Foresight

Intelligent Infrastructure Systems

Port Traffic Modelling

by

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This theoretical study looks at an idealised redistribution of port traffic to investigate the potential impact on road freight. The work was commissioned on behalf of the Office of Science and Technology by the Department for Transport as part of the Intelligent Infrastructure Systems project, looking at the possible transport futures over the next 50 years. This theoretical study does not reflect the official point of view of any organisation or individual, are independent of government and do not constitute government policy.

The study models the impact of re-routing GB port traffic. New procedures have been added to the GB Freight Model to allow the impacts of redistributed traffic patterns to be measured.

CONTENTS

1. INTRODUCTION

MDS Transmodal (MDST) were commissioned by the Department for Transport (DfT) to produce data from the GB Freight Model (GBFM), informing the Government's Foresight Intelligent Infrastructure Systems (IIS). The data was generated from a series of model runs, focusing on the inland impact of port traffic, and the effect of redistributing flows between GB ports.

Four result sets (scenarios) have been produced:

1. The impact on UK traffic volumes if all freight were delivered to the closest ports.
2. The impact of redistributing 1% of GB port traffic from selected major ports to Liverpool. The ports being considered are: Felixstowe, Southampton, London (including Tilbury), and the Medway (including Thamesport).
3. As above (2), but with a 3% diversion to Liverpool.
4. As above (2), but with a 5% diversion to Liverpool.

Within items 2-4, the impacts have been separated out in the following way:

1. Traffic is diverted from Felixstowe to Liverpool.
2. Traffic is diverted from Southampton to Liverpool.
3. Traffic is diverted from London to Liverpool.
4. Traffic is diverted from the Medway to Liverpool.
5. Traffic is diverted from all four ports equally to Liverpool.

The results have been documented in a summary spreadsheet supplied to the DfT, and detailed results have been compiled into a database allowing further analyses to be made from the model results.

2. METHODOLOGY

All the results have been generated inside the GB Freight Model, a software tool containing origin-destination (O/D) data and the means to assign traffic flows by transport mode to the transport network. Here, only ***international traffic flows affecting the road network*** have been considered, i.e. Import and Export flows, moving inland by road.

The main ***exclusions*** are therefore:

- Domestic GB freight.
- Port traffic that is not moved inland, e.g. bulk cargo arriving by sea and departing by sea.
- Port traffic moved inland by rail.

Much of the work considers ***containerised traffic only*** but the outputs for result set 1 have also been repeated for all modes of appearance.

The model has been set up with inputs for 2003, including UK Trade Data (sourced from Customs & Excise) and Port Statistics (sourced from the DfT's Maritime Statistics), and it is calibrated to produce realistic outputs for that year.

An intermediate database is produced, which is then fed into a final stage capable of selecting specific traffic flows (e.g. for a given port), modifying them (e.g. transferring traffic from one port or region to another), and then assigning them to a road network, so that impacts can be measured. In this way, the diversions applied can be seen as manual modifications to a common set of traffic flows.

There are three main variables:

- The volumes of traffic considered (e.g. containerised traffic or total traffic)
- The number of ports that are exchanging traffic, and their net gains/losses.
- The rules that decide which flows are exchanged.

Table 1: Illustration of Concept: Hypothetical base case

	Merseyside	Hampshire	Suffolk	Total
Liverpool	30	20	10	60
Southampton	20	40	30	90
Felixstowe	30	20	50	100
Total	80	80	90	250

Table 2: Illustration of Concept: Hypothetical Case 1

	Merseyside	Hampshire	Suffolk	Total

Liverpool	**30+10=40**	20	10	**70**
Southampton	20	40	30	90
Felixstowe	**30-10=20**	20	50	**90**
Total	80	80	90	250

The concept can be illustrated by comparing Table 1 and Table 2. By transferring a preset volume (10) from Felixstowe to Liverpool, the port market shares change, but the inputs and outputs from the three regions remain constant. By transferring Merseyside-based traffic from Felixstowe to Liverpool, it is to be expected that total road vehicle kilometres (VKms) fall, even though the quantity of freight produced or consumed stays the same. In other words, by re-routing traffic to local ports from more distant ones, the impact on the road network can be ameliorated.

Table 3: Illustration of Concept: Hypothetical Case 2

	Merseyside	Hampshire	Suffolk	Total
Liverpool	60	0	0	60
Southampton	0	80	10	90
Felixstowe	20	0	80	100
Total	80	80	90	250

By reducing the number of constraints affecting the quantity of traffic that can be exchanged, and the number of ports able to swap tonnages, it is possible to arrive at a redistribution in which the row and column totals remain at their original levels, but the table cells are redistributed so that each port handles more local traffic. This is not an optimal distribution in terms of vehicle kilometres generated because some traffic is still travelling outside its own zone to reach a port, but it demonstrates how the distribution can be modified to achieve a given objective (lower VKms) without altering regional production or consumption or port market share.

Full optimisation is achieved like this – see below:

Table 4: Illustration of Concept: Hypothetical Case 3

	Merseyside	Hampshire	Suffolk	Total
Liverpool	80	0	0	80
Southampton	0	80	0	80
Felixstowe	0	0	90	90
Total	80	80	90	250

In this case, all traffic is re-routed to the nearest port so as to minimise road traffic volumes for a given regional pattern of traffic generation. However, note that this alters the relative market shares of the ports, in a way that is not pre-set or constrained.

Result set 1 has been modelled using the Case 3 methodology (Table 4), and sets 2 to 4 use the Case 1 methodology (Table 2). The Case 2 methodology, a compromise between optimisation and realism is used as a benchmark.

3. BASE CASE

A base case has been constructed, to enable comparisons between scenarios and the modelled present day circumstances.

The figures are based upon 2003 Trade Data.

Table 5: UK Total Trade, 2003, Millions of Tonnes

	UK Imports	UK Exports	Total
Unitised	74.5	40.9	115.4
Conventional	171.2	152.5	323.7
Total	245.7	193.4	439.1

The flows that do not move inland by road are excluded, reducing the total volume from 439.1 million per annum to 224.0 million. The unitised definition is refined, so that containerised traffic can be separated out. The remaining unitised traffic is mainly lorries on roll-on roll-off services.

Table 6: UK Trade, 2003, Moving Inland by Road, Millions of Tonnes

	UK Imports	UK Exports	Total
Total	128.2	95.8	224.0
Of which:			
Containerised	21.2	10.8	32.0

A provisional estimate of road vehicle kilometres generated by this traffic is estimated using a coarse zoning structure (counties). It shows that approximately 4,320 million road vehicle kilometres, or about a sixth of total GB road freight has either an origin or a destination at a port.

Table 7: UK Trade, 2003, Moving Inland by Road, Millions of V.Kms

	UK Imports	UK Exports	Total
Total	1,796.7	2,524.7	4,320.3
Of which:			
Containerised	266.9	315.1	582.0

The provisional estimates are then revised, partly by removing flows that are identified as data errors, such as container traffic through ports with no container facilities, and partly by re-estimating the network impacts by using finer (postcode district) zones.

Table 8: UK Trade, 2003, Moving Inland by Road, Revised Estimate

	Tonnes	Tonne Kms	Vehicle Kms
Total	223.9	47,135	4,032
Of which:			
Containerised	31.9	4,508	386

Table 8, therefore, shows the base case traffic volumes, before any re-routing or re-distribution has been considered.

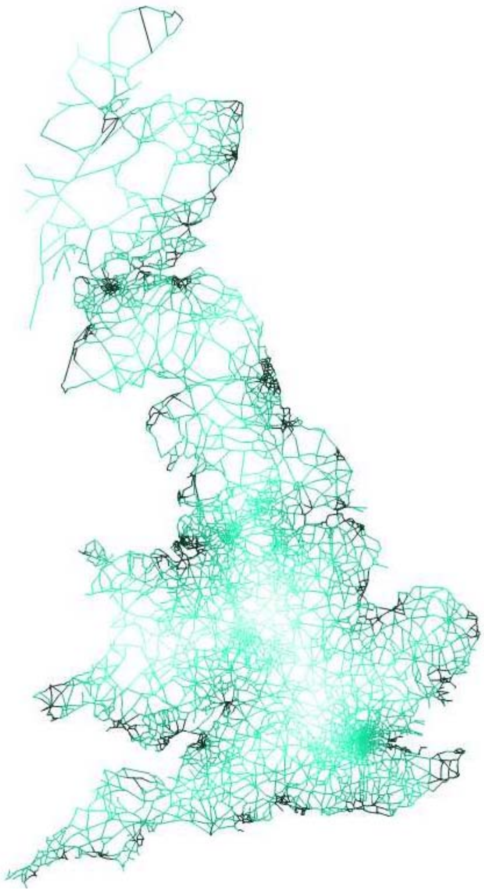
The model runs have all been labelled, so that they can be cross-referenced in the spreadsheet.

The base case results are labelled:

B1: Base case, total traffic (i.e. 223.9 million tonnes)
B1C: Base Case, containerised traffic (i.e. 31.9 million tonnes)

Traffic distribution has been analysed by classifying each road link according to its proximity to a port. This is illustrated below:

Figure 1: Classification of Road Links



The darker lines indicate links close to ports. This system can be used to see if a given scenario affects the areas close to the ports, or the main inland corridors (M1, M40, M4, M6 etc) carrying the longer distance flows.

4. RESULT SET 1

The impact of re-routing all traffic to the nearest ports.

The results from this first scenario, in which traffic is re-routed to the nearest ports, are split into two groups:

S1: Scenario 1, covering total traffic.
S1C: Scenario 1, covering containerised traffic.

In **S1**, all freight moving inland to or from a port has been re-routed to the nearest port.

Table 9: Scenario S1

	Million Vehicle Kms	Million Tonne Kms	Million Tonnes	Avg. LOH Kms
Without Redistribution	4,032.08	47,135.00	223.95	210.47
With Redistribution	900.98	10,532.41	223.95	47.03
Change	3,131.10	36,602.59	0.00	163.44

As there are relatively few constraints, the impact of allowing all flows to find the nearest port is very large. Traffic falls by just over 75%, a net reduction of 3,130 million vehicle Kms. The ports gaining the most traffic tend to be those close to the main cities or the main motorway network, including London, Runcorn, and Sharpness.

The impact on the road links ranges from a 55% reduction for links within 10Km of a port, to approximately 90% for links over 90Km from a port. The average length of haul (LOH) falls from 210.47 Kms to 47.03 Kms.

On its own, this redistribution is unrealistic, but it establishes a theoretical maximum impact.

In **S1C**, only containerised traffic has been re-routed, and only the main, existing container ports have been allowed to attract cargo.

The ports included are: Felixstowe, Southampton, London/Tilbury, Liverpool, Thamesport/Medway, Hull, Immingham, Middlesbrough/Tees, Grangemouth/Forth, Cardiff, Goole, Avonmouth/Bristol, Tyne, Harwich, Clyde, Portsmouth, Ipswich and Grimsby. Today, this group accounts for over 95% of containerised traffic in the UK.

Table 10: Scenario S1C

	Million Vehicle Kms	Million Tonne Kms	Million Tonnes	Avg. LOH Kms
Without Redistribution	385.65	4,508.20	31.97	141.02
With Redistribution	175.20	2,048.14	31.97	64.07
Change	210.44	2,460.06	0.00	76.95

The relative change is lower than before (approximately 54% reduction in VKms) as there are fewer ports to reallocate traffic to, and also because rail has a significant share of long haul inland transport from the main container ports. The average length of haul in the base case is therefore lower than in the total trade example, and higher after the optimisation is applied. The traffic reduction rate within 10 Km of a port is 31% and around 90% over 90 Km.

This is a more realistic outcome, because traffic is being transferred to ports with container facilities, but no account is taken of existing capacity, so some of the re-distribution outcomes are unrealistic e.g. large gains by Goole and Ipswich.

Table 11: Scenario S1C – Constrained Port Market Shares

	Million Vehicle Kms	Million Tonne Kms	Million Tonnes	Avg. LOH Kms
Without Redistribution	385.65	4,508.20	31.97	141.02
With Redistribution	324.04	3,787.98	31.97	118.48
Change	61.61	720.22	0.00	22.54

Table 11, therefore, follows the theoretical example set out in Table 4, where the rows and columns (region totals and port totals) are constrained, but the cells are reorganised according to length of haul. This is a better indicator of what is achievable, approximately a 16% improvement, as it involves neither a reorganisation of industrial location nor major upheaval in the ports sector. It suggests that if container traffic were sorted according to GB destination in a transhipment centre and then shipped to the nearest port with capacity, significant reductions in traffic could still be achieved.

5. RESULT SET 2

Table 12 shows a summary of the impacts following a redistribution of 1% of container traffic to Liverpool, incorporating model runs S21C, S22C, S23C, S24C, S25C, S25CF.

The methodology follows the theoretical example in Table 2. A preset amount of traffic, amounting to 1% of total container traffic (319,000 tonnes) has been re-assigned from a source port to Liverpool. Felixstowe (Fxt), Southampton (Stn), London (Lon) and Medway (Med) have been modelled individually as source ports, and as a group (S25C) in which they are all diverting traffic equally.

In results S21C to S25C, a distance decay algorithm has been used to decide which flows are diverted, meaning that traffic going to regions closer to Liverpool are diverted first until the preset level is reached. If there is not enough traffic in zones close to Liverpool to reach the target, traffic from other zones is added in.

This explains why the results tend to be better for the larger ports (Felixstowe and Southampton) and when all four ports are treated as potential sources. Once the model has exhausted traffic from zones close to Liverpool, the outcome can be a net increase in traffic because it is converting flows such as Kent-Thamesport to Kent-Liverpool.

The final result (S25CF) is a variation on S25C. The port-to-port transfers are the same, but the methodology has been relaxed slightly so that instead of Liverpool keeping its current traffic and gaining suitable flows from other ports, all the ports in the analysis can exchange traffic. It therefore achieves the same target levels, but the net reduction in traffic is higher. The methodology is similar to the theoretical example in Table 4.

Table 12: Result Set 2: Redistribution of 1%

	Million Vehicle Kms	Million Tonne Kms	Million Tonnes	Avg. LOH Kms
Without Redistribution	385.65	4,508.20	31.97	141.02
S21C: From Fxt to Lpl	381.06	4,454.58	31.99	139.24
S22C: From Stn to Lpl	381.65	4,461.44	31.99	139.45
S23C: From Lon to Lpl	383.23	4,479.94	31.99	140.03
S24C: From Med to Lpl	385.20	4,502.94	31.99	140.75
S25C: From All to Lpl	381.62	4,461.17	31.99	139.46
S25CF: All to Lpl – Exch.	353.98	4,138.03	31.99	129.36

6. RESULT SET 3

Result set 3 follows the methodology outlined above (see page 8), except that the amount of traffic transferred to Liverpool amounts to 3% of containerised tonnes (957,000 tonnes per annum).

The impact again depends on the amount of traffic in the base case that is connected to zones closer to Liverpool than the existing port.

Table 13: Result Set 3: Redistribution of 3%

	Million Vehicle Kms	Million Tonne Kms	Million Tonnes	Avg. LOH Kms
Without Redistribution	385.65	4,508.20	31.97	141.02
S31C: From Fxt to Lpl	371.27	4,340.17	31.99	135.66
S32C: From Stn to Lpl	379.71	4,438.84	31.99	138.75
S33C: From Lon to Lpl	390.61	4,566.18	31.99	142.73
S34C: From Med to Lpl	397.42	4,645.85	31.99	145.22
S35C: From All to Lpl	374.41	4,376.86	31.99	136.83
S35CF: All to Lpl - Exch	348.16	4,069.97	31.99	127.23

7. RESULT SET 3

Result set 4 follows the methodology outlined above (see page 8), except that the amount of traffic transferred to Liverpool amounts to 5% of containerised tonnes (1,595,000 tonnes per annum).

The impact again depends on the amount of traffic in the base case that is connected to zones closer to Liverpool than the existing port.

	Million Vehicle Kms	Million Tonne Kms	Million Tonnes	Avg. LOH Kms
Without Redistribution	385.65	4,508.20	31.97	141.02
S41C: From Fxt to Lpl	363.56	4,250.05	31.99	132.85
S42C: From Stn to Lpl	387.34	4,527.98	31.99	141.53
S43C: From Lon to Lpl	405.33	4,738.34	31.99	148.11
S44C: From Med to Lpl	412.26	4,819.37	31.99	150.64
S45C: From All to Lpl	372.44	4,353.84	31.99	136.10
S45CF: All to Lpl - Exch	344.82	4,030.94	31.99	126.01