UK MARINE MOTORWAYS STUDY

Funded by:

Engineering and Physical Sciences Research Council (EPSRC) and the Department for Transport (DfT)

LINK Future Integrated Transport (FIT) PROGRAMME

Summary Final Report

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1. INTRODUCTION

The aim of the UK Marine Motorways (UKMM) study is to establish the operational and commercial viability of fast freight ferry services on UK coastal routes as an alternative to long-distance road transport. The Engineering & Physical Sciences Research Council (EPSRC) and the UK Department for Transport (DfT) funded the study through the DfT LINK Future Integrated Transport (FIT) Programme.

To conform with EPSRC/DfT Link FIT funding programme guidelines, a broad based science and industry partnership was formed to undertake the study (Table 1). The composition of the partnership ensured specialist expert input in regard to seaports, road transport, transport logistics, shipbuilding, ferry transport, and economic development, in addition to research skills in maritime transport and transport logistics.

Table 1: Science and industry partners participating in the UK Marine Motorways (UKMM) project
SCIENCE-BASED
TRi Maritime Research Group, Transport Research Institute, Napier University
Logistics Research Centre, Heriot-Watt University
INDUSTRY-BASED
Aberdeen Harbour Board
A&P Falmouth Ltd
British Ports Association
Clydeport PLC
John G Russell (Transport) Ltd
Scottish Enterprise
Tibbett & Britten Group PLC
The Isle of Man Steam Packet Company Ltd
CONSULTANTS
Mercury Maritime Ltd
Centre for International Transport Management, London Metropolitan University

The study was divided into five linked work packages, each with an individual measurable objective, as follows:

- **Work Package 1**: To identify, based on a detailed assessment of existing road goods traffic flows, UK sea routes (a maximum of four) for further investigation.

- **Work Package 2**: To investigate and analyse technological developments in fast freight ferry transportation, to select fast freight ship designs appropriate to market needs, and to assess service operability factors in respect of selected fast craft for each route.

- **Work Package 3**: In designing and testing a new transport system that enhances integration between modes, to establish potential demand for fast freight ferry services on selected UK coastal routes.

- **Work Package 4**: To fully investigate all regulatory factors and implications in relation to the safe and efficient operation of fast freight ferries at sea and in port on selected routes.

- **Work Package 5**: To identify modal shift potential of fast freight ferry combined transport services, and their contribution towards developing a new integrated transport system, and to evaluate the commercial viability of such services.

2. ROUTE SELECTION

Four routes were selected for further study based upon detailed evaluation and scoring of key variables such as sea distance compared with road, road freight traffic flows, road traffic congestion, regional population and GDP. All other routes initially considered were disregarded from this point onwards (see Table 2). Three of the routes selected are on the UK east coast, with one on the west coast. Although highest scoring routes were selected, scores were used as a guideline, and not an absolute result.

Table 2: Final Scores for proposed UKMM routes, and top four routes selected

				Variable (Weighting)			
Routes selected*	**Route**	**Distance/ Time (25%)**	**Freight Flows (40%)**	**Conges-tion (15%)**	**Population (10%)**	**GDP (10%)**	**Score**
1	**Humber – Thames**	**1.50**	**4.10**	**4.00**	**4.00**	**3.20**	**3.34**
2**	**Forth – Thames**	**3.83**	**2.80**	**3.30**	**4.00**	**3.50**	**3.32**
2**	**Forth – Tees**	**2.00**	**4.10**	**1.80**	**3.50**	**1.80**	**2.94**
3	**NE Scotland – Thames**	**4.67**	**1.30**	**3.70**	**3.00**	**3.70**	**2.91**
4	**Clyde – Mersey**	**2.17**	**3.40**	**2.30**	**3.00**	**2.30**	**2.78**
-	Tees – Thames	2.33	1.90	4.20	3.50	2.80	2.60
-	NE Scotland – Humber	3.83	1.80	2.00	3.00	2.80	2.56
-	Forth – Humber	2.50	2.40	1.70	3.50	2.30	2.42
-	Newhaven/Shoreham – Plymouth	2.00	1.80	2.80	3.00	3.30	2.27
-	NW Scotland – Mersey	2.72	1.50	2.70	3.00	2.30	2.22
-	Clyde – South Wales	3.50	1.00	2.70	3.00	2.30	2.21
-	NE Scotland – Tees	2.67	1.50	2.20	2.50	2.50	2.10
-	Ramsgate/Dover – Weymouth/ Portland	1.83	1.80	3.00	1.50	1.50	1.93

*The shaded rows represent the four selected routes
** These two routes have been combined into one 3-port route for further study.

The basic rationale for selection of only four specific routes was to enable the research to be sufficiently focused over the required timescale of the project. It was also considered that the general findings emanating from the study for selected routes could be applicable to other routes that did not make it to the second stage in this particular instance.

The four routes selected for further investigation (see Figure 1) were as follows:

- **Route 1:** Humber–Thames
- **Route 2:** Forth–Tees–Thames (Forth–Thames, and Forth–Tees)
- **Route 3:** NE Scotland–Thames
- **Route 4:** Clyde–Mersey

To a large degree, assessed on the basis of criteria selected, UK east coast routes scored favourably, with Humber–Thames recording the highest score of 3.06. The second and third placed routes were Forth–Thames and Forth–Tees. The latter two routes were subsequently combined to form one route for further study, (the study specifically sought to analyse at least one three-port itinerary). The third east coast route selected was NE Scotland–Thames. The fourth route selected for investigation was Clyde–Mersey.

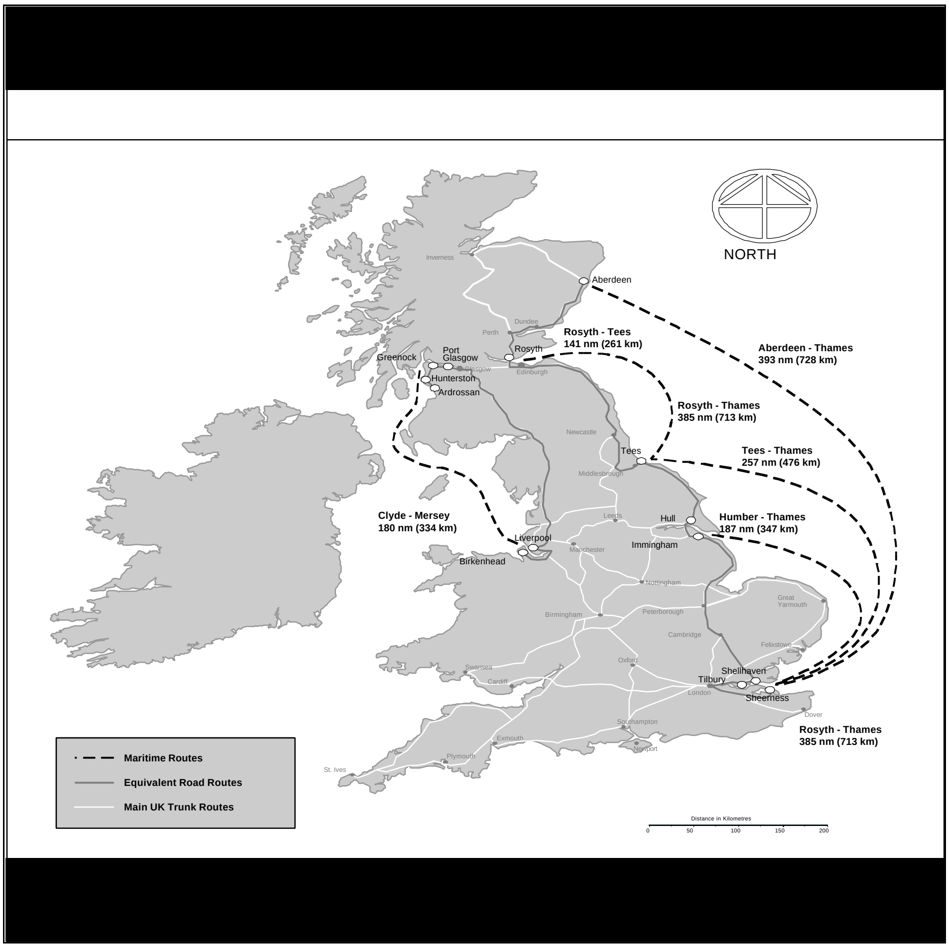

Figure 1: UKMM routes selected for investigation

3. FERRY TECHNOLOGY

The aim of WP 2 was to investigate and design alternative sea transport solutions based on existing fast ferry technology, and to then test these options during the demand assessment in WP3, thereafter refining the desired service specification accordingly.

Specific objectives of WP 2 were as follows:

- To analyse technology and market development in the fast freight ferry sector;
- To select fast freight ferry designs/types for further evaluation;
- To prepare outline route schedules and provide an operability analysis.

While a review of published material offered substantial data on recent newbuild ferries, it was decided to also undertake a survey of shipbuilders specialising in fast and high-speed ferry production. This survey was intended to generate additional technical and financial information regarding current fast ferry designs (i.e. fast ships offering significant freight trailer capability) being offered to the market, and to support collection of secondary data. The aim of the survey was essentially to augment the secondary data analysis which considered all relevant recent newbuilds, plus generate new data on designs being offered to the market, and therefore to avoid 'missing out' on any new innovative design approaches that could alter vessel economics in one way or another. A total of 24 questionnaires were distributed to shipbuilders worldwide, of which 8 (33%) were returned completed.

The result of this review, survey and subsequent analysis suggested that there were basically three distinct types of ferry that could be employed on a coastal ferry service. These ship types were classified as follows:

- Conventional (i.e. ships offering a service speed below 24 knots)
- Fast conventional (i.e. service speeds between 24 and 30 knots)
- High-speed (i.e. service speeds above 30 knots)

Based on both secondary and primary data collected, it was established that, of these ship types, the *average* conventional ferry offered the largest trailer capacity of 151 units (and hence also higher lane metre space and DWT). This ship type also offered the lowest average service speed (i.e. 21 knots), installed power and fuel consumption (see Figure 2).

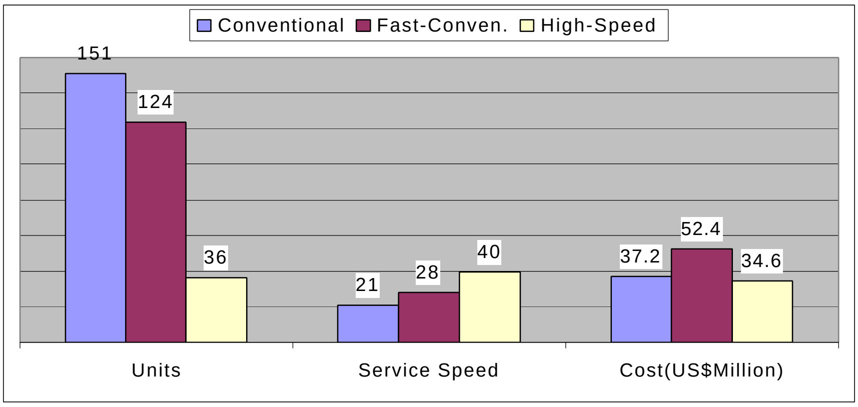

Figure 2: Average trailer capacity, service speed, and purchase price by vessel type

The *average* fast conventional type of ship offered a middle ground solution between conventional and high-speed (i.e. 28 knot service speed), albeit with still relatively high payload (124 units). However, the average power requirement for the fast conventional ship is more than double that of the conventional ferry, resulting in increased fuel consumption.

The *average* high-speed vehicle ferry offered the lowest trailer capacity of all three ferry categories (i.e. 36 trailers), and hence reduced lane metres and DWT. With a faster service speed averaging 40 knots, the high-speed craft requires a far higher power output resulting in increased fuel consumption.

Additional analyses was undertaken to generate a per-unit (i.e. trailer) vessel comparison across key variables. Ship capital costs were estimated based on information provided by yards and from published data sources. To ensure a more meaningful comparison, costs associated with provision of passenger accommodation and spaces were stripped out to give an estimated capital cost for a RoRo vessel. Although admittedly very approximate, figures are based on cost estimates for passenger accommodation provided by shipbuilders. Moreover, the final cost estimates generated total capital costs not dissimilar to comparable RoRo vessel prices.

The results of this exercise indicated that a conventional ferry has a per-trailer power requirement of 0.127 MW, which is one third that of the fast conventional ship (0.350 MW), at 28 knots the latter being 25% faster (Figure 3). With a per trailer power demand of 1.120 MW, the 40-knot high-speed craft requires almost 10 times the per-trailer power of a conventional ship, and more than 3 times that of the fast conventional ferry.

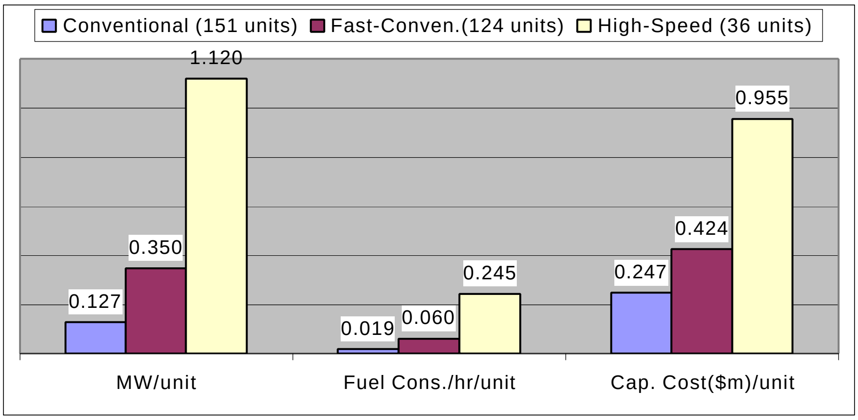

Figure 3: Average power, fuel consumption and capital cost per trailer, by ship type

Fuel consumption figures are given in tonnes per unit/hour. At 19 kg per trailer/hour the conventional ship consumes about one third the fuel per trailer/hour of the fast conventional ship (i.e. 60 kg per trailer/hour). The high-speed vessel has a fuel consumption rate of 245 kg per trailer/hour, which is almost 13 times that of the conventional ship, and 4 times that of the fast conventional ferry.

Per trailer slot capital cost also differs significantly by ship type. Cheapest is the conventional ship with a capital cost of $247,000 per trailer slot. The average fast conventional trailer slot cost is 70% higher at $424,000. Slot capital cost is greatest for the high-speed ship, at $955,000 per trailer, which is more than double the slot cost for the fast conventional ship, and almost 4 times that of a conventional ship.

4. FERRY OPERABILITY

Unlike conventional or fast conventional vessels, high-speed freight ferries could be subject to a wave height restriction imposed by the UK's Maritime and Coastguard Agency (MCA), as the IMO (International Maritime Organisation) High-Speed Craft (HSC) Code places additional constraints on operation of a high-speed vessel compared with the IMO SOLAS regulations. This means that when the sea state is above a certain level, decided by the MCA for a given high-speed vessel, the ship is either unable to sail, or if already at sea must seek shelter.

It is difficult to say precisely what effect this sort of restriction would have on high-speed freight services as, given the current absence of pure high-speed freight ships, existing regulations apply to high-speed passenger craft offering some vehicle capacity. Moreover, at this stage it is not certain what size of high-speed craft would be involved, although given the probable payload required it is unlikely that a vessel much (if at all) below 1,000 DWT would be used.

We have estimated possible downtime due to weather for high-speed craft serving North Sea routes as shown in Table 3. Assuming the MCA were to impose a Significant Wave Height limit of 3.7m (as is similar to Irish Sea routes), then North Sea coastal services maintained by high-speed vessels could incur sailing restrictions on up to 32 days a year. This would be equivalent to a cancellation rate of 9%.

Table 3: North Sea routes – estimated sailing restriction based on 3.7m Significant Wave Height limit

	WINTER	SPRING	SUMMER	AUTUMN
Exceeded	4.5%	1.8%	0.3%	2.5%
Days	16	6	1	9
Total Days pa	32			

However, builders of high-speed craft argue that larger vessels of the type envisaged for UK coastal service would not incur anywhere near this level of downtime due to wave height restrictions. Austal Ships of Henderson, Western Australia, pointed to the Stena HSS experience on the Irish Sea (the HSS, standing for 'high-speed sea service', is a 120m long, 1,500 DWT catamaran, capable of carrying 50 trucks plus over 1,000 passengers at speeds in excess of 40 knots). The HSS is understood to have recorded only a 0.3% cancellation rate over 5,000 crossings. Austal maintain that certainly no more than a 1% cancellation rate would be fair for such large high-speed craft.

Aside from wave height limitations, speed reduction in adverse weather is another issue to consider. For a high-speed craft, as a rule of thumb there is a need to allow speed reductions of approximately half a knot for every half metre of wave height up to 2 metres, 1 knot for every half metre between 2 to 3 metres, and 2 knots for every half metre thereafter. This means that, for a 40 knot vessel in a 3 metre sea, its speed would be around 36 knots.

In regard to manning arrangements, a high-speed craft operating under the HSC Code would require 2 crew changes over a 24 hour period (i.e. 2 x 12 hour shifts). On longer routes this would pose added costs for crews to be accommodated overnight at either end of the route. Moreover, this could also imply a need for 4 crews per ship, assuming the vessel could be operated round the clock similar to a fast conventional ship. The main difference here is that due to the smaller engine compartment on a high-speed craft, ongoing maintenance at sea tends to be difficult. This means that sufficient maintenance time has to be allocated when the vessel is in port. Generally most high-speed craft are maintained through the night prior to the start of the next day's operations.

Notwithstanding these issues, high-speed craft builders maintain that under SOLAS, crew size would be broadly the same as required on a conventional ship. In the cost modelling we have therefore assumed for the purpose of this analysis that all ship types – conventional, fast-conventional and high-speed - have the same crew costs.

5. DEMAND ASSESSMENT

The objectives of work package 3 of the UK Marine Motorways project are as follows:

- To identify the potential market segments and characteristics of users of UK coastal RoRo ferry services;
- To establish the general ferry service specification required by users of domestic UK RoRo ferry services;
- To indicate the general level of market acceptability to the concept of coastal RoRo ferry routes in the UK.

A total of 420 companies throughout the UK were approached of which 35 agreed to take part in semi structured interviews. The survey results indicated that the UK transport and logistics industry shows little current interest and awareness of the opportunity for UK coastal RoRo ferry services. Load time sensitivity issues and supply chain structure were found to be more important in defining suitable target markets than commodity groups. Those supply chains based on centralised or hub-and-spoke distribution systems with a high delivery time sensitivity and short lead times would require a highly sophisticated coastal RoRo solution (i.e. fast and well integrated services) in order to have any chance of achieving modal shift.

Within many time sensitive supply chains there are nevertheless opportunities for companies to use scheduled and slower transport modes. For example, grocery retailers currently use rail freight for slow moving stock ranges such as wines and spirits and non-food general merchandise, whilst network parcel and pallet carriers offer their customers two and three day services as well as next day delivery.

Figure 4 illustrates the different target markets that may be attracted to use specific types of RoRo services, and their desired service features. This indicates that all three RoRo ship types are appropriate to serving somewhat different markets, or market segments. In turn, the challenge for any ferry operator will inevitably be to deploy the specific type of tonnage best suited to acceptance by the majority of the market. Further, the market exhibits a degree of concentration around a small number of key transport users albeit different players are active on different routes.

In the UK long distance freight transport sector the majority of movements involve articulated vehicles, with a significant number of refrigerated and hazardous cargoes. Imbalances in flows are a key feature of the market due principally to intrinsic imbalances in regional trade flows as well as hauliers' need to triangulate movements in order to maximise revenue opportunities. Seasonality and repositioning of empty trailers has little noticeable effect overall.

Companies presently look for a six days a week service preferably operating over a Monday to Saturday period. The required minimum number of sailings is one ferry per day per route in each direction, although two (or more) sailings/day would offer far greater scheduling flexibility to users. The preferred time of sailing for most traffic flows would be to depart early to mid evening and arrive early morning (prior to 6am), although there is believed to be some scope to build daytime traffic as well.

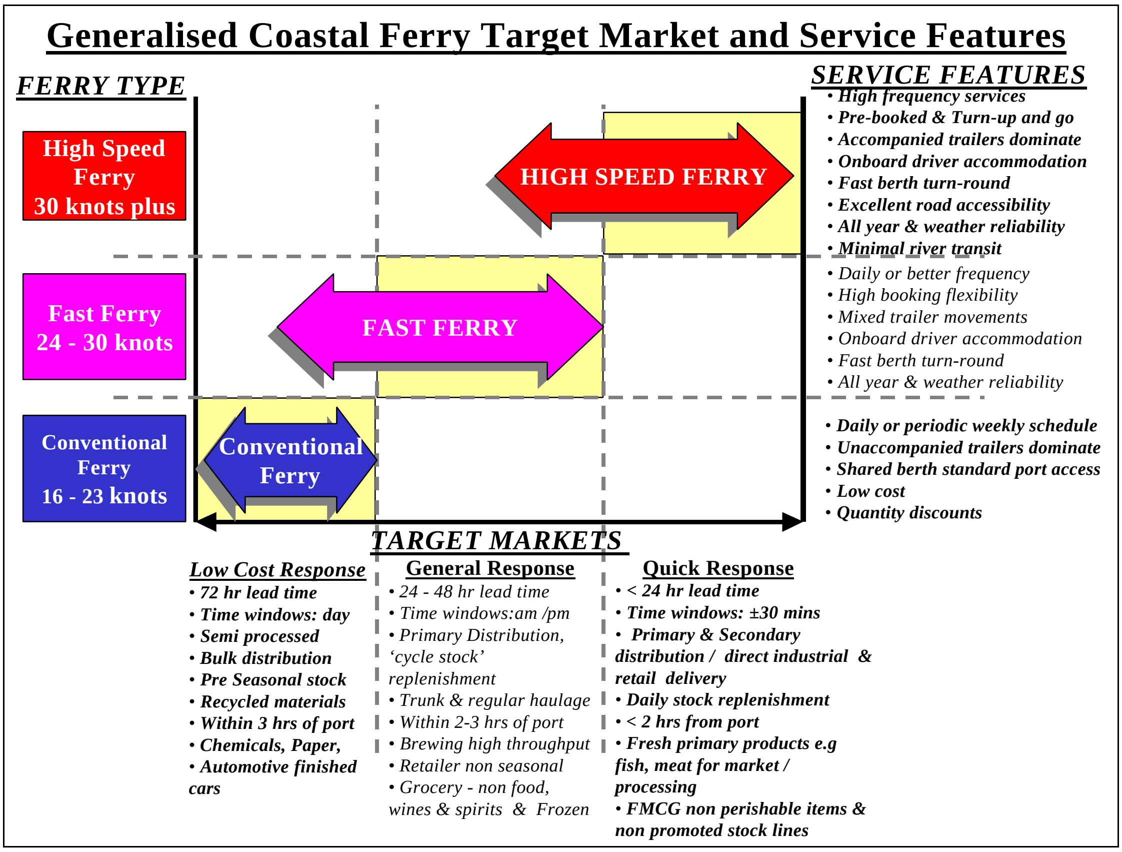

Figure 4: Target market and service features, by RoRo ship type

Unaccompanied movements would be expected to be a significant requirement on RoRo ferries regardless of route distance. However, the use of unaccompanied movements is dependent upon finding suitable reliable partners to work with as well as saving in labour and vehicle costs. The majority of customers would expect to deal with a ferry operator initially on a trip basis. Over time the number of companies wishing to enter into longer contractual periods would increase. There will inevitably be a start-up period during which usage will take time to develop, and customers will be testing the service for reliability and other key attributes.

The preferred ports for transport companies on routes under evaluation, according to survey results, are Port Glasgow, Liverpool, Aberdeen, Teesport, Thamesport, Tilbury, Rosyth and Immingham. Port choice is an important decision factor in ferry usage. For instance, on the Thames estuary, due to the greater relative congestion in and around London and the proximity to onward inter modal connections to the Continent, there was some preference for a north of river site such as Shellhaven as opposed to Thamesport due to its better road access.

Transit time, service frequency and service reliability are key factors in regard to the attractiveness of coastal RoRo services but these are perceived to be below that of road based haulage. Logistics suppliers have a major role on mode choice through their influence on daily operational freight routing decisions. Shippers have a greater strategic and long term input through the design of their supply chains and wider environmental policies.

While the current level of interest in coastal RoRo ferries appears to be low, the underlying concerns surrounding the freight transport industry favour the RoRo ferry over the medium to long term due to pressures from customers, legislation, environmental and cost changes. Major concerns stem from trunk road congestion, fuel price increases, driver availability and future driver regulation enforced through the Working Time Directive. The competitive position of coastal RoRo ferry services relative to road is susceptible to influence through government legislation and taxation changes which could alter the current competitive advantage of road transport.

Figure 5 illustrates the relative competitiveness of each RoRo vessel type compared with existing transport modes and highlights some of the forces for market change either way. The conventional ferry is viewed as a low cost response option, suited to cargo with longer lead times, and where the main competition is from rail and existing coastal shipping methods, as well as road. The fast conventional ferry is considered capable of further improvement in terms of road to sea modal shift compared with rail, although it would be unable to penetrate the quick response market dominated by road. In terms of transit time, the high-speed RoRo is believed to be very adequate for road freight business requiring more moderate lead times, but would also be potentially capable of capturing some of the quick response short lead time market. Overall, only the high-speed RoRo option would be capable of meeting the logistics needs of most long distance road freight market sectors.

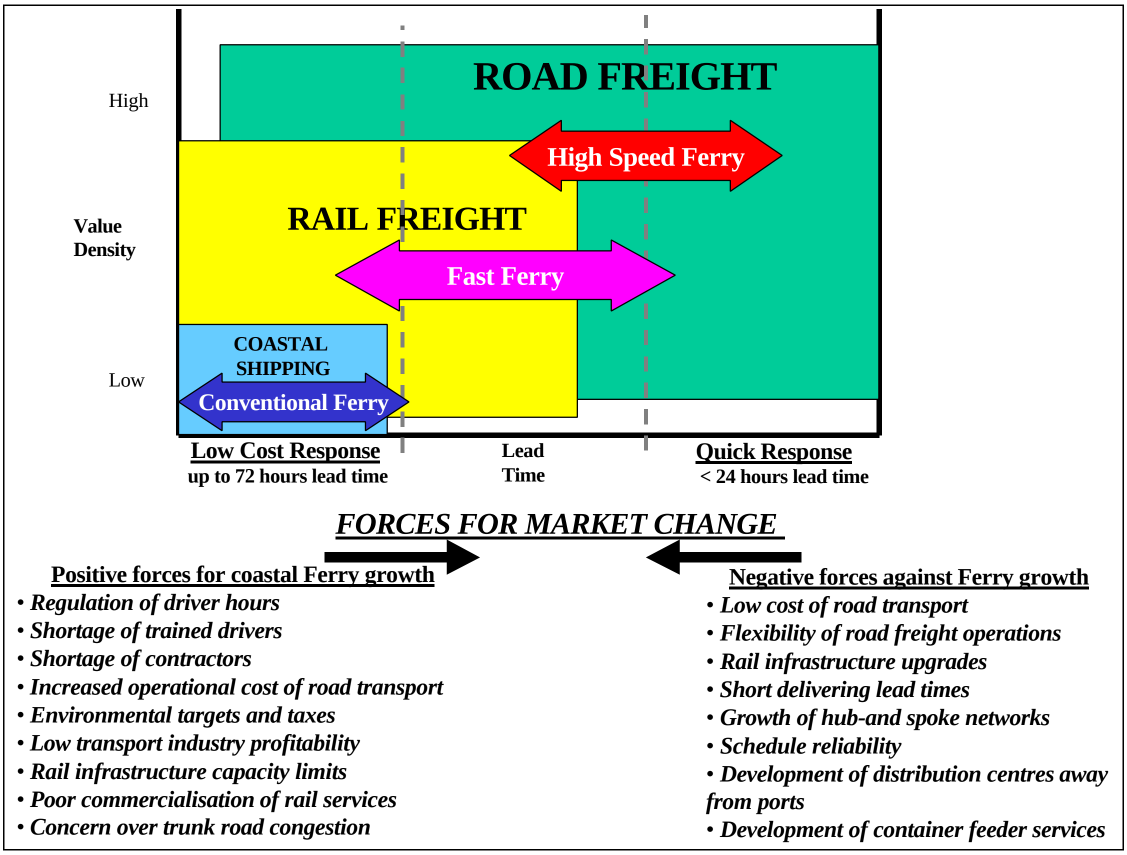

Figure 5: RoRo ferry modal competitiveness and forces for change

Extending this analysis, the study investigated traffic volumes currently moving by road on each route, the likely additional transport capacity that would be provided by RoRo services, and the market share required by new coastal services. In order to do this, the following assumptions were made:

- Vessel capacity of 100 trailers in each direction, unless a 3-port itinerary where capacity would increase to 150 units/trip (i.e. with 50 units off/on at intermediate port of call);
- Daily service, so 14 trips per week on each route, 50 weeks/year;
- Very limited port traffic hinterlands, with total road market estimated to comprise only traffic with an origin/destination of approximately 2 hours/150 km drive of each port;
- Estimated RoRo ferry volumes based on vessel load factor of 75%;
- Potential to carry trade cars, passenger vehicles, caravans etc. ignored.

From the subsequent analysis it became evident that some routes required a very high market share (e.g. Aberdeen-Thames, Forth-Thames), whereas others less so (Table 4).

Table 4: RoRo load factor and market share for daily service

	Hum-Tha	For-Tee-Tha	For-Tha	Abe-Tha	Cly-Mer	Abe-Hum-Tha
Ship capacity (trailers)	100	150	100	100	100	150
Single trips/week	14	14	14	14	14	14
Annual capacity	70,000	105,000	70,000	70,000	70,000	105,000
Load factor 75%	52,500	78,750	52,500	52,500	52,500	78,750
Market share	12.1%	12.3%	29.8%	128.0%	15.7%	15.1%
Total road market	432,200	640,440	176,460	41,010	334,730	522,320

In order to overcome the market size constraint, 3-port itineraries were modelled on two routes (i.e. Aberdeen-Humber-Thames, and Forth-Tees-Thames). This gives the RoRo service the potential opportunity (and challenge!) to penetrate multiple markets along a coastal corridor, as well as overcome the market share constraint of a point-point route.

As to the likely level of market penetration for coastal RoRo services in practice, findings from the earlier demand analysis addressing this issue were inconclusive. As Task 3 demonstrated, certain freight market segments may be attracted to coastal RoRo services, whereas other segments might not. However, a key finding from Task 3 was that the faster (and more frequent) the RoRo service, then the more likely it would meet the transport needs of multiple freight market segments. Conversely, the slower the speed (e.g. conventional, or even fast-conventional ferry speeds), then only relatively few market segments might be attracted.

The modelled ship capacity of 100 trailers in this instance is largely a reflection of the earlier survey of RoRo ships, as presented in Task 2. However, selecting vessels of this size may not in fact constitute an optimal solution for the coastal shipping challenge facing the UK. For instance, it may be that smaller capacity, fast/high-speed vessels (e.g. say 60-80 trailers) would offer a more appropriate mix of speed and capacity, based on market size and market demands, rather than perhaps much larger and slower ships. Indeed there would be other benefits from this, such as faster ship turnaround in port, plus the fact that smaller (i.e. shorter) vessels would be able to access more ports.

RoRo fleet requirement for each route is dependent on a number of factors, and in particular voyage distance, ship speed (less sea margin), port turnaround time, and number of ports in the itinerary. The ideal outcome, bearing in mind the need to maintain a minimum daily service frequency (at least) on each route, has to be to deliver a requirement for a precise number of vessels as anything else results in either slack in the schedule or insufficient ship time. Matching a vessel to each route may therefore require some adjustment to service speed; that is, to vary service speed upwards or downwards as the case may be, in order to identify a more precise vessel or fleet fit for a given route.

For the high-speed RoRo option, as an example we have modelled the same vessel service speed in respect of all routes (i.e. 70 km-hr/38 knots). It would appear from this that the fast port-port transit times which depending on the route in question varies from between 4.1 hours to 15.8 hours, would be competitive with road haulage, even taking account of the fact that a short road haul is still necessary at both ends of a route (Table 5). The time impact of driver rest breaks will to some extent help sea transport compensate for the latter.

The results indicate that a 38-knot high-speed craft would be capable of maintaining up to 3 single trips/day on each of the shorter routes (e.g. Clyde-Mersey, Humber-Thames, Forth-Tees). By implication, if two vessels were to operate each route, frequency would increase to some 3 sailings a day in each direction. Such high frequency, whilst far more attractive to the market, raises additional questions concerning the higher level of market penetration required, and this would probably necessitate employment of vessels offering somewhat reduced carrying capacity (i.e. less than the 100-units/ship modelled).

In the case of 3-port itineraries, one high-speed vessel is easily capable of completing a single trip each day, although this leaves quite a bit of slack in the schedule. Two slightly faster vessels of 44-45 knots serving each 3-port route could probably achieve between them a total of 6 single trips in each 48-hour period, although this may require improvements in port turnaround, which is possible given employment of vessels with reduced capacity.

Table 5: High-speed RoRo - number of vessels for daily service

Route	Distance/km	Sea margin	T'round /hrs	Ship speed /km-hr	Hours/ trip	Trips/ day/ship	Ships reqd
Clyde-Mersey	334	10%	3	70	8.2	2.9	0.7
Aber-Humber-Thames	819	10%	6	70	18.8	1.3	1.6
Forth-Tees-Thames	737	10%	6	70	17.5	1.4	1.5

When taking into account overall market needs in terms of the different freight segments, in addition to market size constraints, operationally the more attractive options for coastal RoRo freight ferry services in the UK appear to be:

- High-speed vessels capable of offering door-door transit times competitive with road transport;
- Ship speed adjusted to take account of optimal vessel employment on each route;
- Ideally each route served by two ships rather than one, to provide for greater frequency and to limit the effect of downtime giving improved reliability;

- Scale back ship capacity to help overcome market size constraint, and speed up port turnaround.

6. INTEGRATION AND SAFETY

Work Package 4 of the UKMM study considered the following issues:

- Assessment of RoRo ferry terminal facilities and intermodal transport integration;
- Analysis of navigation and safety issues, in port and at sea;
- Review of crewing and training issues.

Data was obtained on existing terminal facilities and intermodal transport integration for respective ports and port areas. Additional data was collected relating to navigation and safety issues in port areas. Information was gathered through semi-structured telephone interviews with harbour masters, port managers and other port authority personnel. This information was supported with data from port handbooks, port directories, port websites and industry news.

The main finding from this exercise was that existing and/or planned ports in the UK would be suitable for coastal RoRo services. However, some additional RoRo terminal capacity may need to be provided within established ports, plus improvements made in terms of road access. An essential pre-requisite for all ports is a need to ensure very fast ship entry, exit and turnaround times, and similarly for trucks entering or departing ports. In other words, a seamless combined transport solution.

Each port considered has a set of standard procedures regarding safety and environmental issues as dictated by government regulations (e.g. Maritime and Coastguard Agency waste management plans, oil spill response plans etc.). Pilotage exemption certificates are available to Masters calling regularly, thereby helping to reduce costs.

Existing legislation highlighted a distinction between cargo and passenger Ro-Ro vessels. The navigational equipment pertaining to both categories of vessel (cargo & passenger) was subsequently compared, and vessel construction and operation under either SOLAS or the High Speed Craft (HSC) Code requirements was considered. Little difference was found to exist between navigational equipment requirements for cargo and passenger categorised vessels identified under both Codes, and the present prescriptive requirements for navigational equipment for each of the study group of vessels also identified that there was little difference between the navigational equipment requirements of SOLAS and the HSC Code.

In terms of the navigation aspects of the study, appropriate coastal charts were analysed followed by identification in some detail of the most appropriate course for safe navigation on each of the routes, with indicative passage plans developed. Courses plotted are considered to be valid for each of the study group of vessels providing adequate draft and a sufficient safety margin from obstacles and hazards.

The passage plans for the east coast routes suggested that there are few options to safely reduce the distance between the proposed courses. However, for the west coast Clyde–Mersey route two passage plans were identified having approximately 6 nautical miles difference between them. The shorter route, while offering more shelter from Westerly conditions by transiting east of the Isle of Man, necessitates navigation through slightly more restricted channels.

The study also considered the requirement for identifying features of the harbour transit pilotage, from the respective fairway buoys to berthing at the respective harbours for each route, and sought to consider local navigational hazards, traffic density and speed restrictions that may be applicable. Maneuvering characteristics of the study group of vessels was considered and comments made on the regulatory approach to safety and on the International Safety Management Code requirements, as applicable to all the vessel types contained within the study group.

With regard to safety in port and at sea, therefore, existing legislation and working practices would help to ensure a safe and environmentally friendly operation. Inevitably with fast vessels there will be a need for extra care, although to a very large degree this would be built into relevant passage plans, augmented by ISM and HSC Code requirements.

7. COMMERCIAL VIABILITY

RoRo ferry costs were calculated for all three categories of vessel – conventional, fast-conventional and high-speed. The high-speed vessel modelled is the EHSCV (European High Speed Cargo Vessel) currently being promoted by Spanish shipbuilder IZAR, based on a design by UK naval architect Nigel Gee and using Rolls Royce gas turbine engines. Relevant cost data for this vessel was provided by the EHSCV consortium. While data for conventional and fast conventional ship categories is derived from earlier survey work in the UKMM project, in the absence of a pure high-speed cargo RoRo as reference point, earlier survey findings in this regard were to a large extent indicative only. The recent design work and active promotion of the EHSCV therefore provided a timely opportunity to assess and compare this specific design of vessel with established conventional and fast conventional options. Relevant cost details for all three ship types are presented in Table 6, with the EHSCV layout plan shown in Figure 6.

Table 6: Estimated daily vessel costs by vessel type

Vessel type		**Conv RoRo**	**Fast-Conv RoRo**	**Izar/NG EHSCV**
Capacity	Trailers	100	100	100
Speed	Knots	21	28	38
Vessel price	US$m	24.70	42.40	80.00
Vessel cost/day	US$	10,775	18,496	34,898
Crew, R&M, Insurance/day	US$	3,330	3,950	5,266
Total vessel cost/day	US$	14,105	22,446	40,164
Total vessel cost/day	GB£	9,795	15,587	27,891

An example of the methodology used to estimate door-door RoRo costs, in this instance for the high-speed ferry option, is shown in Table 7. The same methodology has been employed to estimate costs for other ship categories.

Port costs are calculated by summing port charges (estimated at £1,000 per port call), and cargo handling charge (£40 per trailer, or £20 at each end), plus ship time in port (3 hours assumed for port turnaround).

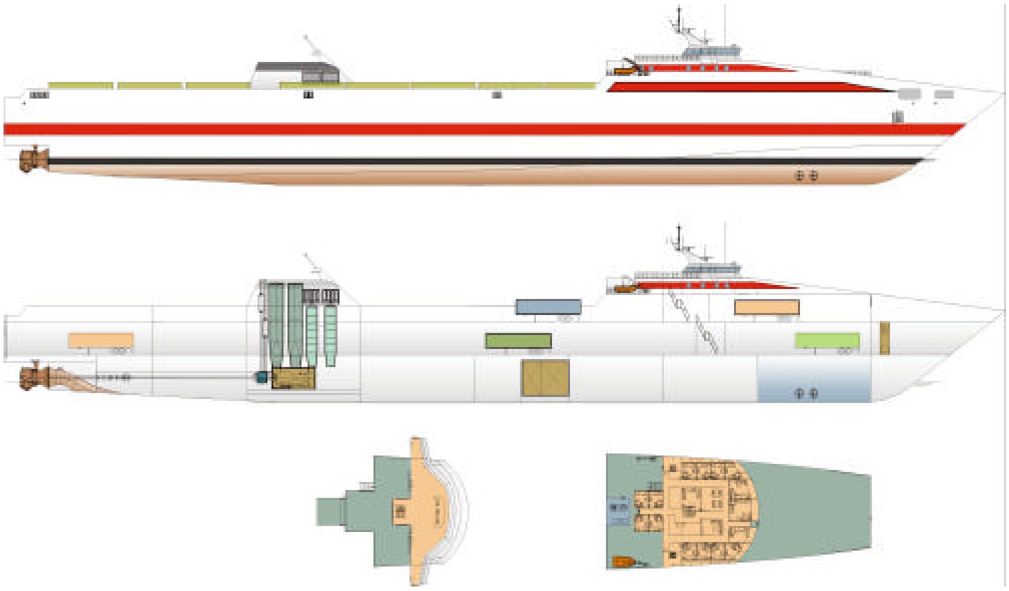

Figure 6: IZAR's EHSCV (European High Speed Cargo Vessel)

Table 7: High-speed RoRo ferry costs

		GB£
Capacity:	100 trailers	
Speed:	40 knots	
Vessel		
RoRo ferry cost/day:		27,891
Bunkers	288 Tonnes	
Fuel price	£90	
Fuel costs		25,821
	Total	53,712
	Per trailer	537
	Per trailer/km	**0.32**
Port		
Port costs		1,000
Cargo handling:		
2 x 100 units @	£40	8,000
Ship time	3 Hours	3,486
		12,486
Per trailer		125
Local collect and deliver		200
Slot cost per trailer		**325**

Table 8: Conventional RoRo and road haulage door-door costs per trailer compared (GB£)

	By Sea				By Road				Difference Sea/Road		
Route	Fixed/unit	Ship/km	Dist/km	Cost/RoRo	Fixed/unit	Variable/km	Distance/km	Cost/Road	Cost £	%	Diff/sea-km
Humber-Thames	302	0.15	347	354	165	0.41	299	288	66	23%	0.19
Forth-Thames	302	0.15	713	408	165	0.41	665	438	-29	-7%	-0.04
Tees-Thames	302	0.15	476	373	165	0.41	429	341	32	9%	0.07
Forth-Tees	302	0.15	261	341	165	0.41	235	261	80	31%	0.31
Aberdeen-Thames	302	0.15	728	411	165	0.41	887	529	-118	-22%	-0.16
Aberdeen-Humber	302	0.15	473	373	165	0.41	603	412	-40	-10%	-0.08
Clyde-Mersey	302	0.15	334	352	165	0.41	357	311	40	13%	0.12
Average			476	373			496	369	4	1.2%	0.01

Table 9: Fast conventional RoRo and road haulage door-door costs per trailer compared (GB£)

	By Sea				By Road				Difference Sea/Road		
Route	Fixed/unit	Ship/km	Dist/km	Cost/RoRo	Fixed/unit	Variable/km	Distance/km	Cost/Road	Cost £	%	Diff/sea-km
Humber-Thames	309	0.23	347	389	165	0.41	299	288	101	35%	0.29
Forth-Thames	309	0.23	713	473	165	0.41	665	438	35	8%	0.05
Tees-Thames	309	0.23	476	418	165	0.41	429	341	78	23%	0.16
Forth-Tees	309	0.23	261	369	165	0.41	235	261	108	41%	0.41
Aberdeen-Thames	309	0.23	728	476	165	0.41	887	529	-53	-10%	-0.07
Aberdeen-Humber	309	0.23	473	418	165	0.41	603	412	6	1%	0.01
Clyde-Mersey	309	0.23	334	386	165	0.41	357	311	74	24%	0.22
Average			476	418			496	369	50	13.5%	0.10

Table 10: High-speed RoRo and road haulage door-door costs per trailer compared (GB£)

		By Sea				**By Road**				**Difference Sea/Road**	
Route	Fixed/unit	Ship/km	Dist/km	Cost/RoRo	Fixed/unit	Variable/km	Distance/km	Cost/Road	Cost £	%	Diff/sea-km
Humber-Thames	325	0.32	347	435	165	0.41	299	288	147	51%	0.43
Forth-Thames	325	0.32	713	552	165	0.41	665	438	114	26%	0.16
Tees-Thames	325	0.32	476	476	165	0.41	429	341	135	40%	0.28
Forth-Tees	325	0.32	261	408	165	0.41	235	261	147	56%	0.56
Aberdeen-Thames	325	0.32	728	556	165	0.41	887	529	28	5%	0.04
Aberdeen-Humber	325	0.32	473	475	165	0.41	603	412	63	15%	0.13
Clyde-Mersey	325	0.32	334	431	165	0.41	357	311	120	38%	0.36
Average			476	476			496	369	108	29.2%	0.23

Based on this approach, and taking the conventional services first (Table 8), the average door-door cost across all UKMM routes using coastal RoRo appears to be similar to direct road haulage options (i.e. £373/sea and £369/road), sea transport being only 1.2% more expensive per trailer-slot. However, the outcome for individual routes differs markedly; on longer routes, the economics of coastal shipping become more favourable, whereas on shorter routes road haulage is less expensive. Average sea distance for all seven routes is 476 km compared with 496 km by road, which means sea transport in the UK enjoys only a marginal distance advantage.

Added to sea leg costs is a local collect-deliver charge estimated at £200 per trailer (i.e. £100 at each end). The latter assumes the initial origin and final destination of trailers is located within a 2-hour drive of the respective ferry terminals, or in other words a maximum port hinterland of 150 kms, reflecting earlier findings from the demand analysis.

For the fast-conventional RoRo option (Table 9), on average the door-door cost of coastal shipping across all seven routes is £418/trailer-slot compared with £369 by the all-road option, a difference of 13.5%.

Door-door cost per trailer slot for the high-speed craft, based on the EHSCV design offering 100-trailer capacity, works out at £0.32 per trailer/km for the sea leg, plus a fixed cost of £325 per trailer-slot (inclusive of local road transport costs). For the high-speed coastal RoRo option (Table 10), average door-door cost is estimated to be £476/trailer-slot compared with £369/trailer based on direct road haulage, representing a cost increase of £108 /trailer or 29.2% for this ship type.

A summary of average cost differences between road and sea transport taken across all seven routes for each of the three RoRo options is presented in Table 11. It should be noted that ferry costs and road haulage costs as indicated do not include an operator profit margin. Moreover, these are ‘slot costs’, that is the cost of providing a trailer slot for a given ship size. Hence variations in utilisation levels (for both ferry and road transport) will also affect the final outcome.

Table 11: Average road/sea trailer slot cost variance (all routes)

RoRo Ship Type	Road/sea cost variance	% change
Conventional	+£4/trailer-slot	+1.2%
Fast-Conventional	+£50/trailer-slot	+13.5%
High-Speed	+£108/trailer-slot	+29.2%

Table 12 estimates break-even distances for all three RoRo vessel types compared with road transport in the UK based on current rates. For the conventional RoRo option, break-even distance is estimated to be 524 km; at this distance the door-door haulage and RoRo rate is the same, £380 per trailer. Break-even distance for the fast-conventional service competing against road haulage is 801 km, involving a transport cost of £493 per trailer. For the high-speed RoRo the break-even distance is much longer, being equivalent to1,732 km and representing a transport cost by road or sea of £875 per trailer.

Further data on the high-speed trailer slot cost breakdown is presented in Table 13 and illustrated in Figure 7. This shows that the actual sea leg costs for even the most expensive coastal option (i.e. high-speed) represents between 41% and 57% of total door-door slot costs, depending on route. The road haulage expense represents between 36% and 46% of door-door slot costs, with shorter sea routes incurring a higher share. Port handling charges make up between 7% and 10% of the trailer slot cost for all routes.

Table 12: Break-even distance and respective transport cost per trailer for each RoRo type compared to all-road

	Road Cost	RoRo Cost	Distance/km
Conventional RoRo	£380	£380	524
Fast-Conventional RoRo	£493	£493	801
High Speed RoRo	£875	£875	1,732

For the high-speed cargo vessel, when averaged across all routes modelled, the door-door trailer slot cost is £476, of which £200 (42%) is for road haulage, £40 (8%) for cargo handling, and £236 (50%) for the sea leg. In other words, the actual cost of the sea transport leg, even based on the more expensive high-speed vessel, works out at approximately one half of total door-door slot costs.

Table 13: High Speed RoRo trailer slot cost breakdown (£)

Route	Sea-leg*	Handling	Road haulage	Total
Humber-Thames	195	40	200	435
	45%	9%	46%	
Forth-Thames	312	40	200	552
	56%	7%	36%	
Tees-Thames	236	40	200	476
	50%	8%	42%	
Forth-Tees	168	40	200	408
	41%	10%	49%	
Aberdeen-Thames	316	40	200	556
	57%	7%	36%	
Aberdeen-Humber	235	40	200	475
	49%	8%	42%	
Clyde-Mersey	191	40	200	431
	44%	9%	46%	
Average	236	40	200	476
	50%	8%	42%	

* Includes cost of ship time in port

A major portion of coastal shipping costs (i.e. two-fifths on average) therefore relates to road haulage, not to sea transport. Sea transport appears to be efficient per sea km for any ship type compared to the cost of road haulage per road km. For all ship types, including high-speed, it is local road transport costs to/from ports that make sea transport less competitive than the all-road alternative, not the cost of sea transport per se.

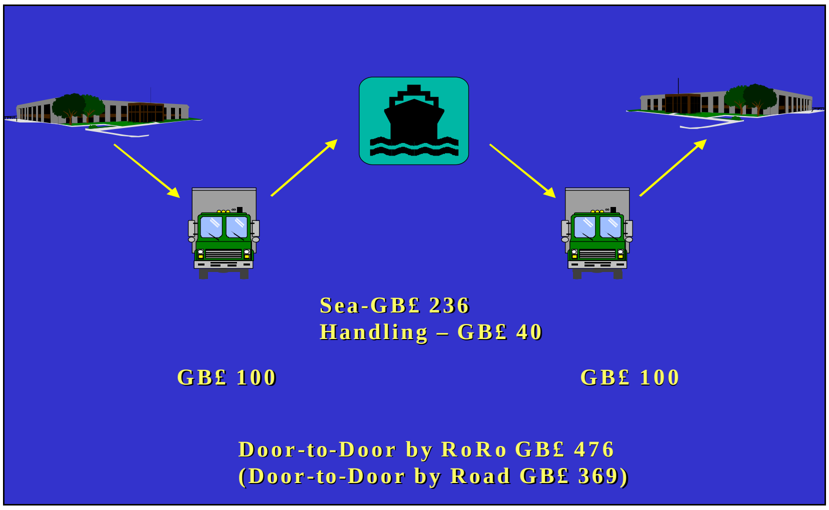

Figure 7: Average door-door high-speed RoRo trailer slot-cost breakdown

Table 14 compares the cost of sea (using high-speed RoRo) and road transport over the average UKMM route distance of 476km, ignoring additional combined transport expense. The sea leg trailer-slot cost for a high-speed ship over this distance works out at £0.49 per trailer/km, whereas by road the cost is £0.77 per trailer/km. Excluding the combined transport element of door-door costs, this demonstrates that sea transport is less expensive per vehicle-km than the all-road option.

Table 14: Road and sea (excluding combined transport costs) trailer-slot cost compared

	Average (sea) distance	Per trailer slot-cost	Cost per trailer-km
Road	476km	£369	£0.77
Sea (high-speed)	476km	£236	£0.49

8. ENVIRONMENTAL IMPACTS

Environmental costs per single trailer trip and per annum for all routes in aggregate have been calculated over respective cost categories. Table 15 presents the outcome of this exercise, comparing a single trailer trip by road (i.e. ‘direct’) and by RoRo. Figures are also annualized for all routes (i.e. the UKMM ‘network’) based on a minimum daily service frequency/rate and assumptions regarding vessel load factors.

The results indicate environmental cost savings from road-to-sea modal shift would be significant. Taking all routes in aggregate, there is an estimated 86% saving in external transport costs, which is equivalent to almost £16.5 million per annum.

Internal cost savings to industry (excluding sea freight) are far greater for unaccompanied trailers than accompanied, reflecting the opportunity cost of carrying a tractor unit and driver by sea. For all routes in aggregate, unaccompanied trailers moved by RoRo would save 77% in internal transport costs, whereas if only accompanied vehicles were carried the saving would be 33%. In addition, road vehicle-kms would reduce by 66%, and tonne/kms by 84%.

Efforts were also made to estimate the effect on air pollution and climate change of a shift from road to sea, however the results of this were inconclusive and more research into these aspects will be required.

Table 15: Totals external costs for all UKMM routes

	Single Trip		Annual Trips		
	Direct	**via RoRo**	**Direct**	**via RoRo**	**Saving (%)**
External Costs (£)					
Network Total	504	71	19,202,838	2,851,937	86%
Internal Costs - Trailer Only (£)					
Network Total	2,850	896	109,536,176	25,683,448	77%
Internal Costs - Tractor/Trailer (£)					
Network Total	2,850	1,912	199,024,710	133,535,194	33%
Highway Distance Travelled (Vehicle Kms)					
Network Total	2,850	1,912	109,536,176	37,654,166	66%
Highway Freight Moved (Tonne/Kms)					
Network Total	54,850	8,553	3,508,487,500	564,812,500	84%

Figures are subject to rounding effects
Network total = all routes combined
Direct = all-road

9. CONCLUDING REMARKS

Results from the demand analysis proved inconclusive as far as forecast usage of coastal RoRo services is concerned. There is clearly more research to be done in this area. However, the study was able to establish key requirements of the road transport logistics sector vis-à-vis any coastal shipping combined transport solution.

Findings indicate that the high speed RoRo ship type appears to offer best prospects for coastal shipping to develop in the UK. The present technology in regard to high-speed vessel and service operations should be sufficient to provide for an attractive combined transport service compared to all-road haulage. Vessel service speeds approaching 40-knots/70 km-hr (i.e. high-speed) would be necessary to ensure that coastal RoRo services offered a comparable transit time to road haulage. In order to address the requirement for high service frequency and to counteract the market share challenge, moderate rather than large capacity vessels may need to be considered (i.e. capacity under 100 trailers).

A slower conventional RoRo service would not be attractive to the majority of the freight market in terms of transit time. Neither is the fast conventional category of vessel (i.e. 24-30 knots service speed) likely to be sufficiently 'fast enough' in regard to transit time on domestic routes compared with road haulage for key freight market segments.

Based on a door-door analysis, the high-speed RoRo (i.e. the preferred ship type) would offer, for the routes considered, an average trailer slot cost almost 30% above the present cost of road haulage. On average, across all routes, the door-door trailer slot cost for a high-speed RoRo would be £476, compared to £369 by road, representing an increase of over £100 per trailer movement (i.e.29%).

A breakdown of the RoRo cost of £476 per trailer-slot shows that this is made up of £200 (42%) for local road haulage, £40 (8%) for cargo handling, and £236 (50%) for the sea leg.

In other words, the actual cost of the high-speed sea transport leg works out at approximately one half of total door-door trailer-slot costs. By implication, a major portion of door-door coastal shipping costs actually relates to road haulage, or the combined transport element of the trip. Compared to the cost of road haulage, sea transport costs (i.e. for the sea leg alone, ignoring combined transport costs) are more competitive per trailer-km for any ship type.

An important conclusion to be drawn from this study is that, while there would be considerable environmental benefits to be gained from moving targeted volumes of freight from road to sea, due to proportionally higher financial costs of short-distance local road haulage to/from ports, modal shift in significant measure is unlikely to occur if this is left entirely to market forces.

To allow sea transport to compete and overcome market distortions in terms of low land transport costs, a consequence of many years public funding applied to road and rail infrastructure, government would need to introduce some form of financial support scheme, however labelled (Sea Access Grant, for example), mainly targeted towards unaccompanied trailers. This could involve, in part, applying annualised external cost savings as a measure of support in return for shifting specified traffic volumes off roads and onto RoRo ferries. How best to bring about such a fundamental market change will inevitably be a matter of debate, although in principle such support would appear to conform with EU rules and policy regarding expansion of short sea shipping and road to sea modal shift. On the basis of findings from this study, as a starting point government would need to consider the following 'menu' of options:

- Measures to reduce local road haulage costs to/from ports, (perhaps combined with measures to increase long-distance road haulage costs);

- Measures to assist in provision of adequate port infrastructure;

- Measures to share some of the risk with the private sector for investments in ships, and to assist service start-up costs.

As indicated in the viability assessment, support has to be targeted towards reducing the cost of local haulage to and from ports, rather than necessarily supporting sea leg operating costs, the latter being competitive with long-distance road transport. This approach would have the added advantage of being attractive to the road haulage industry. In addition, any form of road charging on motorways is likely to lead to pressure for modal shift to sea transport. Support is also necessary to provide adequate port infrastructure in terms of RoRo terminals, and road access improvements.

In order to achieve best outcomes, a new technologically advanced network of coastal RoRo services is likely to require modern specially built vessels. Acting independently, the private sector may consider the risk involved in this to be too great. For such a fundamental change to take place, especially in a marketplace already heavily distorted in favour of road (and rail) transport, with the state actually providing much of the infrastructure, initially at least there will be a need for measures to facilitate some sharing of risk between the private and public sector, and to assist RoRo service start-up costs. One way to do this might be to franchise the operation of each RoRo route over a given period of time, with the level of support based on forecast traffic flows, startup costs and operating deficit. Franchising, through a competitive tender process, would also allow for selection of the most optimal service provider(s) in terms of value for money and overall quality of service.