals	0.77	0.77	0.77	0.77	
Industrial Minerals	2.73	2.73	2.73	2.73	
Automotive	0.41	0.42	0.51	0.61	Growth since FMS forecasts higher than expected. Further growth could be seen if rail is connected to manufacturing plants.
Ore	4.13	0.00	2.07	4.13	Heavily dependent upon UK steel market, therefore expected to remain static at best, but could disappear completely.
Non-ESI Coal	2.95	0.00	1.48	2.95	Decline expected due to market demand.
Domestic Waste	1.44	0.48	1.44	1.44	
NR Engineering	6.36	6.36	6.36	9.21	
Total	**142.39**	**72.47**	**98.47**	**138.00**	

Source: Rail Freight Growth and Mode Shift Study 2016 (AEOCOM/ARUP/LCN-Lavalin)

2 Port traffic forecasts

Background

Port ownership and operation in Great Britain is divided into three categories, namely:

- Trust Ports – owned by independent trusts established by Act of Parliament. Trust ports have no shareholders, with any profits retained by the Trust for the benefit of the port users and other stakeholders. Many of the largest Trust ports were privatised in the early 1990s. Those remaining today tend to be smaller or niche port facilities, the main exception to this being the Port of Dover;
- Private ports – owned by private sector investors. Many of these ports were originally in the public sector before being transferred back to the private sector in the early 1980s. This category of ports are now largely owned by a handful of large multi-port owning companies e.g. ABP, Forth Ports; and
- Local authority ports – essentially privately owned ports but where the sole/dominant shareholder is the local authority e.g. Portsmouth.

Whatever their ownership structure, it has been long standing UK Government policy that all ports are commercially independent, competing for traffic with other ports on an open competitive basis. Investment in new equipment and facilities is at their own commercial risk, on the basis of their own forecasts and business cases. With a few notable exceptions, the Government also has a long-standing policy of not providing any operating subsidies or offering grant funding for new port developments. Given this position, historically the Government did not (and had no need to) produce long-term national forecasts for port traffics.

This position changed in the early-mid 2000s, principally due to the publication of the Future of Transport White Paper in 2004. This stated that one of the Government's objectives was to review ports policy in order to keep track of wider changes affecting ports and to ensure that it continued to have the right basis for the sustainable development of ports. In order to assist and inform this review, the Department for Transport decided to commission a set of long-term port demand forecasts in 2006.

Alongside this policy review, a number of other developments suggested a need for an agreed set of long-term port demand forecasts. Firstly, deep-sea container volumes were growing at a fast rate in the early/mid 2000s, with an expectation that volumes would soon reach and exceed national capacity in this sector. As a result, a number of new container terminal schemes were proposed and considered by the planning system (London Gateway, Dibden Bay at Southampton, Bathside Bay at Harwich and the extension of an existing quay at Felixstowe). With the exception of Dibden Bay, which was refused following a public inquiry, all received consent though to date only London Gateway and part of the Felixstowe extension have been implemented.

Secondly, the Planning Act 2008 introduced a different approach for the granting of planning consent for schemes considered to be nationally significant infrastructure projects (NSIPs). In particular, proposals for large port schemes exceeding certain thresholds were subsequently classified as NSIPs. The Act also required the Government to publish National Policy Statements (NPS) covering long-term need on a sector-by-sector basis (including ports). Consequently, an agreed set of port demand forecasts would be required.

Port Demand Forecasts 2006

Against the above background, the Department for Transport (DfT) commissioned MDS Transmodal in 2006 to produce port demand forecasts to 2030. As alluded to, the forecasts would principally inform the Governments ports policy review, though they also ended up forming the basis of the National Policy Statement for Ports published in 2012. The base year selected was 2004, the most recent full-year dataset available at the time the forecasts were produced. Note that the forecasts are for the United Kingdom i.e. they include Northern Ireland.

The following methodology was adopted for unitised traffic:

- An econometric trade model (called FORK) was used to forecast demand, measured in tonnes. The model used trade data rather than Port Statistics data as trade data was (and still is) available at a detailed commodity level and by overseas country;
- A transport model (GB Freight Model) was used to assign the resulting outputs by seaport, sea-mode (LoLo and RoRo) and inland mode of transport;
- An additional model was used to convert tonnes traded to units handled. The results of this stage were validated against the DfT's Port Statistics for 2004.

Table 9 below describes the FORK model's forecasting methodology.

Table 9: FORK Methodology Adopted in 2006 Port Demand Forecasts

Input data for dependent variables	Quarterly trade data from 1988 to 2004, sourced from data collated by HM Customs and Excise and published by Eurostat.
Segmentation	By 202 trading partner countries, 65 product groups, with volumes measured in tonnes. Bulk flows are separated out using constant factors, the data is tested for outliers and smoothed if necessary.
Input data for predictor variables.	Quarterly or annual macroeconomic indicators for 150 countries: Real GDP, Price Level, and Exchange Rates. Historic and forecast values derived from OECD and IMF publications.
Additional variables	Linear Trend Component, Seasonality, Auto-regressive Component and World Trade growth.
Estimation method	Multivariate linear regression, with the model specification determined by trial and error to maximize the significance.
Forecast period	2005-2006 – using OECD and IMF indicator forecasts. 2006-2020 – based upon 2006 indicator values.

The FORK model split UK trade by direction, trading partner country and by commodity, and attempted to ‘fit’ the quantity of goods traded to macroeconomic indicators for both the importing and exporting economies. If there was a successful outcome, the trade flow was predicted using forecasts of the indicator variables. The trade data used within FORK was derived from Eurostat, broken down into a quarterly time series. It was possible to use published forecast values for the indicator variables for the period 2004 to 2006. Between 2006 and 2020, FORK projected the data with constant values. For the UK this, at the time, implied:

- GDP growth at 2.25-2.5 %;
- Inflation at approximately 2%;
- Exchange rate with respect to the US Dollar at $1.85.

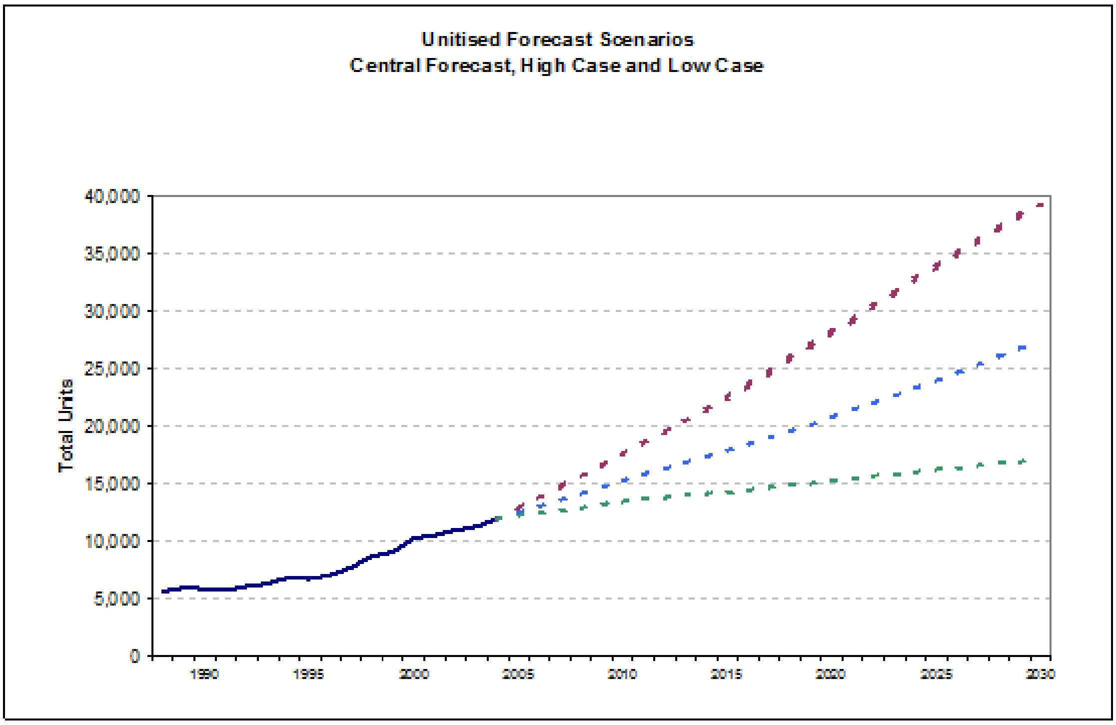
The main forecast scenario was the ‘Central Forecast. In this scenario, import growth dictates the overall growth of unit loads moving through the ports because those units are, ultimately, ‘re-exported’ whether loaded or empty. Import volumes were based upon long-run trends and their relationships with GDP growth and exchange rate change, independently of trends in export growth

However, between the mid-1990s and 2000s imports grew at a faster rate than exports. This was explained by the underlying divergence in the economy between consumption, which has grown steadily, and manufacturing output which had been static. These developments suggested two alternative growth patterns that the unitised sector might follow, namely:

- A Low Case: growth in imports implied in the Central Forecast inhibited by the slower rate of growth of unit load exports over the last 5 years, implying that for imports to grow faster would lead to an unacceptable long run balance of payments deficit; and
- A High Case: growth in imports based upon the higher rates of unit load import growth over the last 5 years, implying that there will be a rapid growth in exports of goods and (particularly) services to avoid a long run balance of payments deficit.

In the Central Case, import unitised tonnes were forecast to more than double between 2004 and 2030, resulting in a compound annual growth rate of 2.91%. In the High Case, the trade volume was estimated to triple over the same period, and the CAGR is equivalent to 4.35%. In the Low Case, the 2030 volume was forecast to be 1.32 times the 2004 figure and the CAGR is equivalent to be 1.07% per annum. Figure 4 below summarises the unitised forecasts produced in 2006.

Figure 4: Port Demand Forecasts 2006 – Unitised Traffic 2006-2030



Source: Port Demand Forecasts 2006

The non-unitised forecasts were developed by carrying out market studies on each major cargo category, based on the DfT's Port Statistics categorisation of port traffics. For each cargo category the secondary research sought to establish the key economic drivers affecting the demand for, and supply of, the cargoes. The secondary research was supplemented by discussions with key shippers, trade associations and Government departments. The evidence obtained was then used to develop forecasts for each category of traffic, which involved developing scenarios for the future for a wide range of industries based on judgments about future policy, market and even societal trends up to 2030. A brief summary of the key economic drivers considered for the main cargo types is given below.

Liquefied Natural Gas

- UK energy policy and the need to reduce Greenhouse Gas emissions;
- Energy demand;
- UK continental shelf reserves; and
- International pipeline imports.

Crude Oil

- UK energy policy and the need to reduce Greenhouse Gas emissions;
- Energy demand, particularly road transport;
- UK continental shelf reserves; and

- International pipeline imports.

Ores

- UK domestic steel production

Coal

- UK energy policy and the need to reduce Greenhouse Gas emissions;
- Energy demand and coal-fired generating capacity;
- Domestic production;
- Likely closures over time of coal-fired generation; and
- UK domestic steel production (coking coal).

Agricultural Products

- Domestic demand, particularly for cereals and grains and animals feeds; and
- Domestic production

Other dry bulks

- Domestic demand for aggregates;
- Domestic (inland) production of aggregates and sea-dredged aggregates; and
- Overseas demand for ferrous scrap.

Forestry Products

- Domestic demand, which is largely determined by population growth;
- Domestic demand for paper and paper-products; and
- Domestic production volumes.

Iron and Steel

- Domestic demand, particularly in construction and car production;
- World demand for steel (as UK also produces steel for world markets); and
- Domestic production (influenced by world market steel prices).

Automotive

- Domestic demand for new imported makes of car, which is related to population growth, disposable income levels, changing tastes/fashions and vehicle regulations; and
- International demand for British produced cars.

Table 10 below provides a summary of the 2006 port demand forecasts to 2030.

Table 10: Summary of 2006 Port Demand forecasts (to 2030)

Mode of appearance	2004	2010	2015	2020	2025	2030	% CHANGE 2004-2030	% CAGR 2004-2030
BULK TRAFFIC GB “major” ports								
Liquid bulk	264	256	270	277	383	290	+10%	+0.4%
Dry bulk	108	103	109	111	103	110	+2%	+0.1%
Other general cargo (including import/export vehicles)	31	34	35	35	36	36	+15%	+0.5%
Total GB non unitised	404	393	413	423	422	437	+8%	+0.3%
BULK TRAFFIC N Irish “major” ports								
Liquid bulk	3	4	4	4	4	4	+24%	+0.8%
Dry bulk	6	6	6	6	6	6	+2%	+0.2%
Other general cargo (including import/export vehicles)	1	1	1	1	1	1	+24%	+0.8%
Total NI non unitised	11	11	11	12	11	12	+12%	+0.4%
Other UK ports								
All categories	15	15	15	15	15	15	-	-
Total UK bulk (including import/export vehicles)	**429**	**419**	**439**	**450**	**448**	**463**	**+8%**	**+0.3%**
UNITISED TRAFFIC								
GB unit load (including Eurotunnel)	146	183	214	248	284	322	+120%	+3.1%
NI unit load	12	13	15	16	18	20	+62%	+1.9%
Total UK unit load (including Eurotunnel)	**158**	**196**	**228**	**264**	**302**	**342**	**+116%**	**+3.0%**
TOTAL UK (including Eurotunnel)	**587**	**615**	**668**	**713**	**750**	**805**	**+37%**	**+1.2%**
% Change p.a.		*2004-10*	*2010-15*	*2015-20*	*2020-25*	*2025-30*		
		+0.8%	*+1.7%*	*+1.3%*	*+1.0%*	*+1.4%*		

Source: MDS Transmodal

As explained above, the 2006 Port Demand Forecasts were incorporated into the Ports NPS published in 2012. This was despite the fact that the forecasts were commissioned before the 2008/9 financial crises and the subsequent fall in demand due during the economic recession and the following ‘austerity’ period. A further iteration of port demand forecasts has not yet been commissioned or produced. The Ports Connectivity Report, published by the DfT in April 2018 continues to quote the 2006 forecasts.

Port Demand Forecasts Update 2007

The Department for Transport (DfT) commissioned MDS Transmodal in 2007 to produce a short update report of the port demand forecasts to 2030 summarised above. The update focused specifically on:

- An update of forecasts for bulk fuels based on the latest available evidence and taking account of projections in the 2007 Energy White Paper; and
- An update of trade car forecasts, taking account of the latest available evidence relating to UK automotive manufacturing and car ownership forecasts.

The report also examined the economic value of the transhipment of containers at UK ports. The new forecasts for bulk fuels and trade cars in Great Britain have been developed by updating the market studies carried out in 2006 for coal, liquefied gas, crude oil and petroleum products.

The 2007 White Paper on Energy had a significant impact on the port traffic forecasts because of the potential impact on shipping movements of liquefied gas, coal, crude oil and oil products. The May 2007 White Paper highlighted the key challenges as being the need to work with other countries to tackle climate change by cutting Greenhouse Gas emissions and the need to ensure secure energy supplies. The measures in the White Paper were intended to put the UK on track to cut Greenhouse Gas emissions by more than a quarter by 2020 compared to 1990 levels, as well as making significant cuts in gas consumption by saving energy, developing cleaner energy supplies and securing reliable energy supplies at prices set in competitive markets.

The change in the forecast for import/export vehicles was driven largely by new car ownership forecasts developed by the DfT, which suggested that car ownership will increase at a faster rate than was envisaged in May 2006. This has led to an increase in vehicle imports, in particular, up to 2030. The forecasts also reflect a slightly lower level of UK automotive manufacturing than in the May 2006 report, leading to a lower level of car exports. Table 11 below summarises the key changes between 2006 and 2007.

Table 11: Comparison of 2006 and 2007 Demand Forecasts

	Million tonnes			
Commodity	**May 2006 Report**		**June 2007 Report**	
	2030 Forecast	% CAGR 2004 - 2030	2030 Forecast	% CAGR 2005-2030
Liquefied gas	37.2	+6.4%	45.4	+7.3%
Crude oil	128.9	-0.9%	133.4	-0.6%
Oil products	111.0	+1.1%	90.2	+0.2%
Coal	39.8	-	40.6	-0.8%
Trade cars	5.8	+0.5%	6.5	+0.8%
Iron & steel products	10.3	+0.2%	10.0	-0.1%

Ores	19.5	+0.3%	18.0	-

3 Road Traffic Forecasts

Background

Highway infrastructure is generally provided by the state (central Government, local authorities or more recently the devolved administrations) and funded from general taxation. The notable exceptions to this are a small number of major estuary crossings where tolls are levied to cover the initial capital costs. Road hauliers operate over the highway network (subject to payment of particular taxes and meeting regulatory requirements), competing for cargoes on an open competitive basis.

Road traffic forecasts are produced by the DfT. Given the above, they are principally used:

- To inform the DfT’s roads strategy e.g. the Roads Investment Strategy
- As an important tool in policy simulation, where understanding future travel demand will assist in understanding how people respond to policy changes and whether those are the right policies to implement;
- In investment appraisal to understand the combined impact and value for money of packages of schemes across the whole network using the National Transport Model (NTM);
- To estimate the mode shift benefits, like reduced congestion, which are used in appraisals for schemes where models of the highway network are not available; and
- To assess the impact of environmental policy, in particular transport's contribution to reducing Greenhouse Gas emissions.

They are also used by a variety of external stakeholders and experts with diverse interests.

The forecasts are designed to provide a national view of possible future trends in road traffic and are used to analyse the implications of a variety of strategic level policy options on traffic levels, emissions and congestion. They provide a tool to understand the case for, and impact of, investment in the road network across the country as a whole, and other road transport policies. The forecasts are not designed to be used to appraise individual road schemes.

DfT Road Traffic Forecasts 2015

The most recent iteration of the DfT Road Traffic Forecasts was produced in 2015. It updated the previous version produced in 2013. The forecasts were produced internally by the DfT, and it is worth noting that they are only for England. The forecasts cover cars, light goods vehicles (LGVs) and heavy goods vehicles (HGVs). The rest of the summary below principally relates to LGVs and HGVs.

The forecasts were produced internally by the DfT using the National Transport Model (NTM). The NTM combines inputs from specialist models covering LGVs and HGVs with its own passenger traffic forecasts to produce a combined forecast of road transport.

The HGV inputs were produced using the GB Freight Model (the specialist HGV model alluded to above that forms part of the NTM). However, while the GB Freight Model was developed and is owned by MDS Transmodal, in this case they were not directly responsible for producing the HGV forecasts using the model. MDS Transmodal has an arrangement with the DfT where they are able to use the GB Freight Model internally to generate inputs into the NTM. This was the case with these forecasts.

The rail freight forecasts section above describes the GB Freight Model and how it generates freight forecasts, including how user defined scenarios and assumptions can be ‘tested’ in terms of their impact on mode share. In both the GB Freight Model and the LGV forecasts, GDP (influencing total freight demand) and vehicle fuel efficiency (affecting modal split) were identified as key economic drivers and they were updated in this iteration to reflect the most recent data.

Freight forecasts generated by the GB Freight Model were assigned to the different modes of road and rail using the mode assignment module and then to different parts of the road network in accordance with achieving the shortest journey times between the origins and destinations. The resulting HGV growth rates on different roads and area types and regions were then passed into the NTM enabling the model to estimate levels of congestion and emissions.

LGV demand is also modelled outside of the NTM using an elasticity based approach where LGV demand is a function of diesel price, fuel efficiency and GDP. According to the Report produced by the DfT to accompany the forecasts, there is a long established link between GDP and LGV use which reflects the fact that increases in economic activity result in increases in demand for delivery and construction where LGVs are used. It perhaps should be noted that while recorded LGV demand has increased over the past decade or so, data on the economic activities undertaken by LGVs is more limited. In addition to conveying small freight consignments (e.g. e-commerce deliveries), LGVs are also heavily associated with the service economy.

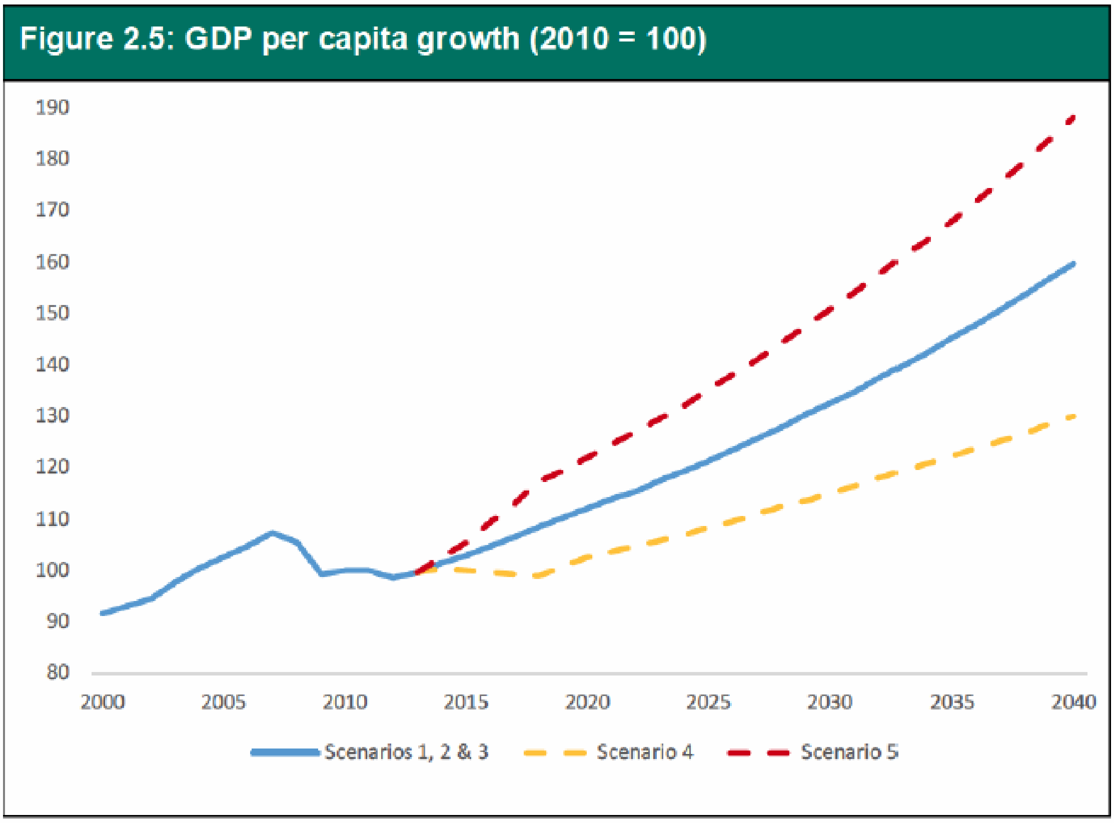
Given this position, the DfT commissioned a research project in 2014 to make better use of existing data, evidence and knowledge of the LGV market to strengthen its modelling of LGV traffic. Recognising the relative lack of data in this area (alluded to above), in particular evidence on how LGVs are used and for what purpose, the project also aimed to identify the potential for new and emerging data sources to develop the DfT’s modelling capabilities in the future. The project subsequently delivered an updated model of LGV traffic that is disaggregated by region and road type. The main conclusion drawn was that GDP and fuel price remain the key explanatory variables.

Fuel price forecasts used in these road traffic forecasts were taken from the DfT's Fuel Price Forecasting Model, which uses the (former) Department of Energy and Climate Change (DECC) oil price projections, planned VAT and fuel duty, and the Office for Budget Responsibility (OBR) predicted GDP deflator to forecast future real prices. The pump price of diesel was forecast to rise in real terms by 30% between 2010 and 2040.

Anticipated fuel efficiency improvements are a key factor in reducing the cost of road travel over time and reduced fuel consumption reduces Greenhouse Gas emissions per vehicle-km. Fuel efficiency improvements for these forecasts assumed a 34% improvement for LGVs and a 14% improvement for HGVs. The combined impact of fuel price and efficiency is a forecast reduction in the cost of fuel per km of 15% for LGVs and an increase of 10% for HGVs.

In terms of future GDP projections, the OBR short and long run GDP forecasts were adopted. As forecasting GDP growth is uncertain, sensitivity tests based on the OBR's 20th and 80th percentile short term forecasts and on low and high productivity long term scenarios were adopted. The graph below, extracted from the DfT's report accompanying the forecasts, illustrates the GDP scenarios adopted.

Figure 5: Road Traffic Forecasts 2015– Assumed GDP Growth to 2040



Source: DfT Road Traffic Forecasts 2015

Overall, five scenarios were subsequently modelled. These are summarised in Table 5 below, extracted from the DfT's report accompanying the forecasts.

Table 12: Road Traffic Forecasts 2015 – Summary of Scenarios Modelled

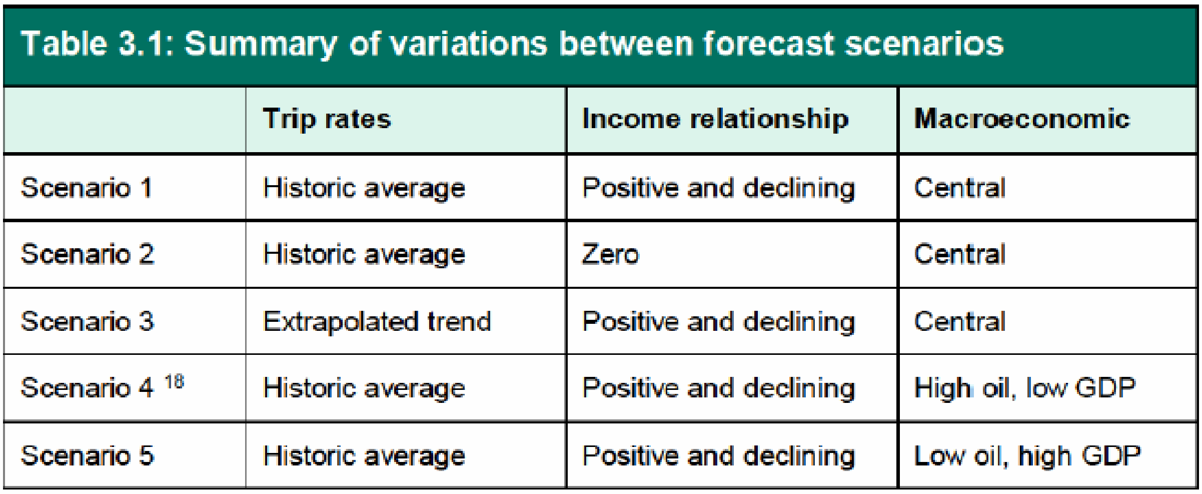


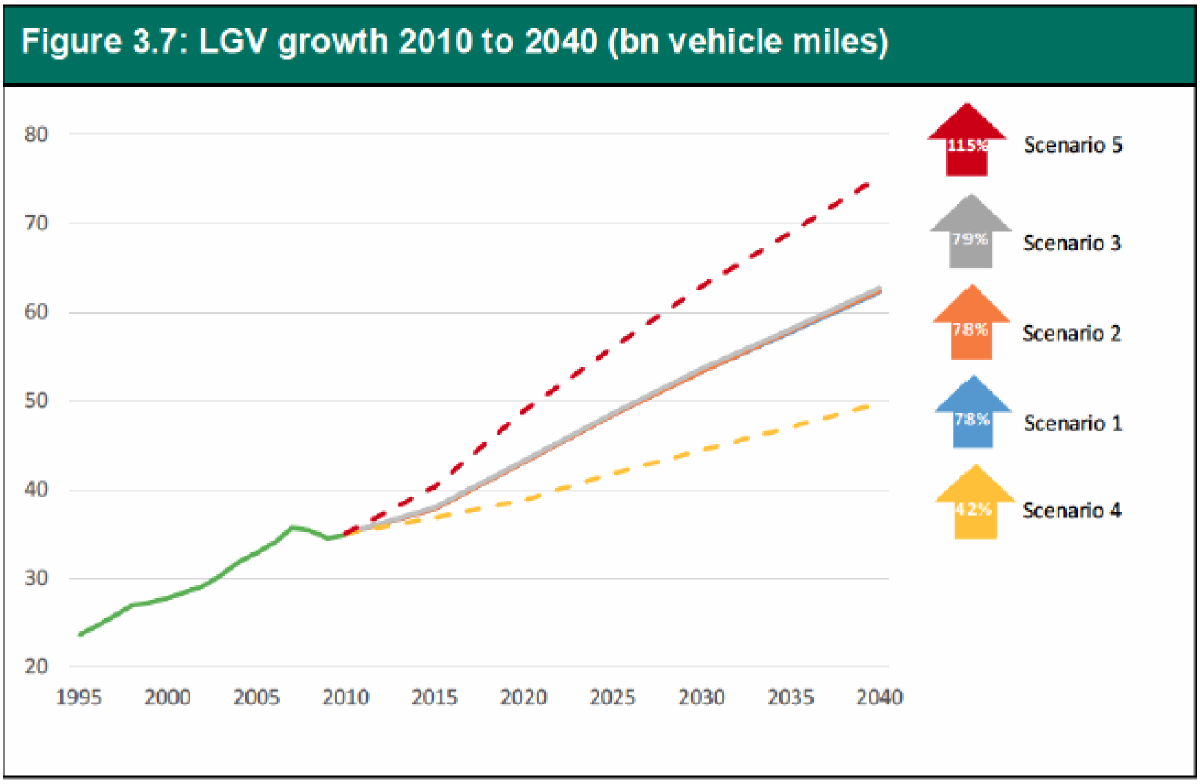
Table 3.1: Summary of variations between forecast scenarios

	Trip rates	Income relationship	Macroeconomic
Scenario 1	Historic average	Positive and declining	Central
Scenario 2	Historic average	Zero	Central
Scenario 3	Extrapolated trend	Positive and declining	Central
Scenario 4 [18]	Historic average	Positive and declining	High oil, low GDP
Scenario 5	Historic average	Positive and declining	Low oil, high GDP

Source: DfT Road Traffic Forecasts 2015

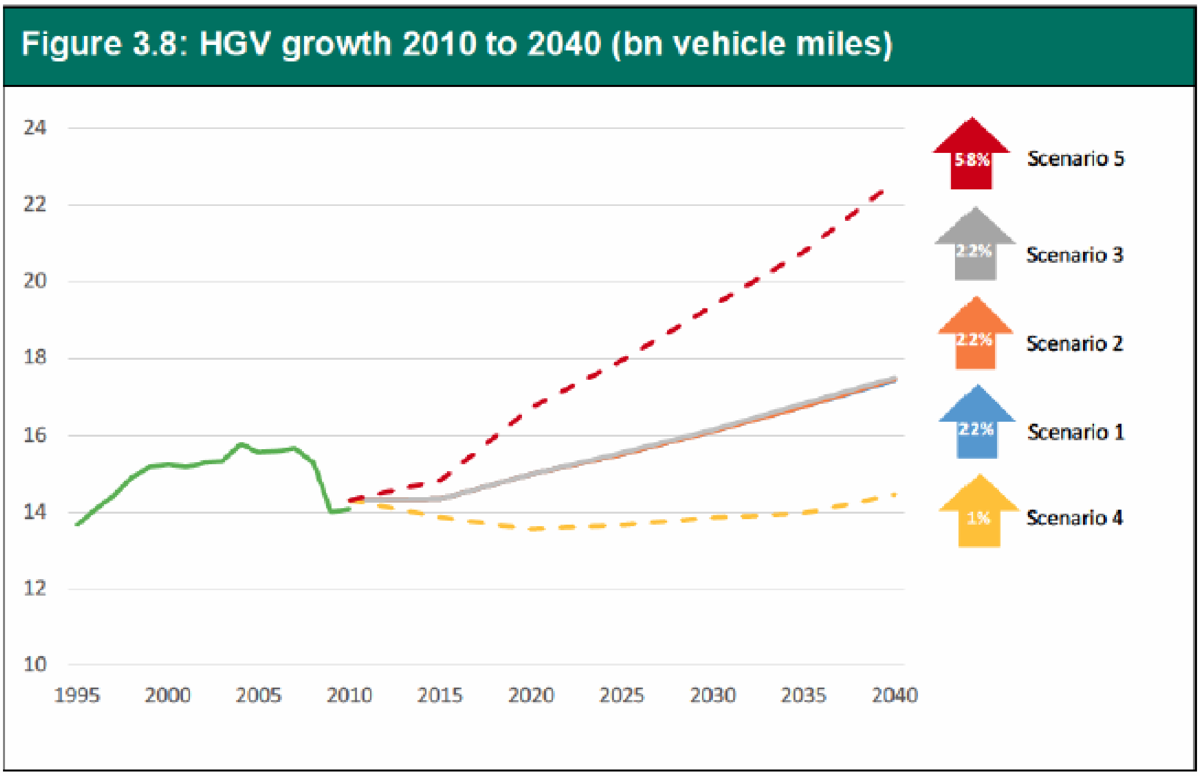
The outputs with respect to LGVs and HGVs are illustrated in the graphs below, again extracted from the DfT report accompanying the forecasts.

Figure 6: LGV Growth to 2040



Source: DfT Road Traffic Forecasts 2015

Figure 7: HGV Growth to 2040



Source: DfT Road Traffic Forecasts 2015

4 Sub-national freight forecasts

Background

Transport for the North was formed as England's first sub-national transport body. It brings together local transport authorities across the north of England alongside Network Rail, Highways England, HS2 and business. Its main role is to add 'strategic value' by ensuring that funding and strategy decisions about transport in the North are informed by local knowledge and requirements, complementing the devolution agenda and drawing powers down from central government rather than up from local government. It seeks to 'speak with one voice' on the transport infrastructure investment needed to drive transformational growth and rebalance the UK economy.

As part of this role, Transport for the North (TfN) published its Freight and Logistics Report in the Autumn of 2016. The report was jointly commissioned by TfN from consultants MDS Transmodal and Mott Macdonald. The report considered opportunities to reduce the cost of freight transport to both users and non-users (for example, reducing the environmental impacts of freight and logistics movements), create new facilities, expand market share in the logistics sector and attract inward private sector investment to the Northern Powerhouse. The report made a series of recommendations for public sector interventions that would encourage the private sector to invest in and operate a thriving freight and logistics industry that will, in turn, support a vibrant and well-connected Northern economy.

Freight forecasts

Supporting the development of the strategy was a series of freight forecasts. The forecasts were produced by MDS Transmodal using the GB Freight Model. The base year selected was 2014 and the forecast year was 2033. The basic methodology adopted was as follows:

- Production of base year traffics (2014);
- Production of a 'do-minimum' scenario for 2033;
- Production of a 'do-something central forecast' scenario for 2033;
- Production of a series of 'do-something' scenarios reflecting 'bundles' of different and focused policy options.

The 2033 'do-minimum Scenario was originally developed and modelled during Phase 1 of the e early stages of the study to provide a counterfactual scenario (i.e. what would happen anyway without any public sector intervention and a private sector response and was principally designed to allow comparisons of the net impact of 'do-something' scenarios.

The 'do-minimum' scenario included the following assumptions:

- Infrastructure enhancements on the road and rail networks that are committed to be implemented by the relevant public infrastructure providers, as well as their impact on road and rail freight flows;
- Expected structural changes in economic sectors (e.g. reductions in coal traffic due to the closure of coalfired power stations);
- Forecast macro-economic trends (e.g. forecast population growth, Gross Domestic Product (GDP) growth), which have been inferred from assumptions used by the DfT to develop road freight forecasts in 2015;
- Trade growth, which affects both port traffic and inland movements to and from ports and the Channel Tunnel;
- New rail freight services that have been contracted for; and
- Expected changes in relative transport costs up to 2033.

The 'do-something central forecast' consisted of a package of infrastructure and policy measures that would transform the connectivity of the North for freight and logistics by all modes. There was a particular emphasis placed on reducing the unit cost of transporting goods to, and from and across the north of England, and encouraging private sector investment in rail and water-connected distribution parks in competitive locations. The measures included investments in the road, rail and inland waterway networks by the public sector, while also developing policies that create a business environment within which the private sector would be encouraged to invest in new distribution facilities and new freight and logistics services. Measures included:

- Road infrastructure enhancements across the northern Pennines, around Manchester and connectivity with port in Hull and Liverpool;
- Securing additional freight capacity on the Trans-Pennine and West Coast Main Line railways, alongside works to allow longer freight trains, 20% increase in operating hours and W10/W12 gauge clearance on key intermodal routes;
- The development rail and/or water connected Multimodal Distribution Parks (MDPs) at an average rate of 50ha per year, to be located at the edge of urban centres, thus minimising the cost of onward distribution by road, enabling sustainable access to employment and futureproofing for the potential longer term introduction of low/zero carbon 'last mile' distribution solutions that can mitigate against air quality challenges associated with increasing economic development in urban centres; and
- Support for port infrastructure enhancements which would generate lower cost shipping services to the northern port.

The 'do-something' bundled scenarios all involve adding and/or subtracting a relatively small number of interventions to or from the 'do-something central forecast' to ascertain the relative merits of different recommendation scenarios. The bundles covered:

- Focus on Road Scenario (do-something central plus road bundle): A scenario that considered the impact on freight and logistics in the north of England of additional public sector measures to further improve the cost-effectiveness of the road freight sector;
- Focus on Rail Scenario (do-something central plus rail bundle): A scenario that considered the impact on freight and logistics in the north of England of additional public sector measures to further improve the cost-effectiveness of the rail freight sector;
- Focus on Waterborne Freight Scenario (do-something central plus waterborne freight bundle): A scenario that considered the impact on freight and logistics in the north of England of additional public sector measures to further improve the cost-effectiveness of the waterborne freight (ports and inland waterways) sector.
- Focus on Environment Scenario (do-something central plus environment bundle): A scenario that considered two exogenous environmental factors, namely: (1) the need to meet EU air quality standards; and (2) the need to meet international agreements on Greenhouse Gas reductions.
- Focus on High Growth Scenario (do-something central plus high economic growth): A scenario that considered the impact on freight and logistics in the north of England of population and Gross Value Added (GVA) growth in line with the TfN Independent Economic Review (IER) Transformed North scenario. This sixth scenario formed a sensitivity test to the preferred recommendations.

Tables 13 and 14 below summarise the outputs from each of the scenarios.

Table 13: Freight km (million) and tonnes-lifted (million) – comparison against 2014 baseline

	2014 Base	2033 Do Minimum	2033 Central	2033 Roads	2033 Rail	2033 Water	2033 Environ't
GB HGV km		4,129.3	2,438.7	2,405.0	2,223.5	2,262.8	4,129.3
of which in the North		1,125.1	1,104.2	1,136.0	1,034.9	1,221.9	1,125.1
GB HGV Tonnes		206.0	197.2	197.2	198.7	197.2	206.0
of which to/from/within the North		101.6	133.3	133.3	133.1	154.9	101.6
GB Train km		3.8	36.5	36.5	12.5	36.5	3.8
of which in the North		-0.5	8.4	8.4	3.0	8.4	-0.5
GB Rail freight tonnes		-10.7	45.5	45.5	58.1	45.5	-10.7
of which to/from/within the North		-10.9	23.3	23.3	31.9	23.3	-10.9

Source: MDS Transmodal GB Freight Model

Table 14: Freight km (Million) and tonnage (Million) – Comparison against 2033 Do Minimum

	2014	2033 Do Minimum	2033 Central	2033 Roads	2033 Rail	2033 Water	2033 Environ't
GB HGV km			-1,690.6	-1,724.3	-1,905.8	-1,866.5	-1,690.6
of which in the North			-20.8	10.9	-90.2	96.8	-20.8
GB HGV Tonnes			-8.8	-8.8	-7.3	-8.8	-8.8
of which to/from/within the North			31.6	31.6	31.5	53.3	31.6
GB Train km			32.7	32.7	8.6	32.7	32.7
of which in the North			8.9	8.9	3.5	8.9	8.9
GB Rail freight tonnes			56.2	56.2	68.8	56.2	56.2
of which to/from/within the North			34.2	34.2	42.8	34.2	34.2

Source: MDS Transmodal GB Freight Model

APPENDIX 3: LIST OF 'MAJOR' PORTS IN EACH PORT REGION

'Major' ports (more than 1 million tonnes of traffic) as defined by the DfT in Port Freight Statistics 2017

Port region	Major ports
Thames and Kent	Dover, London, Medway, Ramsgate
Humber	Goole, Grimsby and Immingham, Hull, River Trent, Rivers Hull and Humber
Lancashire and Cumbria	Fleetwood, Heysham, Liverpool, Manchester
Haven	Felixstowe, Harwich, Ipswich
Wash and Northern East Anglia	Boston, Great Yarmouth
Sussex and Hampshire	Newhaven, Portsmouth, Shoreham, Southampton
North East	Sunderland, Tees and Hartlepool, Tyne
West and North Wales	Fishguard, Holyhead, Milford Haven
Scotland West Coast	Cairnryan, Clyde, Glensanda, Loch Ryan, Stranraer
Scotland East Coast	Aberdeen, Cromarty Firth, Dundee, Forth, Orkney, Peterhead, Sullom Voe
Bristol Channel	Bristol, Cardiff, Newport, Port Talbot, Swansea
West Country	Fowey, Plymouth, Poole
Northern Ireland	Belfast, Kilroot Power Station Jetty, Larne, Londonderry, Warrenpoint

Source: DfT Port Freight Statistics

APPENDIX 4: ASSUMPTIONS FOR QUANTIFED MODELLING OF SCENAROS

The key cost parameters that were used as inputs to the GBFM scenarios and lead to modelled responses are shown in the table below. The inputs have been produced from detailed cost models for the different modes of transport, which affect the mode and routing for freight consignments seeking the lowest generalised cost route through a transport network within the model for both GB domestic, GB-Continent and GB-Ireland flows.

The detailed cost models include calculations of the fixed costs (either time-based or per unit) and the variable costs (per kilometre) of door-to-door transport chains and include all costs that would be incurred by freight transport operators including the cost of equipment, labour, fuel and maintenance.

The road haulage cost model therefore includes time-based fixed costs and variable distance-based of door-to-door journeys, but also includes the time the HGV is stationery for loading and unloading and for repositioning of the HGV to secure a backload. Where an HGV is required for the collection or delivery of an intermodal unit between an intermodal rail freight terminal or a port terminal and an origin or destination that is not co-located with the rail or port terminal, the fixed and variable costs of road haulage are calculated based on the time and distance required.

Rail freight cost models are included for both intermodal rail freight services and bulk freight services, with the fixed costs per unit km or tonne km including fixed traction, wagon and driver costs and terminal handling charges. The variable costs per unit or tonne km include the cost of fuel and track access charges.

All the costs are in 2015 prices.

As well as the generic assumptions included in the table, the model also includes detailed freight rates for individual short sea unitload routes between GB ports and ports in Ireland and on the continental mainland, with different rates for accompanied HGVs, unaccompanied trailers, short sea load-on load-off services and for through Channel Tunnel rail freight services to a variety of continental terminals.

Generic input assumptions to the GB Freight Model

Input parameter	Description	2015 Base Case	2050 Business as Usual	2050 Carbon Reduction	2050 Carbon Survival	2050 Manuf. Renaissance
HGV variable cost/km	Total running cost per km. Standard 6x2 tractor unit, skeletal semi-trailer (tri-axle).	£0.38	£0.49	£0.25	£0.49	£0.25
HGV fixed cost/minute	Standard 6x2 tractor unit, skeletal semi-trailer (tri-axle) and container	£0.45	£0.63	£0.34	£0.33	£0.34
HGV repositioning fixed cost (minutes)	Fixed time cost charged in addition to the single trip time to allow for repositioning for backload & loading/unloading	180min	180min	180min	180min	180min
HGV repositioning variable cost (km)	25km charged in addition to single trip distance to allow for repositioning for backload	25km	25km	25km	25km	25km
Road pricing	Proportion of total environmental costs as road pricing charge on each link on the network	-	-	45%	-	45%
Rail freight intermodal variable cost per unit km	Intermodal rail freight cost per unit km (variable traction, wagons and track access charges)	£0.30	£0.37	£0.36	£0.29	£0.36
Rail freight intermodal fixed cost per unit	Intermodal rail freight cost per unit for rail traction, wagons and terminal handling	£74	£78	£74	£70	£74
Rail freight intermodal additional fixed cost per unit for internal shunt	Intermodal rail freight additional cost per unit for a road transfer to a warehouse on a rail-connected site	£20	£20	£20	£20	£20
Bulk rail freight train variable cost per tonne km	Bulk rail freight cost per tonne km (variable traction, wagons and track access charges)	£0.015	£0.018	£0.018	£0.015	£0.018
Bulk rail freight train fixed cost per tonne	Bulk rail freight rail freight cost per tonne for rail traction, wagons and terminal handling	£1.12	£1.29	£1.15	£0.96	£1.15
Freight van variable cost/km	Standard 'White Van' box body - Electric	£0.45	£0.57	£0.57	£0.57	£0.57
Freight van fixed cost/minute	Standard 'White Van' box body - Electric	£0.27	£0.42	£0.42	£0.42	£0.42

Source: MDS Transmodal GB Freight Model

The significant variations in the parameters in the above table can be explained as follows:

- The increases in the variable and fixed costs for both road and rail between 2015 and the 2050 BAU scenario are based on increases in haulage costs that are assumed in DfT WebTAG guidance;
- The reduction in the HGV fixed cost/minute in the 2050 Carbon Reduction, 2050 Carbon Survival and 2050 Manufacturing Renaissance scenarios compared to the 2050 BAU scenario reflects mainly the reduction in labour costs as a result of the deployment of autonomous HGVs;
- The reduction in the HGV variable cost/km in the 2050 Carbon Reduction and 2050 Manufacturing Renaissance Scenarios reflects the lower costs of fuel through using electricity (and associated lack of fuel duty) rather than diesel.
- Road pricing has been included for the 2050 Carbon Reduction and 2050 Manufacturing Renaissance Scenarios by including 45% of the total ‘environmental’ costs (including the impact of congestion and accidents as well as environmental emissions) as an additional charge per kilometre. The environmental costs are based on the values used to calculate the DfT’s Modal Shift Benefits for its sustainable freight grant schemes.
- The (relatively low compared to road) reduction in the rail fixed costs in the 2050 Carbon Reduction, 2050 Carbon Survival and 2050 Manufacturing Renaissance scenarios compared to the 2050 BAU scenario mainly reflects the reduction in labour costs as a result of the deployment of autonomous trains.
- The lower rail fixed costs in the 2050 Carbon Survival scenario compared to the 2050 Carbon Reduction and 2050 Manufacturing Renaissance scenarios is due to an assume lower capital cost for a diesel locomotive than for an electric locomotive; this reflects an assumption that older (existing) diesel locomotives would continue to be used in the rail freight operators’ fleets instead of newer electric locomotives.

END NOTES

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