AN INVESTIGATION OF CONTAINER TRAIN SERVICE PROVISION AND LOAD FACTORS IN GREAT BRITAIN

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Abstract

The continued growth in the volume of international trade poses considerable economic and sustainability challenges, particularly as transport routes become more congested and concern grows about the role of transport movements in accelerating climate change. Rail freight plays a major role in the inland transport of containers passing through the main British container ports, and potentially could play a more significant role in the future. However, there is little detailed understanding of the nature of this particular rail market, especially in terms its current operating efficiency. This paper examines container train service provision to/from the four main ports, based on analysis of a representative survey of more than 500 container trains between February and August 2007. The extent to which the existing capacity is utilised is presented, and scenarios by which the number of containers carried could be increased without requiring additional train service provision are modelled, to identify the theoretical potential for greater rail volumes. Finally, the paper identifies the challenges involved in achieving higher load factors, emphasising the importance both of wider supply chain considerations and government policy decision-making.

1. Introduction

The continued growth in the volume of international trade poses considerable economic and sustainability challenges, particularly as transport routes become more congested and concern grows about the role of transport movements in accelerating climate change. Global growth in the movement of international standard (ISO) freight containers has been particularly rapid, with a compound annual growth rate of 10.5 per cent in the 1990s and 12.8 per cent since 2000, resulting in global port volumes estimated at more than 400 million TEU in 2006, a significant increase on the 230 million TEU in 2000 (OSC, 2007). A TEU is a twenty-foot equivalent unit, meaning a standard 40 foot container is two TEU. Growth rates at British ports have been lower but still considerable, at around 5 per cent per annum between 2001 and 2005 (Network Rail, 2007). The Eddington Transport Study (HM Treasury, 2006a) highlighted the role of efficient freight distribution in supporting the British economy, and specifically identified the importance of enhancing the performance of the major container ports and the inland transport corridors linking ports to their hinterland. There is a growing body of evidence that transport activity is a major, and growing, contributor to global climate change (see, for example, HM Treasury, 2006b; IPCC, 2007) and that urgent action is needed to reduce the environmental impacts of transport movement.

Rail freight currently plays a major role in the inland transportation of containers passing through the major British ports. Official rail freight statistics do not isolate port-based container flows, but they make up almost the entire domestic intermodal category. This category experienced growth of 16 per cent in the number of tonne kilometres between 1999/00 and 2006/07, and accounts for 20 per cent of all rail freight moved in Britain (ORR, 2007). In mid-2007, the ports that were served by dedicated container train services were Felixstowe, Southampton, Tilbury and Purfleet (both within the Port of London), Thamesport (Kent) and Seaforth (Liverpool); the former two are by far the most significant for both port container throughput and rail freight activity. Rail has the potential to play a more significant role in the future, for both economic and environmental reasons. As a result of varying assumptions, there is not yet a consensus on the precise environmental benefits of rail freight over road haulage, but the evidence suggests that rail has substantially lower carbon dioxide emissions per tonne kilometre than has road (McKinnon, 2007). In theory at least, rail may also provide an alternative to the increasingly congested road network, thus offering economic benefits through time savings and load consolidation. As carbon auditing of supply chains develops, there is likely to be a need for a more detailed and precise understanding of the nature of

specific types of rail freight flow, which in turn demands a more sophisticated awareness of the operating characteristics at a more disaggregated level than has traditionally been the case.

Given the importance of mode choice in this freight sector, this paper aims to better understand the nature of the rail market for the inland movement of containers to and from the key ports in Britain. There is little detailed understanding of the nature of this particular market, particularly in terms of the detailed nature of service provision and operating efficiency. The key trends and characteristics of containerised goods flows and, specifically, their impacts on Britain's rail freight network were analysed in previous research by the author (Woodburn, 2007). The present paper seeks to develop the earlier work, particularly through the analysis of original survey data of container train load factors, in the specific context of the growing problems of accommodating growth in freight traffic on the British rail network. The paper has four specific objectives:

- to identify the current level of service provision, both in terms of number of trains operated and the container carrying capacity of these trains
- to examine the extent to which the existing on-train capacity is utilised (i.e. the load factor)
- to model the theoretical potential for carrying greater rail volumes without requiring additional train service provision under a number of different scenarios
- to set out arguments relating to the challenges involved in achieving higher load factors and longer trains

The next section presents a background to the problem, focusing primarily on the challenges associated with catering for growth on the rail network in the context of container traffic moving to and from the key deep sea ports. Section 3 details the survey methodology adopted for this research and discusses its validity. The subsequent four sections deal with each of the paper's objectives in turn, before conclusions are drawn.

2. Background

There is a relatively long and informative history of investigating railway efficiency (see, for example, Gathon and Perelman, 1992; Cowie and Riddington, 1996; Preston, 1996), largely using econometric techniques at a national level, though tending towards passenger operations instead of freight. Interest in the topic has grown as the deregulation of rail systems has spread from North America to Europe and elsewhere. Chapin and Schmidt (1999) considered the effects on technical and scale efficiencies resulting from rail freight industry consolidation in the US, but did not consider operational capacity-related issues. Before progressing on to the specifics of rail capacity utilisation, it is important to clarify the terminology adopted for this paper, particularly given the varied uses in previous work. In the rail industry, capacity utilisation most commonly relates to the number of train movements over defined routes or sections of the network. In defining the term, Gibson *et al.* (2002) refers to the availability and utilisation of train paths on a track section, and this concept is widely used in rail operations and policy documents. Wagon utilisation typically relates to the number of journeys undertaken in a given time period (see, for example, IRIS, 2001), rather than referring to whether or not the wagon was loaded on any given journey.

There is a strand of previous research that has examined capacity issues relating to intermodal rail freight. Much of this attention has focused on intermodal terminal throughput and utilisation rather than the trains themselves. In two separate studies (Ferreira and Sigut, 1995; Ballis and Golias, 2002), the critical role of terminals in the performance of intermodal freight systems was argued and the effects of new types of facility were modelled. Through a literature search, Wiegmans *et al.* (1999) identified a range of characteristics that are instrumental in classifying terminals and determining their performance, but train load factors are not included as a relevant factor. Other authors have developed modelling techniques to assess aspects of the intermodal rail freight market. Macharis and Bontekoning (2004) provide a comprehensive review of operations research opportunities within the intermodal system and identify the challenge of load assignment to trains at terminals, while Corry and Kozan (2006) developed an assignment model for load planning, again highlighting the many variables that make this such a complex task.

There is no evidence that any European studies have identified and assessed different intermodal load factors through data collection and analysis unlike, for example, the study of the road freight sector conducted by Léonardi and Baumgartner (2004), who found that load factor improvements were one potential means by which environmental impacts could be reduced. In the US, Lai and

Barkan (2005) evaluated different intermodal train loading combinations regarding their fuel efficiency, and the authors have subsequently developed this analysis to incorporate aerodynamic efficiency (Lai *et al.*, 2007). Load factors and container spacing were found to have significant impacts on fuel and aerodynamic efficiency, although the practicalities associated with improving load factors were not fully explored. In any case, the characteristics of the American intermodal market are distinct from those pertaining in Europe. There is a growing body of research comparing the environmental impacts of road haulage and intermodal freight. In their review of the topic, Kreutzberger *et al.* (2003) found that load factor was one of many attributes that influences the relative performance of the transport types, but that intermodal was almost always better performing than road haulage alone. Detailed comparisons of different load factors were not investigated. Janic (2007) has approached the topic from a cost internalisation model, focusing on a comparison of a road-rail system with road alone. The rail element assumes a 75 per cent load factor, with no allowance for divergence from this. In an interesting application of the emerging life cycle analysis technique, Spielmann and Scholz (2005) compared road, rail and water, but explicitly stated that no adjustment had been made for different load factors.

Given the potential for variations in train load factors to affect both environmental and economic impacts of rail freight, it is surprising that no statistics are published relating specifically to this issue that could be used to inform debate and lead to a consensus on the extent to which load factors could or should be influenced through changes to the management of the supply chain or through public policy measures. By contrast, annual statistics relating to vehicle empty running and load factor (known as lading factor) are produced for the British road haulage sector (DfT, 2007a). The British government, Network Rail and the freight operating companies have recognised the importance of capacity utilisation in rail policy making and network management and operation. However, there is little consideration of freight train load factors in any published documents. As a consequence of the rapid growth in both freight and passenger volumes on the rail network since the mid-1990s, capacity issues have moved up the agenda and a policy document specifically addressing rail network capacity utilisation was developed by the Strategic Rail Authority (SRA, 2003). The major part of this document focused on the constraints on train pathing through the network and on measuring and understanding passenger train utilisation and crowding. The SRA acknowledged weaknesses in rail freight data, with greatest attention being focused on the ability to increase the number of freight trains operated and means by which freight trains can be lengthened, for example through infrastructure enhancements and increased locomotive power. A key element of the policy was to encourage the operation of the longest practicable trains, without any consideration of existing or potential load factors. As of late-2007, two recent policy documents define the approach to rail freight capacity and its utilisation, these being Network Rail's Freight Route Utilisation Strategy (RUS) (Network Rail, 2007) and the government's White Paper for railways (DfT, 2007b). Of note is the clear intention to accommodate growing rail freight volumes. Particular constraints that are identified are network availability, loading gauge restrictions and limitations on train lengths, weights and speeds.

Train lengthening has been identified as one potential way in which growth can be accommodated and, indeed, features as the most important capacity enhancing measure for container trains recommended in the Freight RUS. It argues, for example, that an increase in train length from the typical 24 wagons at present to 30 wagons on Felixstowe services would be possible in the longer term if certain infrastructure improvements take place (Network Rail, 2007). In its response to the RUS consultation phase, however, Freightliner (2006), the biggest of the container train operators, argued that train lengthening would be a viable solution in some situations but it is not a universal capacity enhancing measure. The company argues that even if route and terminal infrastructure was enhanced, commercial considerations are in some cases likely to limit the desirability of longer trains due to insufficient volumes, while in other instances factors such as maximum trailing weights have been reached given the currently available motive power. Within existing overall train length constraints, there is potential to increase TEU capacity on trains that operate on routes where gauge enhancement to allow the movement of high cube containers on standard rail wagons has not yet taken place. In the most extreme cases, notably routes serving Southampton, carrying capacity can be reduced by one third (Network Rail, 2007), though in practice the reduction is not as great as this due to the mix of wagon types used. As high cube containers become more dominant (HPUK, 2003), the pressure for gauge enhancement of all core and diversionary routes increases and the implications for train capacity of non-clearance become more significant.

Given the attention devoted to capacity-related issues, it is surprising that only a small number of studies have considered existing intermodal load factors, and when they have the concept has been applied to specific flows or corridors. For example, the IRIS project conducted a cost

comparison exercise for different options on a specific customer flow from Southampton with sensitivity testing using two different load factors (IRIS, 2001). Elsewhere, evidence to container port development Planning Inquiries has discussed load factors as well as the more common capacity utilisation considerations. One case, the Felixstowe South Reconfiguration Inquiry, stated that the existing load factor for container trains serving Felixstowe was less than 70 per cent but would increase to 85 per cent by 2016 (HPUK *et al.*, 2004) as a result of increasing volumes and improvements to the rail network to allow greater efficiency. It is not clear, though, whether this assumed increase was based upon any rigorous assessment. Overall, it is evident from this synthesis of the available literature that container train load factors have been largely neglected as a focus of attention, with the main emphasis being on network utilisation, terminal throughput and train lengths. This paper will focus on the potential role of improved load factors to carry a greater number of containers without recourse to the more expensive infrastructure and rolling stock related solutions.

3. Method

This paper develops the previous research through an assessment of the number and length of container trains operated, together with their load factors, at a disaggregated level. In the context of container train operation, this is a measure of the number (and length) of containers carried on the train as a percentage of its total carrying capacity. The research is based on a survey of container trains serving the four principal rail-served ports (i.e. Felixstowe, Southampton, Tilbury and Thamesport). A total of 578 container trains were surveyed between February and August 2007, which is equivalent to one complete week's worth of scheduled trains operating to and from these four ports, or 4 per cent of scheduled services to and from these ports during the survey period. For 563 of the sampled services, the entire train was videoed; the remaining 15 were recorded manually due either to them being stationary or because of recording equipment failure. In all cases, a complete record of the train's load was documented. Of the services to/from other ports, Seaforth (Liverpool) was excluded for practical reasons, since the combination of its remote location relative to the four main ports and the timing of the daily export train presented difficulties. Purfleet was excluded because its thrice-weekly service was inaugurated after the survey methodology had been developed and, in any case, caters only for the short-sea market to/from Belgium and Netherlands (Cobelfret, 2007), unlike the other ports which focus on deep-sea routes. These omissions account for just 16 scheduled trains per week. The survey therefore covers more than 97 per cent of all scheduled container trains arriving at and departing from British ports, based on the summer 2007 schedule.

Considerable attention was paid to ensuring that the sampling framework was as representative of the service provision to and from the four ports as was practicable. As a consequence, the sample is wholly representative with respect to port, freight operating company and direction of flow (i.e. import or export). Table 1 shows the composition of the sample in terms of these three variables, which precisely matched the scheduled service provision at the time of the survey. In addition, efforts were made to make sure that the sample was broadly representative of specific origin-destination pairs. The majority of train services are scheduled to operate on five or six days per week, and these were all surveyed at least four and no more than seven times. Of the 113 services in this category, almost half (48) were surveyed on the exact number of occasions that they operated per week, and only five were over- or under-represented by two survey observations. The few other services that operated less often were surveyed broadly in proportion with their service frequency.

Table 1: Composition of survey sample by port, freight operating company and direction of flow

Port	Import					Export					Total
	FL	EWS	GBRf	Jarvis	Total	FL	EWS	GBRf	Jarvis	Total	Total
Felixstowe	98	10	20	0	128	99	10	20	0	129	257
Southampton	81	35	0	0	116	80	35	0	0	115	231
Tilbury	20	5	0	0	25	20	5	0	0	25	50
Thamesport	15	0	0	5	20	15	0	0	5	20	40
Total	214	50	20	5	289	214	50	20	5	289	578

Key: FL – Freightliner; EWS – English, Welsh & Scottish Railway; GBRf – First GB Railfreight; Jarvis – Jarvis Fastline

As a check on the validity of the survey, Table 2 compares the annual rail volumes for Felixstowe and Southampton based on the most recent published statistics with the grossed up annual estimates for these two ports resulting from the survey data. These two ports have been used for comparison since more than 80 per cent of container trains operate to and from these ports and because little published data exist for rail volumes at Tilbury and Thamesport, making meaningful comparisons difficult.

Table 2: Comparison between published statistics and survey estimates of rail-based container flows (in TEU) at Felixstowe and Southampton

Port	2005		2006		Rail TEU from survey*
	Total TEU	Rail TEU	Total TEU	Rail TEU	
Felixstowe	2,770,000	610,000	3,030,000	695,000	652,000
Southampton	1,375,000	385,000	1,500,000	390,000	446,000

* - grossed up to annual estimate (based on 50 weeks per year)

Source: DfT (2007c); Network Rail (2007); SCT (2007a); author's survey

There are a number of reasons that are likely to contribute to the minor differences between the survey and published data estimates:

- Inherent inaccuracies in estimating rail volumes from published statistics: precise statistics for the number of TEU carried by rail are not published on a regular basis, and rail volumes are variously expressed in terms of number of units (i.e. containers) carried by rail, number of TEU moved by rail, and rail's mode share of containers or TEU handled at ports. For example, comparison of the data presented in the draft and finalised Freight Route Utilisation Strategy (Network Rail, 2006; Network Rail 2007) reveal discrepancies of 15 per cent – 20 per cent in the rail volumes at the two key ports: in both cases, the finalised document had rail volumes revised downwards from the draft.
- Specifically, it is not always clear whether rail's mode share is its share of total TEU throughput or just that of hinterland traffic (i.e. containers being moved to/from inland locations, thus excluding containers transhipped from vessel to vessel). Network Rail data states that the shares quoted are from the total throughput (Network Rail, 2007), while data from other sources (e.g. HPUK *et al.*, 2004) suggests that the rail mode shares generally quoted are of hinterland traffic only. Transhipment activity has reduced considerably in the last 10 years, to 13 per cent at Felixstowe and 5 per cent at Southampton in 2004 (MDS Transmodal, 2006).
- Change in demand: actual change in the number of TEU conveyed by rail between 2006 and the survey period in 2007. This is likely, since there has been an upward trend in container volumes by rail for several years. More specifically, evidence from both Felixstowe (Port of Felixstowe, 2007) and Southampton (SCT, 2007b) points to continued growth in 2007.
- Seasonal fluctuations in demand: the survey was conducted during the relatively quiet period of the year, since container volumes typically peak in the months prior to Christmas. The impact of this is unlikely to be particularly significant given that new weekly records for container handling at Felixstowe's rail terminals were set in June 2007 and again in September 2007 (Port of Felixstowe, 2007); the latter week, at the start of the traditional peak period and after the end of the survey period, was just 0.5 per cent more than the former one, which was during the survey period. In addition, a number of additional trains are typically run during the peak period, so this may further reduce any impacts of seasonality on the loading of specific trains.

In summary, it is likely that the differences between the published statistics and the survey estimates result both from issues relating to the quality of the published statistics and the timing of the survey. As with any survey, there may be minor effects of the sampling framework. Additionally, in the case of Felixstowe, the lower estimate for the survey relative to published statistics is most likely to result from a combination of the influence of transhipment traffic on published statistics and the survey being conducted in the quieter part of the year. For Southampton, a greater increase in service provision in 2007 over 2006 than at Felixstowe may account for the apparent increase when comparing the survey total with that for 2006 from published sources. Overall, the size of the survey sample, the proximity of the grossed up totals to published statistics, and the doubts over the accuracy of the published data suggest that the survey provides a robust data set which allows detailed analysis of the utilisation of container trains serving Britain's key ports. This analysis takes place later in the paper, after a detailed discussion of the existing service provision.

4. Current service provision

The weekly scheduled service provision at the time the survey was conducted was presented in Table 1. Felixstowe and Southampton between them account for 84 per cent of trains serving the four ports, with 44 per cent and 40 per cent respectively. At 9 per cent of the total, Tilbury has a slightly higher share than Thamesport (7 per cent), but it is evident that these two ports are far less significant than the other two. In train operator terms, the dominance is even more marked, with Freightliner operating 74 per cent of trains. EWS, the second largest provider, has a 17 per cent share of service provision. The other two operators, First GB Railfreight and Jarvis Fastline, each serve just one port and have small shares at 7 per cent and 2 per cent respectively. Despite growing competition between operators, the port-based container train market remains highly concentrated, with over 60 per cent of trains that operate to or from the four key ports in reality being operated by Freightliner and serving Felixstowe or Southampton. The mean train length (as measured by the number of wagons) calculated from the survey data was 22 wagons, though considerable variation was observed, from a minimum of 10 to a maximum of 28 wagons. The extremes are relatively rare, however, with a standard deviation around the mean of just 2.9. At 19.5 wagons, Tilbury had the shortest mean number of wagons per train, while Southampton had the highest, with a typical train being 23 wagons long. Felixstowe had a mean train length of 22 wagons, while at Thamesport the figure was 21.5 wagons. If container trains were operated solely by standard 3 TEU wagons, the mean capacity provided per train across all ports would be 66 TEU. This is not the case, though, as Table 3 reveals, emphasising the importance of considering carrying capacity as well as train length. The observed mean capacity per train across the entire sample was 60 TEU, as a result of the use of non-standard (i.e. low floor and pocket) wagons to cater for high cube containers on routes that have not been gauge enhanced for high cube containers on standard wagons. This combination of an observed mean train length of 22 wagons and the inclusion of non-standard wagons in many trains gives a mean train capacity considerably lower than the 72 TEU that would result from all trains operated at the reported 'typical' length of 24 standard wagons. Observed train capacity ranged from 30 to 84 TEU, with a standard deviation around the mean of 9.7. This standard variation is higher than that for train length due to the varying combinations of wagon types used in different observations.

Table 3: Mean TEU capacity provided per train, by port and direction of flow

Port	Mean capacity per train (TEU)		
	Import	**Export**	**Both**
Felixstowe	62.44	62.97	62.71
Southampton	57.87	57.99	57.93
Tilbury	54.40	54.08	54.24
Thamesport	61.25	62.00	61.63
Total	59.83	60.15	59.99

Source: author's survey

As would be expected given the need to balance wagon utilisation, there was very little observed variation in train capacity by direction of travel. Overall, there was only around a 0.5 per cent difference between import and export observed train length. With the exception of Thamesport, which had the smallest sample size of the ports, the individual port differences are less than 1 per cent and are likely to arise from one or both of slight variations in train lengths during the survey period or minor variations in train sampling. Of more interest are the observed variations in average train capacity by port, as shown in Table 3, and by operator, as shown in Table 4. When considering the ports, Felixstowe has a typical observed capacity 16 per cent greater than that of Tilbury, which has the lowest mean value. It would have reasonably been expected that Felixstowe and Tilbury would have higher mean train capacities than Southampton and Thamesport, since the latter two have a far greater reliance on non-standard wagons given the lack of a gauge cleared route for high cube containers, but the evidence does not support this expectation. Instead, the mean capacity for Thamesport trains is only very slightly lower than that for Felixstowe services. From Table 4, it can be seen that the variations between operators are more noticeable than are the differences between ports, with a representative EWS train offering just three quarters of the capacity of a typical Freightliner or First GB Railfreight service. It should be noted, though, that while EWS has the lowest average train capacity its wagon fleet is proportionally better able than other operators to cater for high cube containers on gauge constrained routes, so the data shown

represent only TEU capacity and not more detailed capability considerations. Table 4 also shows disaggregated information relating to operators' typical train lengths at each of the ports that they serve. Only Freightliner and EWS serve more than one port. In both cases, their Tilbury services have lower mean carrying capacities than their trains at other ports. Freightliner services at Felixstowe and Southampton vary little in their mean train capacity, and the same is true for EWS services at these two ports.

Table 4: Mean TEU capacity provided per train, by port and train operator

Port	Mean capacity per train (TEU)				
	Freightliner	**EWS**	**First GBRf**	**Jarvis F'line**	**All operators**
Felixstowe	64.38	45.60	63.00	-	62.71
Southampton	62.61	47.22	-	-	57.93
Tilbury	58.00	39.20	-	-	54.24
Thamesport	64.17	-	-	54.00	61.63
Total	63.10	46.09	63.00	54.00	59.99

Source: author's survey

5. Capacity utilisation

Having identified the container carrying capacity of the sampled train services, this section deals with the second research objective, that being the extent to which the existing on-train capacity is utilised (i.e. the load factor). At this stage, no account is taken of the potential to lengthen existing trains or utilise different wagon types; instead, the analysis simply relates to how well the existing trains are filled. Table 5 shows that, in the complete sample, the mean load factor was 72 per cent but that, as with train lengths, there was considerable variation between ports and, to a lesser extent, in the direction of flow. Overall, import services were more heavily loaded than export ones, most notably in the case of Southampton but also with Felixstowe. By contrast, export services were better loaded than import ones at both Tilbury and Thamesport. On a port-by-port basis, Felixstowe services performed best with a mean load factor of 80 per cent, while at the other extreme the observed average load factor at Tilbury was only slightly more than 50 per cent. At 31 percentage points, load factor variability between the ports was greater in the import direction than it was for export flows, where there was a difference of 20 percentage points.

Table 5: Mean TEU capacity utilisation per train, by port and direction of flow

Port	Mean capacity utilisation per train (TEU carried as % of capacity)		
	Import	**Export**	**Both**
Felixstowe	81.82	78.74	80.27
Southampton	74.04	59.35	66.73
Tilbury	50.78	58.55	54.67
Thamesport	68.18	79.38	73.78
Total	75.07	69.32	72.20

Source: author's survey

In Table 6, the mean capacity utilisation is shown for each operator, both in total and disaggregated by each port that their trains serve; again, there are major variations in observed load factors. First GB Railfreight had the highest average load factor, with its trains from Felixstowe typically 90 per cent full. Freightliner's mean load factor was observed to be 73 per cent, though this ranged from 80 per cent at Felixstowe and Thamesport down to just 58 per cent at Tilbury. With the single exception of First GB Railfreight at Felixstowe, Freightliner services were more fully loaded than its competitors. In the case of Southampton, the difference between Freightliner and EWS was very small, but in the other instances Freightliner services were far better loaded than other operators' trains. It should be noted, though, that the lowest load factors tend to be found where service provision is also low, for example EWS with its single daily service in each direction at Tilbury and a similar situation with Jarvis Fastline at Thamesport. Despite Thamesport being served by 10 fewer services per week than Tilbury, its estimated rail throughput of TEU is considerably greater than Tilbury's due to the much higher mean load factor at Thamesport. From this analysis of the load factors of the surveyed trains, it is evident that significant spare capacity exists at present,

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although the degree of under-utilisation of current capacity varies substantially dependent on the port and operator.

Table 6: Mean TEU capacity utilisation per train, by port and train operator

Port	Mean capacity utilisation per train (TEU carried as % of capacity)				
	Freightliner	**EWS**	**First GBRf**	**Jarvis F'line**	**All operators**
Felixstowe	80.63	57.38	89.99	-	80.27
Southampton	67.09	65.83	-	-	66.73
Tilbury	58.01	41.34	-	-	54.67
Thamesport	80.35	-	-	54.07	73.78
Total	73.40	61.69	89.99	54.07	72.20

Source: author's survey

6. Scope for enhancing utilisation of existing service provision

The third objective is concerned with the theoretical potential for carrying greater rail volumes without requiring additional train service provision under a number of different scenarios. This is of considerable interest, given that the consensus from the literature reviewed earlier was that rail network capability needs to be enhanced to allow longer trains and more services to operate as the key way to allow further growth in this rail market. This section considers the additional volume that could be carried by the existing number of services with 100 per cent load factors under three different scenarios, as follows:

- Scenario 1: existing service provision, with no change to the number of wagons per train or the mix of wagon types
- Scenario 2: existing number of wagons per train, but all have the standard 3 TEU capacity
- Scenario 3: all services operating with 24 standard 3 TEU wagons (i.e. train capacity of 72 TEU), which corresponds to current industry and government plans for the future of the port-based container market on rail

Scenarios 1 and 3 are perhaps more appropriate assessments than Scenario 2. Scenario 1 assumes that operators are able to fill every space on all existing services, thus achieving 100 per cent load factors rather than the 72 per cent observed in the survey. Scenario 3 presupposes that all corridors are able to support the movement of high cube containers on standard wagons and that all trains can operate at the current typical maximum of 24 wagons. Scenario 2 is, in effect, a hybrid option, where all current non-standard wagons can be replaced with an equivalent number of standard wagons as a result of the removal of gauge restrictions. While all three scenarios present hypothetical situations that are not likely to be replicated in reality, the direct replacement of non-standard wagons by standard ones is particularly unrealistic since the different wagon types are of differing lengths and capacities. Table 7 shows how implementation of each scenario would affect the total number of TEU moving to and from the four ports by rail each year compared to the annual estimate based on the survey data. By filling all current trains to their maximum (i.e. Scenario 1), it would be possible to increase the number of TEU by a sizeable 38 per cent, taking rail's share of the existing port throughput of containers from 16 per cent to 22 per cent. Scenario 2 would result in rail volumes rising by 50 per cent over current volumes, with mode share correspondingly rising to 24 per cent. The measures assumed by Scenario 3 would lead to a 65 per cent increase in volumes and 26 per cent mode share.

Table 7: Impacts of each scenario on rail volume and mode share

	Survey estimate	**Scenario 1**	**Scenario 2**	**Scenario 3**
Rail volume ('000 TEU)	1,265	1,742	1,903	2,081
% change from survey	-	38	50	65
Rail mode share (%)	16	22	24	26

Figure 1 reveals how the various scenarios would affect rail volumes at each of the four ports, shown on a cumulative basis since, as Table 7 demonstrated, Scenario 1 would increase the

volume from the survey estimate, and each subsequent scenario would increase the volume from the previous one. This holds true for each individual port as well as for all four combined.

Figure 1: Annual rail volumes (in thousand TEU) at each port under each scenario
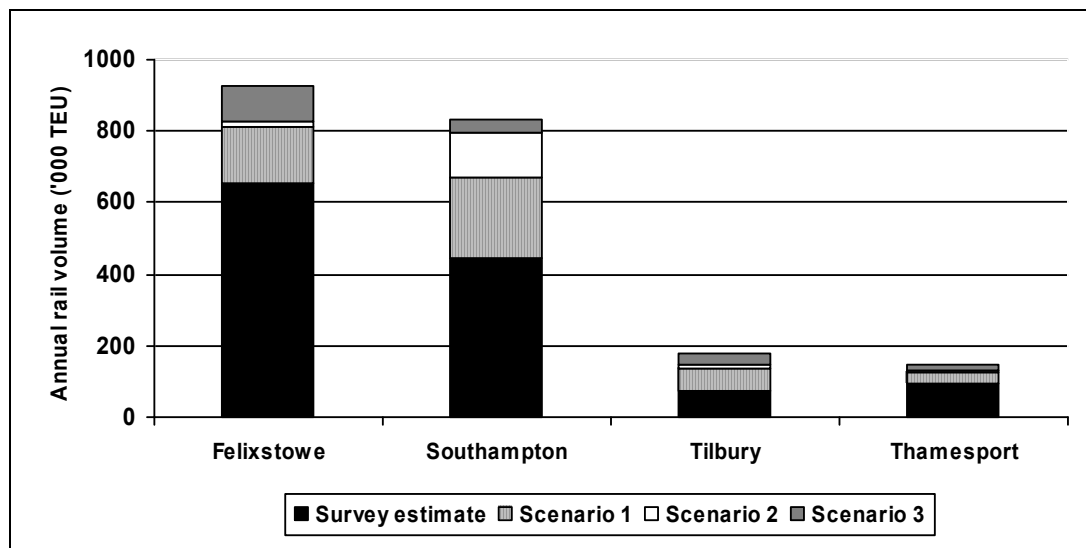
Taking Scenario 3 as the ultimate goal and the paragon of efficient operation, at least for the medium-term until more significant advances in train lengths may come to fruition, it is evident that Southampton and Tilbury in particular fall far short of that level of efficiency. At all four ports, filling existing capacity to the maximum (i.e. Scenario 1) would be the biggest contributor to increased rail volumes. The subsequent effects of standardising all operations using 24 standard wagon trains would be of lower significance, though still important. For Scenario 3, the rail volume at Tilbury would more than double compared to the survey estimates. At Southampton, the rail volume would almost double, but this would be a much more significant absolute growth than at Tilbury as a result of the far greater throughput at the former port. As a logic check on the practicalities of what it would mean to achieve the volumes identified by Scenario 3, rail mode shares for Felixstowe and Southampton have been calculated based on the current throughput of containers. Felixstowe would see an increase in rail's mode share from 22 per cent to 30 per cent, while Southampton's rail share would rise from 30 per cent to 55 per cent. This difference in the magnitude of change is a reflection of Southampton's currently inefficient operation, against the criteria of train capacity and load factors, in comparison to Felixstowe. A 55 per cent rail share at Southampton would be extremely difficult to achieve in practice.

As an alternative to this analysis of the three scenarios, it could be argued that there is over-provision of container train services at present, since the existing volume could be carried by fewer trains. There are three main reasons for not adopting such an approach in this assessment. First, the network of routes is relatively dispersed, making it difficult to rationalise service provision without fundamentally restructuring the way in which the services operate. Second, recent rapid growth in the movement of containers by rail makes it inadvisable to look at downsizing options when further growth would result in a requirement for the resurrection of withdrawn services. Instead of relating the impacts of the scenarios solely to current port volumes, it is prudent to bear in mind that, even to maintain mode share, rail will need to carry more containers in the future as a result of general growth in the container volumes passing through British ports. Linked to this is the third reason, with modal shift from road to rail being encouraged by government policy, so efforts to maximise rail's load factors are consistent with this approach. This section has therefore identified the potential for rail to carry greater volumes of containers through the assessment of the different scenarios which all assume the operation of the existing number of trains.

7. Implications of the research findings

Thus far, the analysis has been fairly hypothetical in nature. The fourth objective aims to contextualise the quantified results by setting out arguments relating to the achievability in practice

of higher load factors and longer trains, with the emphasis being on the former of these two issues. It has been shown that significantly greater volumes could potentially be moved on the existing services. There are many factors that prevent all services running with 24 standard wagons (i.e. 72 TEU capacity) and 100 per cent load factors. These factors can be classified into those that are internal to the rail industry and ones that are external influences. Those that are rail-related include:

- trailing weight limitations – on services where there is a concentration of containers loaded with heavy goods maximum weight limits may be reached with a load of less than 72 TEU; trailing weight limits are typically influenced by locomotive type and route gradients
- rail network and terminal restrictions – the earlier literature review identified length constraints relating, for example, to terminal sidings or passing loops; further, in some cases, terminal handling equipment may not be able to cope with the unloading and reloading of 72 TEU within the current schedules, or be able to deal with the associated storage requirements
- route capability issues – loading gauge is the most significant issue, with the current inability to cater for high cube containers on standard wagons on many rail corridors, including all routes from Southampton and Thamesport
- wagon availability – even if the previous constraints do not apply, there may be an insufficient number of wagons in an operator's fleet to allow all trains to be formed of 24 wagons; this could clearly be rectified should there be a business case for expanding the wagon fleet to cater for train lengthening

Potential external influences comprise:

- insufficient demand – there may be a mismatch between supply and demand, since it is rare for demand to materialise in 72 TEU quantities between particular destinations; in reality, though, rail shares demand with other modes, so could potentially market the available capacity to achieve the desired level of demand
- imbalance of flows by direction on specific corridors – it may be markedly more difficult to fill services in one direction than the other due to the relative volumes of containers involved and the patterns of flows
- government funding – funding to achieve environmental benefits is provided on certain routes but not others, which may influence or distort mode choice through effects on pricing
- daily or seasonal fluctuations in volumes – throughput at ports tends not be constant, but instead is subject to considerable peaks and troughs; this makes it more challenging to achieve a consistently high load factor on all services
- customer demands – short notice demands from customers make efficient load planning more difficult; where customers block book train capacity, the responsibility for filling the train typically passes to them as they have paid for the space, so rail freight operators may have a limited role to play in achieving higher load factors in such instances
- lack of strategic planning – in conjunction with the previous point, rail's potential to undertake block movements of containers is not exploited, for example in moving containers away from congested ports to inland terminals in advance of customers needing them; this could benefit port operations, by freeing up space, and customers, by having the consignments on hand
- mix of container lengths – the deep sea container market is increasingly dominated by 40' containers, while 100 per cent load factors for standard wagons require at least as many 20' containers as 40' ones to fully utilise the space available; 30' and 45' containers are a further complication, though not currently significant in the deep sea market

These points are not intended to be exhaustive, but they provide an indication of the challenges involved in operating fully loaded, 72 TEU trains at all times. Looking within the rail industry, in terms of 'good practice' amongst the operators, First GB Railfreight was earlier identified as having the highest existing load factors, at 90 per cent. If the other three operators achieved the same mean load factor, there would be a 23 per cent increase in the total number of TEU carried by rail, assuming no changes either to the number of services operated or the wagon composition of these services. There are a number of reasons why other operators are unable to emulate First GB Railfreight's high loadings, not least the limited nature of the company's operations, based only on a small number of routes serving Felixstowe, and their use only of standard wagons resulting in an inability to carry high cube containers on routes that have not received gauge enhancement. More realistically, if EWS and Jarvis Fastline were both able to achieve the same mean load factor as Freightliner, the total increase in TEU by rail would be a far more modest 2.5 per cent. While some

improvement in load factors is no doubt achievable through the efforts made by the operators alone, many of the constraining factors are beyond their direct control, and overcoming them would require assistance from the wider rail industry, government and customers. Greater rail network flexibility and capability would be expected to overcome many of the constraining factors but, in order to make more dramatic improvements in efficiency, there is a need for other parties involved (e.g. shipping lines, customers) to work in partnership with the rail industry in identifying supply chain configurations that will be more conducive to rail playing a larger part in the movement of containers between ports and inland locations (and vice versa). The nature of rail freight, with its fixed operating schedules and high capacity services, certainly in comparison to road, makes cooperation and planning vital to maximise the potential that exists.

8. Conclusions

This paper has offered an insight into the nature of the port-based container rail freight market in Britain, in terms both of the capacity provided and the extent to which that capacity is utilised. Three quarters of services surveyed had train lengths of 20 to 24 wagons; there was slightly greater variability in terms of TEU capacity as a result of the wagon mix. Considerable spare capacity was evident on existing services, with substantial variability by port and rail freight operator. If all existing services were fully loaded, there would be a 38 per cent increase in TEU carried by rail and if all were operated with 24 fully loaded standard wagons, rather than the current mix of lengths and wagon types, the growth would be 65 per cent. While the rail freight operators inevitably could be more efficient, there are limits on their influence given that many of the factors influencing train capacity and, more particularly, load factors are beyond their control. Further work is needed to determine actions that would have the greatest practical benefit, though a combination of rail network enhancements, favourable government policies and cooperation between supply chain parties is likely to be needed for significant improvements in train capacity or load factors. This poses considerable challenges in a mixed public-private sector setting, involving many players operating in a competitive market place and with a range of organisations being involved in strategic and operational decision making that will influence outcomes. Success, however, would lead to significant environmental benefits and greater operating efficiencies.

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