FREIGHT TRANSPORT, LOGISTICS AND SUSTAINABLE DEVELOPMENT

A report for

W W F

by

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August 1994

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INTRODUCTION

Road freight transport provides transport and environmental policy with some of its most intractable problems. Lorries are visually very intrusive, noisy, polluting and responsible for much of the impetus behind road building strategies. They are the most visible component of a relatively new and sophisticated production and distribution system that has evolved in a way that weakens local production and consumption links and encourages longer distance supply lines. Over time the distances over which freight moves have lengthened and the amount of dependence on distant sources and complex road freighting operations has increased.

In order to understand the forces that currently mould road freight operations we have to be aware of the importance of the spatial distribution of manufacturing and the geographical location of raw material and intermediate product inputs into a final manufactured product. Such an awareness can reveal the beginnings of a new strategy that will move freight transport operations in the direction of sustainable development. The work of Böge (1994a) has made these processes much more transparent and revealed the opportunities provided by substituting "near" for "far" in sourcing decisions.

Substituting "near" for "far" has much more potential to reduce the demand for freight transport and reduce emissions from this sector (especially CO2) than has modal transfer. Transferring freight from road to rail is important and will play a large part in environmental strategies designed to reduce the environmental degradation of hard pressed corridors. Rail has a much larger part to play, for example, in resolving freight capacity problems across the Pennines and in bringing urgent relief to the residents along the route of the A36 (Southampton to Bristol).

Freight transport strategies have to be alive to a number of influences. They must recognise the importance and growing importance over time of emissions from this sector. These emissions have well recognised negative impacts on human health and even though lorries form a relatively small part of the total number of vehicles their impact on emission inventories is disproportionately large. Freight transport strategies must recognise the commercial importance of moving goods around and satisfying the transport demands from other economic sectors. This will require careful negotiation with interested parties and careful management of all transport modes and all possibilities for local sourcing. Freight transport strategies must reflect the importance of environmental and sustainable development objectives. The Royal Commission on Environmental Pollution in its 18th report concludes:

"..a further increase in the environmental impact of freight transport by road, on the scale implied by DOT's 1989 forecasts, would not be acceptable."

Source: HMSO (1994a) para 10.61

The UK currently lacks a planning framework that would stimulate a freight transport strategy capable of meeting sustainable development objectives, health objectives and supporting a varied and healthy economy at local and national levels. A prerequisite for a successful strategy in this area is an analysis of the demand for freight transport, the main components of the market and the steps that can be taken to move towards a new set of arrangements. In this progression the relative importance and timing of modal shift strategies and fundamental reduction in demand strategies will be of the greatest importance.

SUSTAINABLE DEVELOPMENT AS A PLANNING FRAMEWORK FOR FREIGHT TRANSPORT

The concept of sustainable development has been accepted as a national planning goal (HMSO, 1994b) and has been widely interpreted as advancing development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs. Unlike some other countries eg Germany and the Netherlands, Britain has been very resistant to converting these principles into clear targets and objectives that can inform planning goals at the sectoral and the spatial level. The absence of such clear goals is a major impediment to the successful implementation of sustainable development principles at national and international levels and encourages incremental drift in the provision of infrastructure (especially roads, airport terminals and runways) that will increase the amount of carbon dioxide and NOx emissions.

The absence of clear sustainability targets and objectives also acts as an obstacle to the formulation of innovative strategies that will meet sustainability criteria and at the same time meet basic human needs for economic and social welfare. This point has been summarised by Meadows, Meadows and Randers (1992):

> A sustainable society would be interested in qualitative development, not physical expansion. It would use material growth as a considered tool, not as a perpetual mandate. It would be neither for nor against growth, rather it would begin to discriminate kinds of growth and purposes for growth. Before this society would decide on any specific growth proposal, it would ask what the growth is for, and who would benefit, and what it would cost, and how long it would last, and whether it could be accommodated by the sources and sinks of the planet. A sustainable society would apply its values and its best knowledge of the earth's limits to choose only those kinds of growth that would actually serve social goals and enhance sustainability. And when any physical growth had accomplished its purposes, it would be brought to a stop.
>
> Source: Meadows, Meadows & Randers (1992) page 210

TARGETS AND OBJECTIVES

The UK government and the EU with the support of the UK government has entered into a number of commitments that give formal articulation to sustainable development objectives. They include the Framework Convention on the Atmosphere (Climate Treaty) covering greenhouse gases, the Convention on the Conservation of Biological Diversity and the Convention on Long Range Transboundary Air Pollution. All of these are influenced by concepts of environmental capacity which indicate levels of pollution that should not be exceeded. Clearly any breaches of threshold values that compromise the ability of environmental systems to repair themselves or that trip dramatic changes in temperature or climate will damage the prospects of future generations. The main areas for international targets and objectives are briefly summarised below.

1 *Framework Convention on the Atmosphere (Climate Treaty):* Developed countries are required to take measures aimed at returning emissions of greenhouse gases (in particular carbon dioxide) to 1990 levels by 2000 and to provide assistance to developing countries. Other obligations include compiling inventories of emissions, producing and publishing national programmes of measures to limit emissions and to promote research and public education about climate change. The Convention came into force on 21 March 1994 following ratification by 50 countries. It has been signed and ratified by both the European Union and the UK.

Source: NSCA 1995 Pollution Handbook, page 62

2 *Convention on the Conservation of Biological Diversity*: aims to protect and preserve endangered plants and species on land and in the oceans. This Convention came into force on 29 December 1993 following ratification by 30 countries; it became legally binding 90 days later. Countries will each draw up a list of "protected areas". Use of resources in protected areas - e.g. exploitation of plants for medicines - would need to be paid for with financial assistance additional to current levels of development assistance. It has been signed and ratified by the EU and the UK.

Source: NSCA 1995 Pollution Handbook, page 63

3 **Convention on Long-Range Transboundary Air Pollution**

This convention, which was adopted in Geneva in 1979, was drawn up under the auspices of the UN Economic Commission for Europe (which comprises all the countries of Europe and of North America); it came into force in 1983. The Convention was the result of concern - particularly from Norway and Sweden - that the long-range transport of certain pollutants (mainly sulphur dioxide and nitrogen oxides) was having an adverse effect on the environment of their countries. The Convention says that countries shall "endeavour to limit and, as far a possible, gradually reduce and prevent air pollution, including long range transboundary air pollution". This should be achieved through the "use of best available technology that is economically feasible".

The Convention also deals with the long-range transport of nitrogen and chlorine compounds, polycyclic aromatic hydrocarbons, heavy metals and particles of various sizes. Requirements relating to specific pollutants are set out in protocols to the Convention.

Sulphur Protocol

The Helsinki Protocol, adopted in 1985 and which came into force in 1987, requires signatories to reduce national sulphur emissions, or their transboundary fluxes, by 30 per cent on 1980 levels, to be achieved by 1993. This Protocol was not ratified by either the UK or the European Union, although a number of individual Member States did do so.

This Protocol has now been renegotiated using data based on critical loads assessments; countries are required to reduce, by the year 2000, their sulphur emissions to meet a UNECE-wide target of 60 per cent of the gap between sulphur emissions and the critical load. Particularly sensitive areas of Scandinavia, Germany and The Netherlands where natural and unattributable emissions exceed the critical load have been excluded from the calculations.

Individual countries' target reductions are based on their contribution to acid deposition over the areas included in the calculations. To meet the 60 per cent target, the UK has agreed to reduce its own sulphur dioxide emissions by 50 per cent by 2000, 70 per cent by 2005 and 80 per cent by 2010 (on 1980 levels). (To meet the target by the year 2000 would have required the UK to reduce its emissions by 79 per cent, a target to which the UK would not agree.)

The new Protocol was officially signed in June 1994 and will come into force 90 days after ratification by 16 countries. Within six months of doing so, parties to the Protocol must submit their national strategies for meeting their targets to the UNECE monitoring committee. Progress on the Protocol is to be reviewed in 1997.

Both the UK and EU have signed the Protocol.

Nitrogen Oxides Protocol

The 1988 Sofia Protocol freezes nitrogen oxides emissions, or their transboundary fluxes, by 1994 using a 1987 baseline. This Protocol, which came into effect in February 1991, is due for renegotiation in 1995. (Possible bases for renegotiation being considered include the effects of acidification and eutrophication and/or including the effects of photochemical oxidants.

There is a commitment that subsequent reductions in emissions of both sulphur dioxide and nitrogen oxides will be negotiated "taking into account the best available scientific and technical developments ... and internationally accepted critical loads". The "critical loads" approach takes account of the level of pollutant which a receptor - e.g. ecosystem, human being, plant or material - can tolerate without suffering long term adverse effect according to current knowledge.

Critical loads maps covering the whole of Europe are being drawn up by the European Evaluation and Monitoring Programme (EMEP) under the LRTAP Convention. In the UK, the Department of Environment is preparing maps showing the levels of deposition at which soils in the UK are vulnerable to acidity. Other maps show actual estimates of deposition and where this is likely to exceed the critical load. Maps are also being drawn up for freshwaters.

Both the UK and the European Union have ratified this Protocol.

Source: NSCA (1995), page 65-66

PROGRESS TOWARDS MEETING OBJECTIVES

At the moment there is very little sign of progress in the UK in meeting its targets for greenhouse gas reduction. The Royal Commission on Environmental Pollution (HMSO, 1994a) notes that CO2 emissions from the transport sector doubled between 1970 and 1990 (para 3.58) and that CO2 emissions will show further substantial increases over the next 25 years (para 3.59). The UK government has not produced strategies at the sectoral level to illustrate either (a) how transport can reduce its CO2 emissions or (b) how non-transport sectors will deliver disproportionately large reductions to accommodate a transport overshoot.

UK emissions of NO2 increased from 2365 k tonnes in 1980 to 2747 k tonnes in 1992, a 16% increase (Source: Acid News, December 1995). The Royal Commission on Environmental Pollution note a 61% increase in NOx between 1982 and 1992 (para 3.9). Forecasts of future levels of lorry (HGV) activity indicate a substantial increase in NOx from this sector.

NOx emissions damage crops, forestry, natural vegetation, aquatic ecosystems and materials. Methods have been developed to estimate and map critical levels and critical loads that should not be exceeded if this damage is to be avoided (Umweltbundesamt, 1993). Critical levels are defined as "concentrations of pollutants in the atmosphere above which direct adverse effects on receptors such as plants, ecosystems or materials may occur according to present knowledge" (Umweltbundesamt, 1993, page 18). Critical levels for NOx have been adopted for direct effects on forests, crops and natural vegetation.

Critical levels for NOx (NO and NO2 added in nl 1^{-1}), expressed as NO2 ($\mu g\ m^{-3}$), in combination with concentrations of SO2 (annual mean) and/or exposures of O_3 below their critical level.

Criteria	Annual mean	4-hour mean
Adverse eco-physiological effects	30	95

Source: Umweltbundesamt (1993)

UK emissions of sulphur dioxide show a substantial decrease between 1980 and 1992 though diesel fuels are an important source of sulphur emissions. As low sulphur and sulphur free diesel fuels are available this should not be a problem in the future.

HEALTH TARGETS

NOx reductions form part of UK health targets detailed in "The Health of the Nation" (HMSO, 1991). The relevant target is particularly important in the context of lorries in or near urban areas:

> **Air Quality: Oxides of Nitrogen (NOx) and Photochemical Oxidants**
>
> Emissions of oxides of nitrogen (NOx) contribute to acid rain and to photochemical oxidants. The principal sources are large combustion plants such as power stations and vehicles. Action is in hand to reduce emissions from both these sources.
>
> Under certain weather conditions the WHO Guidelines for peak ozone concentration in air is occasionally exceeded in parts of southern England. Solving this problem will require national and international action to reduce emissions of NOx and of volatile organic compounds which are the precursors of this ozone;

- On a 1980 baseline, reduce emissions of NOx from existing large combustion plants by 30% by 1998;
- Reduce NOx levels in urban air on a 1990 baseline by at least 50% by 2000;
- By 2000 effective national and supra-national controls should be in place to ensure that air quality meets the WHO Guideline for peak ozone concentration.

HMSO (1991) page 102

NOx pollution from lorry activity is predicted to rise to the year 2025 (HMSO, 1994a). It is highly unlikely that the health target can be met.

"STRONG AND WEAK SUSTAINABILITY"

English Nature (1992) has identified two broad interpretations of sustainable development:

1 Weak sustainable development. This requires that environmental considerations are taken into account in policy making but allows these considerations to be "traded-off" against other goals to generate a socially optimal or desirable result.

2 Strong sustainable development. In which environmental considerations act as a constraint on the achievement of other social goals. Development is allowed but subject to certain prior considerations being met. These considerations are sometimes referred to as sustainability constraints or environmental limits.

These two positions reflect the political uncertainties surrounding sustainable development at national and local level in the UK. The first position effectively categorises environmental issues as important only when they do not conflict with other policy goals. This can be seen very clearly in the policies of Lancashire County Council which have a strong element of environmental responsibility in the documentation (eg "Greening the Red Rose County") but in practice demands for road building linked to assumptions about economic growth lead to non-sustainable policies which add to greenhouse gas inventories.

Environmental goals are not lower order "goods" and expectations but of equal significance to economic and social policy goals. In practice economic and social goals are more likely to be achieved through policies informed by sustainable development principles. For these reasons there is a very strong presumption in this report in favour of "strong sustainability" and in favour of the kind of structural change suggested by Meadows, Meadows and Randers (1992). Modal transfers (eg from road to rail) are examples of "weak" sustainability. They will produce environmental gains but they cannot challenge the fundamental processes driving up the demand for freight transport. This level of demand cannot be met by the railway system. "Strong" sustainability will be aimed at the growth process itself and thorough structural change, spatial readjustments, ecological taxation, strengthening of local economies and some modal transfer will reduce the level of demand for freight transport whilst protecting and enhancing social and economic objectives.

ENVIRONMENTAL IMPACTS

The impact of road freight transport on local, regional and global environments is large and rising. Taylor and Fergusson (1993) have shown that carbon dioxide emissions from heavy goods vehicles could rise by as much as 138% by the year 2025. If rail traffic doubles its 1990 share at the expense of road, carbon dioxide emissions are reduced by about 10-15% from the baseline. Emissions of air pollutants generally are a serious and growing problem in the road freight sector and in the case of nitrogen oxides and particulates, cannot be resolved entirely by modal shifts from road to rail.

Lorries with a weight of more than 16 tonnes produce large quantities of carbon dioxide. Over a distance of 1000km at an assumed average speed of 80kph trucks of this size release 400kg of CO2. CO2 and NOx emissions rise dramatically with higher speeds emphasising the importance of speed control for lorries (Topmann, 1994).

A study by the Umweltbundesamt (Federal Environment Office) in Berlin reported in Topmann (1994) shows that traffic is responsible for the greater part of noise pollution. At a speed of 50kph a lorry produces as much noise as 23 cars or in other words 4.2% of one lorry is responsible for the same noise level as one passenger car. Noise levels are higher because of overloading of lorries. "Systematic traffic controls have shown again and again that up to 25% of all trucks are overloaded" (Topmann, 1994).

The environmental impact of freight transport has been summarised elsewhere (Whitelegg, 1993 and Rothengatter, 1991). Rothengatter has produced a particularly useful summary reproduced here as Table 1. Road freight is particularly damaging by comparison with rail and inland waterway. In the case of carbon dioxide lorries produce 207 grams per tonne-km (g/tkm) and trains at 41 g/tkm. These calculations are based on German data but are very similar to EU wide calculations (Tanja, 1993) showing lorries at 181g/tkm and rail freight at 39 g/tkm. The five fold lorry penalty is a major obstacle to achieving CO2 reduction targets and a major source of future growth in greenhouse gas emissions.

Table 1

Development of tonne kilometres and air pollution of goods transport in the FRG (Trend-Scenario).

	Goods Transport					
	Rail		Inland Waterways		Road	
	1987	2005	1987	2005	1987	2005
tonne kilometres	58	69	50	60	145	206
Total emissions (thousand tonnes per annum)						
carbon dioxide	2,364	2,081	2,071	2,372	30,052	38,900
methane	4	3	3	3	43	53
TVOC	5	4	7	8	163	139
nitrogen oxide	13	5	25	28	516	495
Carbon oxide	3	1.1	8	10	350	231
Specific emissions(grams per tonne kilometre)						
carbon dioxide	41.00	30.00	42.00	40.00	207.00	189.00
methane	0.06	0.04	0.06	0.05	0.30	0.30
TVOC	0.08	0.06	0.10	0.13	1.10	0.70
nitrogen oxide	0.20	0.07	0.50	0.50	3.60	2.40
carbon monoxide	0.05	0.02	0.17	0.17	2.40	1.10

Source: Rothengatter (1991)

Such calculations can also be done on a product by product basis as is the case of German yoghurt (Table 2).

Table 2

Selected pollutant emissions per produce and road category in g/tkm

	NOx	SO2	dust
Strawberry yoghurt 150g			
urban roads	1.20	0.10	0.08
country roads	3.60	0.30	0.24
highways	18.00	1.50	1.20
Total	22.80	1.90	1.52
Strawberry yoghurt 500g			
urban roads	1.20	0.10	0.08
country roads	3.00	0.25	0.20
highways	10.20	0.85	0.68
Total	14.40	1.20	0.96
Chocolate pudding 125g			
urban roads	1.80	0.15	0.12
country roads	1.80	0.15	0.12
highways	47.40	3.95	3.16
Total	51.00	4.25	3.40

Böge (1994a) has done a great deal to demonstrate the links between life style, consumption and road freight transport. Her work shows the inadequacy of focussing exclusively on modal shift as a central principle of sustainable freight transport. The European and global pattern of manufacturing, sourcing and distribution are deeply embedded in a spatial system based on long supply lines and just in time transport that cannot respond to pricing and investment signals in the short to medium term.

Böge shows that one 150g pot of strawberry yoghurt is responsible for moving one lorry over a distance of 9.2 m. More recently Böge (1994b) has shown that a 500g container of mushrooms is responsible for moving one lorry over a distance of 65m. The tendency to move food products and manufactured goods over longer and longer distances builds large growth rates into road freight transport and moulds spatial structures into a shape that can only be served by road freight.

Sony (UK) has moved from 8 distribution centres in the UK to one (Thatcham, near Newbury). Operating at one site has reduced the logistic operating costs by nearly £1 million per annum and reduced interest by reducing inventory (Parsons, 1990). All dealers in the UK whether Aberdeen or Plymouth are served by Thatcham adding large amounts of extra tonne kilometres and associated pollution. Sony has also conducted a pan-European analysis with a view to reducing the number of depots on a European scale to 4-6 in total, considerably extending the length of supply lines but reducing inventory costs dramatically.

European trends in freight transport and modal split are shown in Table 3. Road freight has grown at just over 4% pa over a 20 year period whilst rail has declined. This growth in road freight has been accompanied by and stimulated by a number of technological, spatial and organisational factors:

1. The dispersal of economic activities.
2. The process of economic integration in the EU, completion of the internal market and cabotage.
3. The development of a strongly based service economy and the decline of traditional industries with strong raw materials and bulk flow characteristics.
4. The rapid diffusion of logistics based on reducing inventory costs and using the transport system as a storage/production line component. Just-in-Time delivery (JIT) is based on splitting loads into smaller batches which means a higher number of transport movements for a given load.
5. Goods are shipped over longer distances.

6. Rail and combined transport are less competitive over short distances and 66% of all goods in the EU are transported within 50km and a further 20% within distances of between 50-150km, leaving only 14% for longer distances (CEC, 1992, p11).

Table 3

Trends and development of modal split, 1970-1990: Western Europe

Mode	Transport volume		Growth % year	% modal share	
	1970	1990	1970-1990	1970	1990
Inland Freight (thousand million tonne-km) (15 countries)					
• Road	430.98	952.36	4.04	50.06	66.32
• Waterways	105.83	109.58	0.17	12.29	7.63
• Rail	252.76	234.09	-0.38	29.36	16.30
• Pipelines	66.58	121.71	3.06	7.73	8.48
• Air	_ 4.83	18.35	9.31	0.56	1.28
Total	***861.43**	**1436.09**		**100**	***100**

_ 1975 *Figures as quoted in original source

Source: CEC (1994) Europe Environment 1993 Ch.12, Transport

Forecasts of future levels of demand in road freight transport vary enormously. EU documentation refers to a doubling of road freight:

> *"As to the future, forecasts of growth in transport demand show that in the business as usual scenario with a reasonably favourable economic climate the expansion of the road sector is likely to be buoyant. Under these conditions, a near doubling of road transport demand for both passengers and freight seems likely"*
>
> CEC (1992), para 28, p15

More analytical studies with a well defined time framework have produced a percentage increase in tonne kilometres of road freight of up to 149. Table 4 summarises a number of forecasts for Germany and for the European Union.

Table 4

Comparison between various traffic scenarios (% growth factors)

Source	Freight Traffic			Road Freight Traffic			
	West Germany		EC	West Germany		EC	
	tkm	CO2	tkm	tkm	CO2	tkm	CO2
EG '89 (1987-2010)			64			77	
EG '90	27			27	16	42	30
Hopf '90 (1987-2005)	32			42	29		
Prognos '91 (1987-2005)		23		24			
Röhling '91 (1988-2010)	75			76			
Röhling BRD	77			111			
ECMT '90 (1988-2010)			51			74	
NEA '92						149	83
IFEU '91/92 (1988-2000)	34	23		45	20		
Shell '90	66			69			

Key: CO2 = CO2 emissions; tkm = tonne-kilometres. All figures are percentage growth factors.

Source: Hey, C. et al (1992)

Bleijenberg (1993) looks at forecasts of increased activity in the road freight sector. He quotes a forecast based on the "Conventional Wisdom Scenario" prepared by the Directorate General for Energy of the CEC. This predicts a growth of 58% in tonne kilometres over the period 1990-2010. In the same period fuel consumption will rise by 23-57% even taking into account improvements in energy efficiency.

Hey et al (1992) analyse forecasts of carbon dioxide emissions from the road freight sector in every European country (1990-2010). They range from 30-170% with the UK at 30% and Greece at 170%. CO2 emissions from road freight will rise faster than from goods freight as a whole or passenger transport and road freight. They conclude:

> *"It would thus appear that structurally one of the most urgent political measures must be to halt the growth in (road) goods traffic."*
>
> Hey, C. et al (1992) p48

Forecasts of heavy goods vehicle traffic in Great Britain (HMSO, 1989) are based on a constant relationship between GDP and road tonne kilometres. The GB forecast of vehicle kilometres (all heavy goods vehicles) for the period 1988-2025 is for a low growth rate of 67% and a high growth rate of 141%. This forecast was modified downwards in 1992. The new forecast can be seen in Figure 1.

Forecasting is a very inexact science and past forecasts have underestimated the size of the growth in both passenger kilometres and tonne kilometres. Current transport policies are discriminating against rail, coastal shipping and waterways. There is no such thing as a level playing field and the mythology of a free market in transport could not be further from the truth. There is no market mechanism guiding the flow of funds into road building programmes.

The Railway Liaison Committee, which represents all Europe's railways and a number of umbrella organisations such as UIC and UITP, has issued a statement condemning the "persistent and flagrant lack of harmonisation of competition conditions, especially on freight.. (which) ..contrasts sharply with road and air infrastructures which have been expanded and massively modernised, more often than not through public funding"

(Bulletin of the European Federation for Transport and the Environment, 30, July 1994, p4).

Cabotage, deregulation and other single market changes are reducing the price of road transport in real terms (Whitelegg, 1993). At both EU, national and local level grandiose plans are underway to expand road infrastructure at some considerable public cost. The Trans European Road Network (TERN) will cost at least 120 billion ECU. The vast majority of Europe's largest firms are investing heavily in logistics with its demands for road based transport and frequent deliveries of less than full loads to manufacturing and distribution centres. This wave of organisational and spatial change is creating a landscape that is designed for lorries and cannot be served by rail and combined transport.

All these factors point inexorably to a greater emphasis on road freight and a reduced role for the alternatives.

THE MARKET FOR FREIGHT TRANSPORT IN GREAT BRITAIN

Over the past 40 years there has been a steady increase in the growth of road transport's share of freight lifted and moved.

Figure 2 shows that in 1952 roads accounted for 71% of goods lifted, rail 24%, water 4% and pipelines <1%. In 1992 goods lifted by roads had increased to 81%, pipelines 5% and water 7% whereas rail's share had dropped to only 6%. In terms of the type of commodity moved, Table 5 shows that roads, on average, moved 61% of all goods, rail 7%, pipelines 5% and water a very significant 26% of billions of tonne-kilometres in 1992.

Table 5

Freight moved: by commodity: 1992

	Road Bn t-km	%	Rail Bn t-km	%	Water Bn t-km	%	Pipeline Bn t-km	%	All Modes Bn t-km	%
Agri. prod., Live an.	10.9	97			0.3	3	0.0	0	11.2	100
Foodstuffs & Animal	26.1	98	0.3	1	0.2	1	0.0	0	26.6	100
Solid mineral fuels	3.5	33	5.4	50	1.8	17	0.0	0	10.7	100
Petroleum prod.	4.4	7	2.0	3	42.9	71	11.0	10	60.5	100
Ores and metal waste	1.2	67	0.6	33			0.0	0	1.8	100
Metal prod.	6.5	76	1.8	21	0.2	2	0.0	0	8.5	100
Minerals & building	19.4	67	2.8	10	6.6	23	0.0	0	28.8	100
Fertilizers	1.4	88	0.1	6	0.1	6	0.0	0	1.6	100
Chemicals	10.3	94	0.3	3	0.3	3	0.0	0	10.9	100
Machinery manu. good	42.8	90	2.2	5	2.6	5	0.0	0	47.6	100
All commodities	126.5	61	15.5	7	55.0	26	11.0	5	208.2	100

Source: DTp (1992

In this section we will first review factors that influence modal choice and then describe the current freight modal split by commodities and by origin and destination.

There are many similarities between road, rail and waterways; in a recent publication Willeke (1994) wrote:

> *"The performance of the different transport modes can be ranked according to certain requirements: they are required to be reliable, safe, rapid and inexpensive. The various modes possess these qualities to differing extents and in different proportions. The individual modes tend to have a combination of specific aptitude profiles that correspond to the requirement profiles of different buyers of transport services. In the supply of transport services, it is not only the technical properties that count, but also the organisational possibilities - including transport chains and full service packages- which are playing an increasingly important role. These are the preconditions for the overall logistic planning of the function fields of procurement, production, storage and distribution."* pp15

Explicit in the above paragraph is that different modes are multifaceted and occupy similar areas in terms of markets, clients, types of service and the type of goods moved. Willeke (1994) goes on to say that:

> *"Despite specialisation there are many overlapping fields with substitution possibilities and more or less intense substitution"*

This competitive environment therefore means that firms wanting to transport their products will go through a decision making process to select the type of mode which best suits their needs. According to McKinnon (1989) it is the general agreement in logistics literature that firms should observe four basic principles, these are:

1. Comparison of available alternatives
2. Undertake this comparison at regular intervals
3. Base the evaluation on a broad range of criteria
4. Employ a rigorous selection procedure

However from evidence collected in a series of studies over the past twenty years McKinnon says that these principles are not widely applied in practice.

Typically many firms opted for one particular mode only without considering the alternatives. (Bayliss and Edwards 1970; Pike 1982; Gray 1982: Hallet and Gray 1987).
Firms rarely review modal choice, sometimes defined by Cunningham and Kettlewood (1976) as "source loyalty". Their study of 43 consignors in Scotland found that on average they had stayed with the same principal source (firm) and mode for eleven years.
In terms of selection criteria, many studies (Bayliss & Edwards 1970; Sharp 1970: Slater 1982) show that many factors have been identified as influencing modal choice. McKinnon (1989) presents a consolidated list and groups them under three main headings: Consignor related, traffic related, and service related (Table 6). Further, many of the other papers mentioned above have rank ordered responses from firms according to the importance they attach to certain criteria, the result being that high ranking have been consistently attached to:

- Consignment size
- Length of haul
- Transit time
- Cost

Table 6

Factors affecting freight modal choice

Traffic Related	Consignor-related	Service-related
Length of haul	Size of firm	Speed (transit time)
Consignment weight	Investment priorities	Reliability
Dimensions	Marketing Strategy	Cost
Value	Spatial structure of production &	Product care
Value Density	logical systems	Customer relations
Urgency	Availability of rail sidings	Geographical coverage
Regularity of shipment	Stockholding policy	Accessibility
Fragility	Management structure	Availability of special vehicles
Toxicity	System of modal/carrier evaluation	Monitoring of goods in transit
Perishability		unitisation
Type of packaging		Computing facilities
Special handling characteristics		Accuracy of documentation

Having defined a particular set of criteria the process of selecting the best mode can begin. For some goods it is obvious that certain traffic related or consignor related factors may restrict the use of a particular mode. Further, company policy may dictate that transport managers have to find the cheapest route. Conversely, the cheapest mode may not suit a particular firm because it may be slow or unreliable. It is usual, therefore for trade-offs to be made and the optimum combination of variables found. Typically, this involves cost, time and reliability. However, Hodgkin & Starkie (1979) found that transport managers attach high monetary value to the prompt delivery of goods to customers in the expectation that this will assist in maintaining the customers business.

Hodgkin & Starkie's finding are still relevant today. Developments in product sourcing, the location of manufacturing and distribution centres, the use of information technology, and last but by no means least, the development of logistics, has put enormous pressure on the transport system to deliver goods faster, on time, and cheaper; i.e. an environment particularly suited to road haulage which has a high degree of flexibility of supply making it possible to adjust (more rapidly than any other mode) to time, place and quantity requirements of client demands.

The concentration of inventory at fewer and larger distribution centres can be an immensely profitable exercise for a company. It has been estimated that in the UK capital tied up in warehousing amounts to over £80 bn, representing approx. 20% of the value of manufacturing output, (Cooper et al, 1994, pp57).

Using the square root law (Maister 1976) it can be argued that under ideal conditions a single warehouse handling 1 million units per annum should require only half as much stock as a system of four warehouses each handling 250,000 units. Also, the cost of running the warehouse should be less due to economies of scale.

There are however a number of prerequisites in order for this concentration strategy to work:

- products must have a significant degree of commonality
- transport costs must be low relative to other resource costs (such as raw materials and storage
- transport must be reliable
- the company must have centralised marketing control.

Cooper et al (1994, pp43)

The scale at which this type of restructuring is occurring would appear to be increasing, McKinnon (1989) details closures in the UK of food manufacturers' distribution depots over the period 1975-79. The firms surveyed had closed 42 depots, mainly from peripheral regions such as the north east of Scotland, south west England, south Wales and Humberside, and relocated these facilities in fewer (and one assumes larger) depots more centrally located. This, McKinnon says, was a direct result of greater penetration being possible by the extension of the motorway network into these regions during the 1970s. On a Continental scale Kearney (1992) details how prior to 1992 the electrical company Philips used a national strategy of warehousing with at least one depot in each of the EU member states (16 warehouses in total). However the creation of the Single European Market in 1992 has allowed them to concentrate and rationalise inventory holdings into just 3 depots situated in the Netherlands, northern Italy and Spain.

Again the results of concentrating warehousing in fewer facilities will increase the need for transport. Moreover, in these particular cases it is also clear that the provision of better infrastructure to peripheral areas has been the direct cause of jobs lost.

Logistics: this general term encompasses many different strategies for product sourcing and production and distribution controls in order to reduce lead time (elapsed time between ordering a product and receiving it). Generically, techniques and concepts designed to achieve this aim are usually referred to as Requirement Planning Systems (RPS). Further, logistics has a crucial role to play in shaping each of the five prerequisites outlined above, and if all this can be achieved then there is a variety of benefits. Among the most important are:

- better quality control
- opportunities for more rapid product innovation
- economies of scale
- lower total costs
- longer production runs

Cooper et al (1994 pp44)

Just-in-time transport (JIT) is a variant of RPS which has been widely adopted. In a very simple form it involves the removal of some processes which do not add value by reducing machine set-up times and improving the flow of material. JIT also reduces inventory levels to (in theory) zero by more frequent, but smaller deliveries. Cooper et al (1994) give several case studies of what JIT can mean to some companies.

For example, McDonnell Douglas (UK) switched from a conventional manufacturing system to a JIT system in the mid 1980s. A direct result of this has been:

- a relieving of one third of shop floor work space that had been used for the traditional process of "kitting"
- this resulted in a reduction in work-in-progress from £2.2m down to £0.8m.

Clearly JIT can bring significant cost saving to companies Accordingly, it has been seen by many as one of the most important and successful innovations in logistics in recent times. However, the environmental costs are equally significant. For example, instead of one large vehicle delivering goods once a week, JIT means that smaller vehicles will deliver daily or in some cases several times a day. A result of this will be an increase in fuel consumption for the same quantity of goods moved. For example, if one vehicle carries 25 tonnes 100km this will use approximately 49 litres of fuel, whereas five smaller vehicles carrying 5 tonnes each will consume over three times this at 165 litres. In addition to being less energy efficient the use of more vehicles will also increase noise disturbance and visual intrusion.

JIT is more environmentally damaging. In a comparative study of France and the USA (Garreau, Lieb & Millen, 1991) roads were shown to be used to a greater extent (with rail being the loser) after the introduction of JIT.

Clearly then logistics, and JIT in particular, have induced a modal shift towards the use of more road vehicles in the pursuit of greater company profitability at the expense of greater environmental exploitation. Indeed, Willeke (1994 pp18) notes that:

> *"These characteristics [flexibility, in response to market conditions] also make road transport particularly well able to fit into transport chains and combinations with complementary services (freight forwarding, warehousing, handling etc.). However, these service activities can only be developed and implemented because the technical potential of the vehicles is exploited by private, profit-oriented enterprises."* *PP18.*

Freight modal and commodity split

Table 5 details 1992 data on commodity modal split. In all cases except petroleum products and solid mineral fuels (coke and coal) road freight is typically used for two thirds of all movements. Indeed, in some cases (agricultural products, live animals, and foodstuffs, animal fodder) road movements account for nearly all goods moved (>98%). For rail, the major commodities moved are solid mineral fuels, ores and metal waste, metal products, and mineral building materials (sand and cement). It is however only in the solid mineral fuels that rail movements exceed those for road. For water, the principal commodity moved is petroleum products.

Current trends (1982-92) for goods lifted and moved are shown in figures 3 to 5. These graphs indicate that the market for coal and coke particularly, and petroleum products marginally, is actually declining. It is only in the rather broad category of "other traffic" that there has been any significant increase in the volume of trade (goods lifted) and the distance over which these products have been moved. The decline in the volume of coal and coke perhaps reflects the shift away from the use of this product in industry and as the principal material for electricity generation. These data indicate, therefore, that for commodities where modes of transport other than roads are traditionally more important there has been over the 1980s a shrinkage in the volume of goods moved.

Table 7

Freight moved: by commodity: 1992

Commodity percentage value

	NST*	Road Bn t-km	%	Rail Bn t-km	%	Water Bn t-km	%	Pipeline Bn t-km	%	All Modes Bn t-km	%
Agri.prod., live an	0	10.9	8.6			0.3	0.50	0	0	11.2	5.40
Foodstuffs & Animal	1	26.1	20.6	0.3	1.9	0.2	0.36	0	0	26.6	12.70
Solid mineral fuels	2	3.5	2.7	5.4	34.8	1.8	3.30	0	0	10.7	5.10
Petroleum prod.	3	4.4	3.5	2.0	12.9	42.9	77.80	11	100	60.5	29.00
Ores and met. waste	4	1.2	0.9	0.6	3.8			0	0	1.8	0.86
Metal prod.	5	6.5	5.0	1.8	11.6	0.2	0.36	0	0	8.5	4.00
Minerals & building	6	19.4	15.3	2.8	18.0	6.6	11.9	0	0	28.8	13.80
Fertilizers	7	1.4	1.1	0.1	0.6	0.1	0.18	0	0	1.6	0.76
Chemicals	8	10.3	8.1	0.3	1.9	0.3	0.50	0	0	10.9	5.20
Mach'y manu.good	9	42.8	22.8	2.2	14.2	2.6	4.70	0	0	47.6	22.80
All commodities		126.5	100.0	15.5	100.0	55.1	100.0	11	100	208.3	100.0

*NST Classification — Source: DTp (1992)

NST = Nomenclature Statisque de Transport - the classification of commodities for transport statistics used in the European Communities

Table 7 details the percentage of freight moved by commodity (as opposed to mode). This highlights the importance of specific commodities to different modes. For example, whereas road transport accounts for 90% of all machinery and manufactured goods moved; as a percentage of all commodities moved by road this only accounts for approximately 23% of goods moved. The significance of petroleum products to water transport is further highlighted, in that it accounts for approximately 78% of all commodities moved in this way. Put another way, this emphasises the lack of use of this mode of transport for carrying other types of goods! The table also indicates which commodities contribute the most to annual road freight movement in GB. These are:

NST chapter 9: Machinery, transport equipment, manufactured articles and miscellaneous articles. (22.8%)
NST chapter 0: Live animals and animal fodder,
NST chapter 1: Alcoholic and non-alcoholic beverages. Meat, fish, dairy products, fruit, cereals, other foods (inc. tea and coffee). Tobacco.
Bulk cereals, potatoes, other fresh and frozen fruit and vegetables. Sugar (inc. beet). Wood, timber and cork. Wool, cotton, man-made fibres and other textile materials. Hides, skins, rubber. Paper (inc. pulp and waste) (29.2%)
NST chapter 6: Sand, gravel, clay. Other crude materials (stone, chalk and other minerals). Cements and lime. Other building materials (Bricks, etc. concrete, glass, glassware and pottery (15.3%)

Nomenclature Statistique de Transport -EC standard goods classification for transport studies.

Road freight movements within the UK

Figures 6 to 16 show the breakdown of goods lifted between GB standard regions. What is clear from these data is that intra-regional movement of goods is significantly more important than inter-regional movements. Table 8 shows that with the exception of the East Midlands and Greater London, all regions moved more than 50% of all goods within the same region. This corresponds with other data from the Continuing Survey of Road Goods Transport (CSRGT) (1991 Table 6.) average length of haul which shows that for all vehicles this was 83 km. This figure however masks a wide range. For example, rigid vehicles on average travelled 45 km, whereas articulated vehicles travelled an average 133 km. Finally, vehicles up to 25 tonnes (gvw) travelled an average of only 48 km whilst those over 25 tonnes travelled 206 km.

Table 8

Percent Intra-regional goods lifted

	Intra-regional percent
North West	52
North	61
Yorks & Humberside	58
East Midlands	46
East Anglia	51
Greater London	39
South East	55
South West	65
Wales	56
West Midlands	49
Scotland	82

Source: 1991 CRSGT

Table 9 shows that in terms of goods lifted 75% travel less than 100km. However if goods moved data are looked at it is apparent that in terms of million tonne-kilometres, 69% of goods moved travel further than 100km .

Table 9

Commodity and length of haul

Goods lifted and moved

	<25km	<50km	<100km	<150km	<200km	<300km	>300km	Total
Goods lifted (mt)	569	295	254	117	82	104	83	1,505
Percentage	38	20	17	7	5	7	5	99
Goods moved (Mt-km)	7,145	10,789	18,286	14,444	14,397	25,484	34,048	124,592
Percentage	6	9	14	11	11	20	27	98

Source: 1991 CSRGT

Clearly these data support the view that a significant proportion of all freight shifted by road is over relatively short distances, but also that longer distances are important to road haulage. This is reflected in the proportionate breakdown of emissions for different distance bands.

Taking figures for specific emissions per tonne-kilometre from Whitelegg (1993) we can calculate the relative difference between the shorter and longer journeys outlined above. Table 9 shows that 1118 million tonnes of goods lifted (75%) moved <100km. This amounted to some 36200 million tonne-kilometres. The remaining 25% of goods lifted (those travelling >100km) was 386 million tonnes. This amounted to 88372 million tonne-kilometres being travelled.

Table 10 shows the calculated emissions for goods travelling less than and more than 100km. It can be seen that those travelling more than 100km are producing a lot more emissions. To quantify this a little more clearly the figures were worked back to values of emissions per tonne lifted for both categories. These data are shown in the last two columns of Table 10. The conclusion is that the 25% of total goods lifted which are moved >100km are producing levels of emissions approximately 7 times greater than those travelling <100km, even though in actual tonnage these goods account for only 386 million tonnes whereas those travelling <100km account for 1118 million tonnes.

Table 10

Emissions for goods lifted travelling less than/more than 100km

		Total emissions (mt)		gms/tonne lifted	
	g/t-km	<100km	>100km	<100km	>100km
CO2	207.0	7.497	18.290	6706	47383
CH4	0.3	0.011	0.027	10	69
VOC	1.1	0.040	0.097	35	252
NOx	3.6	0.130	0.318	116	824
CO	2.4	0.094	0.212	84	549
HC	1.6	0.058	0.141	52	366

The approach used here to assess road freight movements shows that it is very easy to be misled by the data in the CSRGT, in that, if looked at simply as they are presented it would appear that the greatest majority of goods are moved over relatively short distances. However, if one takes a different approach and considers both the volume of goods lifted and the distance over which they travel at the same time, it becomes clear that the smaller volume moving >100km are producing a disproportionate and very significant amount of the total tonne-kilometres being travelled nationally, i.e. 25% of the volume is being moved 69% of total tonne-kilometres. Thus, these data gives significant weight to the need to assess alternatives to road freight transport for goods moving inter-regionally.

Key commodities transported by road (NST chapters 0,1, 6 & 9)

Table 11 shows that in 1991 NST 0 accounts for 9% of all freight tonne-kilometres. NST 1 accounts for 20%, NST 6, 17% and NST 9, 33%. The aggregate percentage of these four commodities being 79% of all goods moved. Table 12 shows the these commodities account for 82% of all goods lifted. Again if one splits the data for goods moved and lifted greater than and less than 100km similar figures to the above are found.

Table 11

All NST Goods Moved by Length of Haul: 1991

	Distance in kilometres (values in million tonne kilometres)							Percentage		
	<25	25-50	50-100	100-150	150-200	200-300	>300	%	<100%	>100%
NST 0	447	849	1,873	1,438	1,511	2,206	2,421	9	29	71
NST 1	465	1,381	3,623	3,443	3,437	6,112	7,929	20	21	79
NST 2	320	588	627	350	397	633	760	3	42	58
NST 3	226	759	1,695	909	401	438	498	4	54	46
NST 4	54	69	265	188	207	283	189	1	31	69
NST 5	158	242	519	620	807	1,940	2,608	6	13	87
NST 6	2756	4,053	4,842	2,622	1,987	2,645	2,757	17	54	46
NST 7	51	90	187	140	165	399	468	1	22	78
NST 8	93	212	517	778	724	1,913	3,072	6	11	89
NST 9	2576	2,546	4,138	3,955	4,759	8,917	13,346	33	23	77
Total	7146	10,789	18,286	14,443	14,395	25,486	34,048	100	29	71

Source: CSRGT (1991)

Table 12

All NST Goods Lifted by Length of Haul: 1991

	Distance in kilometres (values in millions of tonnes)							Percentage		
	<25	25-50	50-100	100-150	150-200	200-300	>300	%	<100%	>100%
NST 0	25	23	26	12	9	9	6	7	68	33
NST 1	40	36	50	27	19	25	18	14	58	41
NST 2	24	16	9	3	2	3	2	4	86	18
NST 3	15	20	24	8	2	2	1	5	81	18
NST 4	4	2	4	2	1	1	1	1	71	36
NST 5	12	7	7	5	5	8	7	3	52	50
NST 6	222	112	69	22	11	11	8	30	89	11
NST 7	4	3	3	1	1	2	1	1	77	38
NST 8	7	6	7	6	4	8	8	3	44	58
NST 9	218	71	57	32	27	36	32	31	73	27
Total	571	296	256	118	81	105	84	100	75	26

Source: CSRGT (1991)

Table 12 shows that the percentage of goods lifted moving <100km ranges from 58% (NST 1) to a massive 89% for NST 6. Whereas for goods moved <100 km the figures range from 21% to 54%.

NST 0: 32% goods lifted travel >100km. These produce 2.46 times more CO2 emissions than the 68% of good lifted travelling <100km. In terms of emissions per tonne lifted these goods produce 7.59 times more emissions than the 68% of goods lifted being moved <100km.
NST 1: 42% goods lifted travel >100km these produce 3.76 times more CO2 emissions than the 58% of goods lifted travelling <100km. In terms of emissions per tonne lifted these goods produced 7.96 times more emissions than the 58% of goods lifted being moved <100km.
NST 6: 11% of goods lifted travel >100km. These produce only 0.85 times the CO2 emissions produced by the 89% of goods lifted travelling <100km. In terms of emissions per tonne lifted these goods produce 7.45 times more emissions than the 89% of goods lifted being moved <100km.
NST 9: 27% goods lifted travel >100km. These produce 3.34 times more CO2 emissions than the 73% of goods lifted travelling <100km. In terms of emissions per tonne lifted these goods produced 8.02 times more emissions than the 73% of goods lifted being moved <100km.

Clearly an inducement away from road freight transport for goods travelling longer distances, i.e. more than 100km, in any of these key commodities would have a significant effect on amounts of CO2 emissions.

THE MARKET FOR FREIGHT TRANSPORT IN EU COUNTRIES

The relative market shares of road and rail transport in GB indicate a much higher proportion of goods moved by road than in most other European countries. Table 13 summarises the EU situation.

Table 13

Freight Transport in the EU: Tonne-kilometres, 1990.

btkm = billion tonne kilometres

Country	Rail		Road		Total btkm
	btkm	%	btkm	%	Road + Rail
Belgium	9.54	21.2	35.4	78.80	44.94
Denmark	1.73	10.8	14.3	89.20	16.03
BRD	61.36	30.0	143.0	69.90	204.36
Greece	0.65	3.6	17.2	96.40	17.85
Spain	13.41	10.4	115.1	89.60	128.51
France	50.67	27.9	131.0	72.10	181.67
Ireland	0.59	9.8	5.4	90.17	5.99
Italy	21.22	12.2	152.6	87.79	173.82
Luxembourg	0.71	17.60	3.3	82.39	4.01
Netherlands	3.07	5.6	51.7	94.39	54.77
Portugal	1.59	9.0	16.0	90.97	17.59
UK	15.99	10.2	141.2	89.82	157.19
EC	180.53	17.9	826.2	82.07	1006.73

Source: Panorama of the Transport Industry in the European Community, supplement to Transport Europe, August-September 1993.

The data in Table 13 are expressed in diagrammatic form in Figure 17. The UK is using rail to carry approximately one third of the tonne-km carried by French and German railways. At this crude level of comparison it is possible to conclude that there is a great deal of potential for improvement in rail's market share in the UK. France and Germany (unlike the UK) have transport policies that are very supportive of rail freight. Both countries have geographies that are different to the UK but in terms of geographical size, distance, economic and spatial structures are not that dissimilar to the UK. If France and Germany can achieve a one third market share for rail freight then so can the UK.

Whilst one can always find differences between countries in an attempt to rationalise poor market shares for rail freight it is important to note that membership of the European Union spreads a degree of economic uniformity in its provisions for competition, transparency of financial support of railways, cabotage and deregulation. Effectively we have very different market shares within an increasingly uniform system.

Table 14

Rail Freight 1971 - 1990

		1991 bn. tonne-km	1971-1990 % change	1989 % international
CER*	Germany (West)	61.0	- 4%	43%
	Germany (East)	40.0	- 8%	23%
	France	51.0	- 24%	34%
	Italy	21.0	+ 23%	55%
	UK	16.0	- 27%	
	Spain	13.0	+ 47%	11%
	Austria	13.0	+ 30%	71%
	Belgium	10.0	+ 29%	68%
	Switzerland	8.0	+ 25%	72%
	Netherlands	3.0	- 5%	67%
	Denmark	2.0	- 6%	
	Portugal	2.0	+ 106%	14%
	Luxembourg	0.7	- 5%	82%
	Greece	0.6	- 14%	56%
	Ireland	0.6	+ 2%	
NORDIC	Sweden	19.0	+ 30%	43%
	Finland	8.0	+ 45%	29%
	Norway	3.0	+ 2%	37%

**Community of European Railways (CER)*

Source: Markham, J. (1995)

Table 14 shows change over time in rail's market share in a number of EU and Scandinavian countries in the period 1971-1990. The UK's performance (-27%) is very poor indeed. Spain has increased its rail freight tonne-km by 47%, Italy by 23% and a number of other countries by figures in the range 20-30%. The potential for rail freight is there and rail is not as moribund as is frequently asserted in the UK. The realisation of the potential very much requires clear transport policies and well-targeted investment decisions. The high performers show what is possible and represent generalised estimates of what can be achieved.

US data (Gordon, 1991) shows a remarkably balanced distribution of freight carried by different modes. This is compared to Great Britain in Table 15.

Table 15

Ton Miles (USA) and tonne-km (GB) carried by different modes of transport: modal split percentages

Mode	USA	GB
Water	16	26
Rail	37	7
Pipeline	20	5
Truck	26	61
Air	<1	<1

Source: US data is in ton-miles for 1991, Supplied by Eno Foundation for Transportation Inc
GB data is 1992 (Transport Statistics, Great Britain, 1993), Table 1.12, page 40

The data on water-borne transport needs careful interpretation. In the US 82 billion ton-miles are accounted for Great Lakes traffic and 380 billion ton miles by rivers and canals. In Britain the water-borne component consists of 53.1 billion tonne-kilometres of maritime transport (including 39.0 billion tonne-kilometres of coastwise traffic) and 2.0 billion tonne kilometres on inland waterways.

The US data is influenced by rail's competitive advantages over long distances but distance itself does not explain the very large differences between the US and GB particularly when US fuels costs (considerably lower than in Britain) are taken into account. The US has invested heavily in intermodal technology with 50% of the business of truckers characterised by loads which use rail for a significant part of their journey (Chamberlain, 1994). The success of US freight transport policy in an environment which might be expected to favour road owes a great deal to the uniformly high quality of intermodal systems and the ease with which freight can move from one system to another.

Gordon (1991) describes the "piggyback" facilities available in the US:

> *"Freight carrying truck trailers (are) shipped less expensively with much greater operating efficiency and substantially greater energy efficiency than previous systems. Railmaster transports its backhauls with nearly a full load and its delivery times are close to those of average truck deliveries"*
>
> Gordon (1991) page 143

Statistics on combined/intermodal transport use the TEU as a basic unit. The TEU or "twenty foot equivalent unit" is a standard container with a capacity of 30-35 cubic metres, a payload of 18-22 tonnes and a tare of 2-3 tonnes.

US railways have no restrictions on maximum weight, height and length of trains and it is possible to operate double stack trains with capacities of up to 560 TEUs. These trains are 2.8km long. The European maximum is 80 TEU. It would not be possible to replicate the US system in Europe but it is possible to resolve all the incompatibilities of track gauge and loading gauge, electrical power supplies, braking and signalling systems that render European railways so ineffective as freight movers across international frontiers. It is also possible to increase rail capacity where this is a problem and to invest heavily in intermodal facilities where there are heavy flows of lorries and/or demands for new road capacity.

A recent report from the American Trucking Association concludes:

> *"The current outlook for the comparative costs of truck and rail freight places truck transport at a continuing disadvantage over time"*
>
> American Trucking Association (1994)

The importance of distance as a determinant of modal share is exaggerated. Holzapfel (1995) describes freight flows in the Ruhr area of Germany where 80% of transport by rail is for distances of less than 50km. Given that the majority of goods transport is for short distances the realisation of rail's potential depends on tapping markets for freight for flows of less than 100km in length. Since this coincides in the UK with transport corridors of greatest stress eg Trans-Pennine movements this provides opportunities rather than problems.

THE INFRASTRUCTURE AND THE POSSIBILITIES

Much of the discussion about European freight transport refers to multimodal, combined or intermodal transport. The terms are used interchangeably. They identify the use of more than one mode of transport in combination to complete successfully one shipment from its origin to its destination. Any shipment using coastal shipping, deep sea shipping or inland waterways is almost certainly intermodal. Freight would have been delivered to the port or inland waterway terminal by road or rail and similarly transferred at its destination. Intermodal transport requires a uniformity of hardware and a sophistication of software and management to make it work and is capable of operating in a wide variety of combinations. Trains can carry containers, whole lorries (inc the tractor unit/drive cab), swop bodies and much more. Shipping (including inland waterways) can carry containers and special vehicles designed to be compatible with trains and lorries.

European Union Council directive 75/130/EEC defines combined transport as the transport of goods in which the lorry, trailer, semi-trailer, swap body or container are carried by rail or waterway for part of the journey and road for the initial or terminal haul. Road hauls must be to the nearest rail depot and cannot exceed 150 km when combined with waterways (Markham, 1995).

Britain is severely disadvantaged in comparison with other European countries in the quantity and quality of its intermodal transport infrastructure. Paradoxically Britain is particularly well endowed with port infrastructure and the GB port system represents one of Europe's most underutilised transport resources.

The Intercontainer map of rail container terminals in Europe shows 11 in Britain and 82 in Germany (West and East combined). Norway has 15 and Finland has 14. The difference in levels of provision in these countries reflects political priorities and historic transport investment and has nothing whatsoever to do with the geography, the commodities or the distances that freight has to move in those countries. Britain has chosen to invest in road based transport and to ignore the potential of rail, waterway and combined transport.

Over the period 1981-1991 the number of freight wagons in the UK (BR, Freightliner and BR customers) declined from 105,500 to 34,400 (a 65% reduction) and the number of freight depots declined from 378 to 83 (a 78% reduction).

Table 16 shows the capacity of UK shipping to move freight in comparison with other European countries.

Table 16

Shipping: Development of the EU fleet by Member State, 1992

	No. of ships	DWT (thousand)	TEU (thousand)
EC	5,391	94,805	*848
Belgium	31	50	
Denmark	494	7,868	145
Germany	832	6,937	288
Greece	1,423	43,531	70
Spain	368	5,059	17
France	199	5,378	56
Ireland	67	195	4
Italy	828	10,672	60
Luxembourg	48	2,624	20
Netherlands	518	4,368	107
Portugal	75	1,342	6
United Kingdom	508	6,781	76

Source: Panorama of the Transport Industry in the European Community, Transport Europe, August-September 1993

**Figure as given in original source*

The capacity of the UK shipping fleet given in Table 16 is 76000 TEUs (Twenty Foot Equivalent Units). This compares unfavourably with the Dutch, German and Danish totals though is better than the French. In theory all of Europe's shipping fleet is available for work to/from or within the UK so a national comparison does not automatically lead to the conclusion that the capacity is not there. What it does show is that the UK is less well equipped than comparable countries to take advantage of the market for combined transport and has allowed its shipping capacity to decline.

Britain's ports offer enormous potential for increasing their freight market share. There are more than 300 ports offering commercial services in Britain including many on the eastern seaboard offering the potential for direct sea services to mainland European destinations in exchange for long road journeys to Channel Ports. (Maritime Studies, 1994). Ports such as Goole and Hull already operate in an intermodal environment but have enormous capacity to link into inland waterways (in the case of Goole) and into landbridge rail options (where Hull could utilise rail/sea intermodal possibilities to serve the NW of England, Liverpool and Ireland).

The UK port system "suffers" from a 50% overcapacity problem (Maritime Studies, 1994). This is an unusual state of affairs in transport where most discussion is about capacity problems and the urgent need to add to existing capacity (Nijkamp et al 1994). The continuing neglect of maritime transport as an efficient alternative to much of the long distance road haulage in the UK is particularly perverse given the absence of capacity problems in the port sector and the abundant evidence of inadequate capacity on the road system.

The potential for rail/port/coastal shipping intermodalism in the UK is very difficult to estimate. Ports handled 500,000,000 tonnes of cargo in 1992 (approximately 333 million were import/export and 163 million domestic) and 150,000 ships. Given the 50% overcapacity estimate it would not be unreasonable to expect that ports could process another 250,000,000 tonnes of cargo through a proportion of the 300 ports in service offering enormous reductions in tonne-km of freight shipped by road.

Table 17 provides a useful summary of the provision of basic transport infrastructure in Europe. Rail length in Britain is very much below that of France and Germany which are countries of comparable population size. Road length data shows the UK to be less well provided for than Germany and France.

Table 17

Road and Rail Infrastructure 1991

Thousand kilometres

	Road network			**Rail network**	
	All roads	of which motorways	All roads per 1,000 square kilometres (kilometres)	In operation	Rail network per 1,000 square kilometres (kilometres)
Great Britain	360	3.1	1,561	16.6	72
Belgium	_ 128	_ 1.6	_ 4,205	3.5	114
Denmark	71	0.7	1,649	2.3	54
Germany_	_ 550	10.4	1,538	44.1	124
France	810	7.5	1,489	33.5	61
Greece	116	0.1	878	2.5	19
Irish Republic	92	0.0	1,340	1.9	28
Italy	_ 304	6.2	1,011	19.6	65
Luxembourg	5	0.1	1,972	0.3	105

Netherlands	105	2.1	2,541	2.8	69
N. Ireland	24	0.1	1,702	0.3	24
Portugal	_ _ 19	0.5	_ 208	3.1	34
Spain	_ 153	2.7	337	_ 14.3	28

_ Estimated from previous years

_ Includes former Federal Republic of Germany and German Democratic Republic in both years

_ Excludes urban roads in the area of the former German Democratic Republic.

_ Excludes urban roads.

Source: Transport Statistics Great Britain 1993

Figure 18 shows the UK inland waterway system. Whilst there are many examples of intermodal potential it is instructive to consider the case of Goole, Humberside. Goole is 80km from the open sea and allows sea going vessels to penetrate that distance inland. It is adjacent to the M62, is rail linked and is connected via the Aire and Calder Canal to Leeds, Sheffield and South Yorkshire. It is ideally located to connect the north of England and the Midlands to mainland Europe and Scandinavia. The port has a fully equipped container terminal (Boothferry) which cost £5 million to build. The cost of widening the M6 through Staffordshire is approximately £8.5 million per mile and is 100% funded out of public expenditure. The cheaper, more useful and environmentally preferable option of investing in intermodal facilities was not funded out of public expenditure.

The UK has been poorly served by the last 40 years of transport policy and transport investment. The bulk of public money has gone into the road system. The rail system now serves fewer potential and actual destinations than is the case with our mainland European competitors and the provision of intermodal facilities is poor. Ports, coastal shipping and inland waterways do not even figure in policy discussions and have been sidelined to the point of irrelevance. Rail investment has had to perform against criteria which were loaded against that mode and within a set of rules that were stacked in favour of the road alternatives.

COMBINED TRANSPORT

The Kearney report (Kearney, 1990) confirmed the environmental, economic and organisational advantages of combined transport and predicted a tripling of international combined transport in Europe in the period 1990-2005. From a low base this would take the total to 43.2 million tonnes.

Combined transport (mainly road-rail) has grown rapidly in France and Germany with Novotrans (France) and Kombieverkehr (Germany) providing specialist combined transport services in those countries. In Germany combined transport volume has been increasing by 8-10% annually. In 1990 wagon load transport accounted for 26.6 million tonnes or 9.5% of all freight carried by the German federal railways whereas the combined transport tonne-km share was 21.7%. The share of combined transport for cargo carried over 400km is more than 40% and combined transport accounts for 5.9% of all long distance road transport in Germany. The combined transport potential in Germany is estimated at around 100 million tonnes in the year 2010 and the combined transport share of long distance traffic is expected to rise to 15% (Goldammer, 1992).

The 1992 German Federal Traffic plan contains a commitment to develop 31 "Gueterverteilzentren" or multi-modal transfer points. It is expected that 13 will be built in North Rhine Westphalia and will substitute for 1.9 million lorry trips. The Cologne-Eifeltur centre alone will remove 1000 lorries per day (Gutter, 1992).

Combined transport is growing fast in the US (American Trucking Association, 1994) reporting a 6% growth between 1992 and 1993. Over the period 1991-2000 a 4.9% average annual expansion of intermodal revenues is anticipated.

On a European scale Intercontainer with 25 member countries supplies a range of intermodal transport services and was responsible for 11 billion tonne-kilometres in 1991 and the Union Internationale des Societes de Transport Combine Rail/Route (UIRR), 20 million tonne-km (CEC, 1994).

Combined transport still has a low market share in spite of very strong growth tendencies in Germany and the United States and its rapid incorporation into plans to remove lorries from heavily stressed transport corridors as in the case of Swiss transit traffic. There are no technical problems with intermodalism as a viable freight transport alternative. Its costs compare favourably with the costs of new road construction and motorway widening, its environmental performance is vastly superior to road freight but its political support is poor. Its suitability for corridor applications makes it an appropriate alternative in all those situations where motorways are undergoing widening and there are parallel rail routes eg M62, M6.

Simons (1994) has summarised the advantages of different modes of transport with a very practical overview:

To transport a cargo of 1775 tonnes which fits inside one inland waterways vessel of 95 metres length, the following equivalents would be needed:

By rail: 60 wagons, train length 600 metres
By road: 90 lorries, a convoy of 1000 metres in length

Distance covered with 5 litres of fuel per tonne carried:

Inland waterway vessel	500km
Rail	333km
Road	100km
Air	6.6km

It is not difficult to conclude from these performance characteristics that there is an overwhelming case for freight transport planning to be organised to use the most appropriate modes for the circumstances where environmental, efficiency and performance goals are optimised. This would produce a very different modal split to that observed for Britain in Table 15 but one that would deliver freight as well as environmental gains and improvements in international competitiveness.

A FREIGHT TRANSPORT PLAN

Britain has no planning framework for its freight transport needs. Planning is dominated by free market principles enshrined in deregulation and cabotage. Cabotage at a European level is the right to operate in any EU country on the same terms as a domestic haulier. This is intended to reduce the costs of road haulage and to encourage economic integration (Whitelegg, 1993). Deregulation is essentially freedom of entry to the market to encourage entrepreneurs to participate in providing road freight transport services unfettered by regulations other than safety and training matters. Britain deregulated its road haulage industry in 1968 to be followed by France (1986), Denmark (1989), Belgium (1991) and the Netherlands (1992).

Road haulage throughout Europe is characterised by a substantial amount of illegality which represents a major cost advantage to road that is not available to the severely regulated rail sector (Whitelegg, 1990). The existence of this problem has been confirmed by the European Union in the report of an enquiry into road freight transport (CEC, 1994).

Lorry drivers and road hauliers routinely ignore social regulations that control the number of hours per day that a driver can drive. Overloading, speed infringements, and mechanical defects add to European road safety problems and confer cost advantages on road hauliers. Very little effort in a deregulated market goes into monitoring and control. The European Commission (CEC, 1994) estimates that one sixth of 300,000 lorries surveyed in France contravened the regulations in some form and in Germany of 600,000 lorries surveyed, 20% had contravened the regulations.

The free market rhetoric is at odds with the public expenditure reality. Transport is a large area of public spending where priorities and expenditures bear no relation whatsoever to any market of any description. Successive governments have decided that road freight is a national priority and have allocated investment priorities accordingly. This is not a market mechanism.

The demand for road freight is heavily influenced by the prevailing fiscal regime particularly fuel taxes and duties and infrastructure priorities. It is inconceivable that road freight could have grown to its present position of dominance without the road spending programme since the UK's first motorway opened in 1958. The period since 1959 has seen heavy expenditure on roads and a major cut in rail facilities and rail expenditures (Henshaw, 1991). German research quoted in Whitelegg (1993) shows that lorries in Germany pay only 15% of the measurable costs they impose through road wear, accidents, pollution etc. This represents an effective 85% subsidy and has led to increasingly strong pressure on the EU to increase the costs of road transport in recognition of the polluter-pays principle. Dieter Teufel from the Environment and Forecasting Institute in Heidelberg (Germany) quoted in Whitelegg (1992) has compared the performance of lorries and trains on a number of different parameters and these are summarised in Table 18.

Table 18

Differential impact of road and rail freight transport on a number of environmental variables

	Unit, per tkm	Lorry	Rail
Primarenergie	g coal equivalent	98.4	23.7
Endenergie	g coal equivalent	85	11
CO2	kg CO2	0.22	0.05
NOx	g NOx	3.60	0.22
NOx 1993	g NOx	3,18	0,16
CO	g CO	1.58	0.07
CxHy	g CH	0.81	0.05
Dust	g Dust	0.27	0.03
SO2	g SO2	0.23	0.33
SO2 1993	g SO2	0.17	0.12
Accidents	injured/billion tkm	248	10
Space	m^2/year-tkm	0.007	0.0025

Source: Whitelegg (1992)

Kageson (1993) has calculated the external costs for different modes of transport and used the information to suggest specific increases in the cost of fuel to redress the fiscal bias towards road freight.

The Dutch government has produced a national transport plan based on a number of environmental and economic objectives that provides a planning framework for the different modes (Haq, 1994). The objective is to transfer freight from road to rail and canal and to pursue this at a corridor level by evaluating a number of alternatives for infrastructure provision when growth in demand is forecast. Haq has contrasted the planning process and policy framework on the Amsterdam - Utrecht corridor with the UK Trans-Pennine study. The former has recommended a number of improvements to the rail system, including an increase in number of tracks from 2 - 4 (and some road expansion) and the latter has ignored railways as an option.

A non-governmental Dutch plan (Werkgroep 2duizend, 1993) has outlined a scheme for urban distribution centres to reduce lorry movements in cities, operational strategies to reduce empty running, arrangements for picking up return loads and substantial investments in multi-modal transport and transfer points between road/rail/water transport. The environmental benefits of the "new course scenario" are substantial and are summarised in Table 19.

Table 19

Environmental effects of "new course scenario" compared with a business as usual scenario (Basic scenario 2015)

1990 = 100

Environmental Effect	**Basic Scenario**	**New Course Scenario**	**Sustainability Target**
	2015		
Energy Use	147	54	50
CO2 Emissions	148	57	50
NOx Emissions	70	14	18

Source: Werkgroep 2duizend (1993)

The city of Leiden in the Netherlands has taken the initiative in producing an ambitious plan to reduce the number of lorries on its roads by 80% in the next ten years.

The Werkgroep 2duizend (1993) plan assumes an increase in tonne kilometres from 69 billion in 1990 to 124 billion in 2015 but a completely different modal split. Table 20 compares the modal split data.

Table 20

Dutch freight transport modal split (percentages)

	Road	**IW**	**Rail**
1990 Actual	50.7	44.5	4.8
2015 Business as Usual	52.9	41.3	5.9
2015 New Course Scenario	21.1	45.8	33.1

IW = inland waterway   Source: Werkgroep 2duizend (1993)

The change in modal split is achieved by the following:

- Opening of urban distribution centres (UDC) to consolidate loads so that lorry capacity is used to the full on trunk haul sections. Bigger lorries are kept out of urban areas and the UDCs ensure that empty running and part loading is eliminated and lorry traffic is in more energy efficient lorries.

- New logistic procedures and information systems to ensure that return loads are available or can be picked up at intermediate points on the return journey.

- Full use of rail and water-borne transport for all trunk haul journeys and parts of journeys where these modes are appropriate

The whole package of measures is described by Werkgroep 2duizend as "green logistics" but would be more appropriately described as an optimal transport system with respect to service quality, economics and the environment; in effect a "least cost" approach to freight transport planning. The current system of logistics and freight transport is so illogical and self-defeating (Whitelegg, 1994) that a new formulation can be designed without recourse to compartmentalised "green" objectives.

THE SCOPE FOR REDUCING ROAD FREIGHT TONNE-KILOMETRES IN THE UK

There are five ways to reduce the environmental damage caused by freight transport (Werkgroep 2duizend, 1993). These are:

1. Technical improvement of the vehicles to reduce energy consumption and emissions.
2. Optimum use of transport logistics resulting in more efficient capacity utilisation.
3. A shift from environmentally damaging modes of transport (road) to better performers (rail, shipping and inland waterway).
4. Changes in the spatial organisation of transport, production and markets resulting in reduced distances at the same production volume.
5. Reduction of production and consumption levels so that fewer goods need to be transported.

The same taxonomy has been identified by Hey (1992) and Holzapfel (1995) has concentrated specifically on regional co-operation as a way of reducing tonne-kilometres. Using the yoghurt data in Böge (1994a) Holzapfel shows that substituting regional sources of supply for the longer distance flow reduces tonne-km by 67%. The vast majority of these savings are on the motorway system.

It is very clear indeed from these analyses that the greatest potential for reducing tonne-km of road freight lies in the short term in substituting environmentally friendly modes of transport for ALL long distance road freight and for all road freight on corridors of greatest transport stress even where these distances are less than 100km. In the longer term regional forms of co-operation as recommended by Holzapfel have the potential to reduce demand for transport itself. Both solutions will require new investment in intermodal facilities, direct rail access to freight despatchers and receivers and direct water access where appropriate.

Table 21 quantifies the scale of the transfer to rail following these assumptions

Table 21

Road freight transfer potential

BTKM = Billion tonne kilometres

Category	Present_	Transferable	
	BTKM	%	BTKM
Goods moved >100km	86.8	100	86.8
Goods moved <100km	34.5	25	8.6
Totals	121.3		95.4

_ Transport Statistics Great Britain, 1993. Figures refer to 1992; Table 4.3, page 84

A transfer of 95.4 billion tonne-km from road to rail/water/coastal shipping/combined transport could not take place without investment in extending the capacity of alternative modes of transport and the intermodal transfer facilities to allow all modes to work efficiently in combination. There are no technical reasons why this transfer could not take place given the investment in capacity, vehicles and technical compatibilities. There are, however, very real capacity constraints on all transport modes (especially roads) to take increasing amounts of freight into the future.

Table 21 refers to an existing situation. The Department of Transport (1993) presents the current government forecasts of future levels of lorry kilometres. They are summarised in Table 22.

Table 22

Forecasts of freight traffic

(vehicle kilometres: goods vehicles only)

1992 = 100

	Lower	Upper
1995	104	107
2000	112	121
2005	120	136
2010	128	154
2015	138	173
2020	148	196
2025	159	222

Source: Department of Transport (1993), Table 4.8, page 87

A realistic time scale for installing capacity and facilities would take us to 2005 by which time the vehicle kilometre figure will have risen by 20-36% (from a 1992 base). Coping with such increases is not just a problem for "environmentally friendly" modes of transport. The problem is just as great if not greater for traditional road haulage. The impossibility of supplying enough road space and parking space for the 2025 forecast of lorry kilometres (59-122% above 1992 base) should be enough justification in itself for moving in the direction described in Table 21. Problems are likely to become particularly acute for a road transport system that has become accustomed to selling reliability through "just-in-time" (JIT) systems. JIT transport now accounts for 28% of all shipments, and this proportion is rising. (CEC, 1994).

Rising congestion is already a serious problem on the M25, M62, sections of the M1 and M6 around Birmingham and on the M40 and sections of the M4. The current motorway widening programme is an indicator of the seriousness of the congestion problems and a measure of the demand for inter-urban freight transport. This congestion has the potential to transform "just in-time" to "just-too-late" with serious repercussions for an industrial and spatial structure predicated on rapid deliveries by road and minimum inventories.

Railways (1992 figures) carried 15.5 billion tonne-km of freight. It is highly unlikely that they could carry the additional 95.4 billion tonne kilometres implied by Table 21. Fortunately they would not have to. The UK port system and coastal shipping have the capacity to take some of this load as does the inland waterway system. The UK port system is dense enough to provide very direct access to many important concentrations of population and economic activity and reduce the total amount of tonne kilometres. The ports effectively provide the basic infrastructure for a regionalised production and consumption system of the kind described by Holzapfel (1995).

CASE STUDIES

Three case studies are presented in Appendix 1. They are:

1. A combined transport (combined transport) link along the west coast main line (WCML) from London to Manchester. The analysis uses the CSRGT 1991 data of goods lifted from the North West and West Midlands regions to the South East and Greater London area as a basis for the calculations. It omits international road freight travelling along this route as finding suitable data that could be objectively evaluated was difficult.

2. A Trans-Pennine combined transport link from Immingham dock on the Humber estuary to Seaforth dock at Liverpool. The analysis considers both international road haulage and domestic goods moved along this route as it was possible to estimate the share of this volume of traffic.

3. An inland waterway connecting the Manchester Ship Canal (MSC) to the Yorkshire broad gauge canal system at Rotherham. Estimates of potential traffic using this mode of transport was calculated from the data already collected for the Trans-Pennine combined transport route.

The three case studies have shown the potential for transferring freight from road to alternative modes, the relative costs of infrastructure and the reduction in lorry numbers that this would produce. These results are summarised in Table 23

Table 23

Summary of case study results

	Freight transferred (million tonnes)	Lorries eliminated
1. WCML	15.5	1,292,083
2. TPCT	0.373-0.414	31,116-34,558
3. TPWW	0.630	52,500

WCML = West Coast Main Line TPCT= Trans-Pennine Combined Transport
TPWW = Trans Pennine Waterway

The WCML potential for transferring freight from road to rail represents 50% of the estimated road freight flow on that corridor (31 million tonnes). Since a great deal of this freight will begin and end its journey away from a rail head the transfer is more correctly described as a transfer from road to trunk haul rail with associated local collection and distribution by lorry. The figure of 50% is realistic and can be replicated on other corridors in the UK.

Transport 2000 in evidence to the House of Lords European Communities Committee, Sub-Committee B (9.6.94) estimated that vehicle kilometres amongst vehicles with four or more axles (the most likely category to be using motorways) could be reduced by 45% if rail freight doubled its tonnes carried.

For the purposes of this analysis we shall assume that a transfer on this scale can take place on each of the main transport corridors in the UK. These corridors are defined by the concentration of road building and motorway widening activity in Department of Transport (1990). They include the M1, M6, M62, A1/A1(M), M4, M3, M2/M20. Within the time and resource constraints of this study it is not possible to replicate the WCML analysis for each corridor. Nevertheless it is a reasonable assumption that similar investments with similar results are possible.

In 1992 goods vehicles were responsible for 28.4 billion vehicle kilometres of which 8.4 billion or 29.5% of the total were on motorways (Department of Transport, 1993, Table 4.9).

The potential transfer from road to trunk haul rail/combined transport has already been estimated in the WCML case study as 50% of the total volume. If we apply this to the total volume of freight traffic on motorways in Britain (50% of 8.4 billion km) we can deduce a potential volume for transfer of 4.2 billion vehicle km or just under 15% of the total of all vehicle kilometres on all roads.

4.2 billion vehicle kilometres can be translated into individual lorry trips taking 12 tonnes as the average load and 83 km as the average length of haul. 12 tonnes is justified earlier in this report and 83 km average length of haul can be found in Table 4.3 of Transport Statistics Great Britain (1993). The calculation is shown below:

4,200,000,000 /83 =50,602,409 /12= 4,216,867

The development of rail/combined transport options with relatively modest investments as in the case of the WCML can substitute for 4,216,867 lorry movements.

This total is well within the range of possibilities assumed by the Kearney report and by recent mainland European experience. In 1991 Intercontainer (the European railway combined transport operator) handled 240,000 TEUs in transit traffic through Switzerland (4.8 million tonnes). This capacity will be trebled on the opening of new tunnels and track (Intercontainer Gazette, 3/92). This capacity has been installed to solve the problem caused by roads carrying 21,000 lorries per day.

TRANS-PENNINE COMBINED TRANSPORT

The case study made detailed calculations about modal transfer and very little investment in combined transport facilities. This led to a "base level" transfer of freight from road to rail on a specific corridor of 373,399 - 414,698 tonnes and a removal of 31,116 - 34,558 lorries per annum from the road system.

There are particularly serious capacity problems on the Trans-Pennine corridors (Transport Planning Associates, 1991) with heavy flows of lorries (Table 24) and they are serious enough to warrant a more radical solution.

These corridors are ideally suited to a combined transport solution utilising the technology of the German "Rollende Landstrasse" which can carry whole lorries including driver and cab as well as trailers and swap bodies.

Table 24

Traffic flows on main Trans-Pennine corridors

Trunk Road	1990 Flow (AADT)	No. of HGVs (AADT)	% HGVs	Volume capacity Ratio (Peak)①	Average Trip Length (kms)
M62 (J21-22)	78,000	15,600	20	0.7	137
A66(T)	10,000	2,300	23	0.6	254
A65(T)	11,000	1,000	9	0.6	103
A59(T)	13,000	1,400	10	0.7	94
A646(T)	11,000	800	7	0.6	39
A628(T)	10,000	2,900	27	0.7	119
A6(T)	6,000	700	11	0.3	100
A523(T)	7,000	800	11	0.5	95
TOTALS	146,000	25,500	14.75	0.58	118

Source: Transport Planning Associates, 1991

① A ratio of >0.7 leads to unstable flows and congestion.

Trans-Pennine lorry traffic is very close to Alpine transit in scale but unlike the Alpine situation has led to demands for an increase in highway capacity and no interest whatsoever in the five railway lines that have ample capacity to take this freight. The UK government has announced plans to widen the M62 in spite of considerable opposition and environmental destruction and Lancashire County Council are campaigning for a new Trans-Pennine motorway to link Burnley and Skipton. Sections of this are already in place as the M65.

Rail/combined transport has the potential to capture a significant proportion of existing traffic and remove the "need" for new highway construction.

On the basis of the WCML calculations and the achievements of Alpine transit shift from road to rail we estimate that 50% of the 25,500 lorries per day can be removed from the Trans-Pennine roads. This would require a great deal of investment in intermodal transfer facilities, rolling stock, locomotives and associated equipment but is a realistic possibility with costs no greater than the capital costs of road improvements proposed in Transport Planning Associates (1991).

Trans-Pennine Freight movements represent an excellent opportunity for the development of CT alternatives over distances which compare very well with the success of rail freight in the Ruhr area of Germany (Holzapfel, 1995).

INLAND WATERWAYS

The results of the Trans-Pennine waterway calculations show a large and completely neglected potential for utilising this mode as an alternative to road freight. Because of the enormous variations in individual waterway/navigable river capacities and physical characteristics it is not possible to generalise from this case study to the whole of the UK inland waterway system. This problem would be compounded by variability in the availability of cargoes and manufacturing/distribution sites adjacent to waterways to take up the capacity offered by a rejuvenated waterway system. An attempt is made, however, to generalise to three other inland waterway systems on the grounds that they serve densely populated areas with large traffic generators. They are the Thames, the Medway and the Severn.

What the case study does show is that for one waterway system it is possible to capture enough freight from the parallel road system to eliminate 52,500 lorries. It is very likely that similar potential exists in the case of the River Thames, River Medway and River Severn. In the case of the Thames and the Medway the potential is there to relieve one of the UK's most congested areas. Each is assumed to have the same potential for transfer as the case study ie 630,000 tonnes and substitute for 52500 lorries.

No case studies were undertaken for the port sector. The role of ports in the UK economy has been reviewed by Maritime Studies (1994) which identifies a large, well organised, productive and underutilised transport infrastructure. Ports traditionally served a well-defined hinterland (Hilling and Browne, 1992) but the geographical logic of imports and exports starting and/or finishing their journeys within (say) 50km of the nearest port has decayed considerably in recent years. This decay is reflected in the decline of ports located to the north and west of the Severn-Tees axis (up to 70% decline in the period 1969-1981) and an increase in trade for the Channel and south coast ports. East Anglian ports have also experienced a "boom" based largely on increased container traffic and Ro-Ro operations to mainland Europe. Traffic through the ports of the Wash and North East Anglia increased by 45% during the period 1975-1992 while the Haven ports (Ipswich, Harwich and Felixstowe) experienced a 272% increase over 1975 (Maritime Studies, 1994).

Ports have the capacity to intercept long distance road haulage, particularly to south coast and Channel ports and to substitute sea miles for road miles for those shipments destined for mainland Europe. The same tendency can be harnessed to minimise distances travelled by imports.

Ports have the capacity to substitute sea miles for road miles in the case of domestic traffic. Road freight from Scotland, the NE of England, the SW and the south coast destined for London and the SE can be transferred to coastal shipping for those commodities and those processes where the coastal option is appropriate. It is clear the potential is there but due to time and resource constraints this potential transfer has not been quantified. The conclusion of the Group Transport 2000 Plus in the report to the European Commission was that:

"The potential of coastal transport needs vigorous enhancement"

CEC (1990), page 38

There is an urgent need for more research in the port/coastal shipping area to identify the scale of the potential transfer in conjunction with the logistic needs of those economic activities purchasing transport services. Unlike rail/combined transport which can match the performance of conventional road in the short term an increased market share for ports and coastal shipping will demand a restructuring of logistics and new patterns of manufacturing and distribution. This is a longer term issue but also a longer term source of additional capacity for freight transport that will almost certainly be needed.

SUMMARY OF TRANSFER POTENTIAL

From the case studies and the evaluation we conclude that rail/coastal shipping/waterways and combined transport have the potential to transfer significant amounts of freight away from road transport. The evaluation of costs (Appendix 1) demonstrates that the costs associated with this transfer can be contained within the present road construction budget (c £2.3 billion per annum). The transfer potential is summarised in Table 25

Table 25

Transfer potential: Summary

	Mode	Lorries removed per annum
1	Rail/CT	4,216,867
2	Inland waterways/CT	210,000
3	Ports/CT	N/A
	TOTAL	**4,426,867**

Note: Ports/combined transport have not been evaluated for reasons explained in the text

The total of goods moved by road freight in Britain in 1992 was 126.5 billion tonne kilometres. Taking average values for tonnes carried per vehicle (12) and length of haul (83km) this translates into 127,008,032 lorry trips per annum. The calculation is shown below:

126,500,000,000/83 = 1,524,096,385 /12 = 127,008,032

The total of lorries eliminated in Table 25 is 3.5%. of total lorry trips in Britain. It is very important indeed to note that the total removed from motorways is 50% and that this scale of reduction in lorry traffic brings with it considerable environmental benefits particularly in reducing CO2 emissions. The potential for reducing local lorry trips is much more problematic and will require a greater level of physical restructuring of production, consumption and land use than is the case for modal transfer.

Modal transfer at current levels of demand for freight transport has significant potential to reduce tonne-km, reduce pollution and remove the need for motorway widening and new motorway/high quality road construction. It can reduce tonne-km of road freight overall by 15-25% and by more than 50% on specific corridors (eg Trans-Pennine) given investment comparable with Swiss Alpine and German "Rollende Landstrasse" initiatives.

Modal transfer cannot civilise the lorry in urban areas and cannot cope indefinitely with the growth in demand for freight transport. Its benefits are very quickly eroded as the volume of goods moved rises. The development of rail/combined transport, inland waterways, ports and coastal shipping will buy time and will reduce CO2 emissions from the transport sector. In the longer term the only solution to environmental problems generated by road freight transport is a stabilisation and reduction of the volume of goods moved.

More importantly the existing pattern of road dependency cannot be relied upon to service the needs of European economies into the future. Modal transfer in the short term and demand reduction in the longer term will be necessary to deliver sustainable transport in the freight sector.

DEMAND REDUCTION

Hey et al (1992) identify two main ways by which the demand for transport can be reduced:

1. Procurement logistics involving the substitution of "near suppliers" for "far suppliers" and the minimisation of distances over which goods travel.

2. Distribution logistics involving the elimination of "useless" transport (Whitelegg, 1994). A great deal of road freight transport makes very circuitous journeys dictated by the pattern of distribution centres and national/international supply chains. It is possible to substitute direct for circuitous trips.

Holzapfel (1995) has identified a 67% reduction potential in lorry kilometres in one sector of the food industry, 75% of which is on motorways. Holzapfel takes the view that these savings underestimate the potential savings in a number of other industrial sectors:

> *"Compared with the potential savings in the yoghurt example, the potential savings in industrial sectors with a more complex supply structure, like for instance the car industry, are certainly much bigger. A theoretical analysis shows that the number of transport links grows with low integration of the production process and with high numbers of suppliers. The figures that were taken in the case of our yoghurt example (as for foodstuffs in general) to calculate the related potential savings were chosen in a way that they lead to an underestimate of feasible potential savings".*
>
> Holzapfel(1995)

Strutynski (1994) has presented an argument for the reduction of freight transport through "lean production". He demonstrates how new forms of regional co-operation amongst suppliers and manufacturers in the car industry can substitute "near" for "far" and reduce distances over which goods are moved by at least 50%. His conclusion is that a 5-fold increase in the cost of road freight transport would produce this shift in organisation and spatial structure.

It is clear from the work of Strutynski (1994), Holzapfel (1995) and Böge (1994a) that there is a potential of at least 50% to reduce freight transport by road and that this potential has nothing to do with modal shift but is simply the result of substituting "near" for "far". The implications of this could not be more significant.

Regionalised systems of production and consumption offer long term economic benefits and a degree of spatial equity to Europe's local economies. The gains in environmental performance as a result of eliminating significant amounts of long distance transport can be captured to ensure genuinely sustainable freight transport. No matter how successful our strategies for modal transfer are they will be diluted over time as the volume of freight rises.

TOWARDS A SUSTAINABLE FREIGHT TRANSPORT SYSTEM

The definition of sustainable freight transport in Werkgroep 2duizend (1992) was a 50% reduction in CO2 compared to the 1990 level. This was described in Table 19. As Table 19 shows this target was informed by the knowledge that freight transport activity would rise (in the basic scenario) to an indexed value of 148 in 2015 compared to 100 in 1990. A target of 50 is, therefore, very difficult to achieve.

In the UK context sustainability can be achieved by a three stage progression towards a similar reduction in CO2 from the road freight sector:

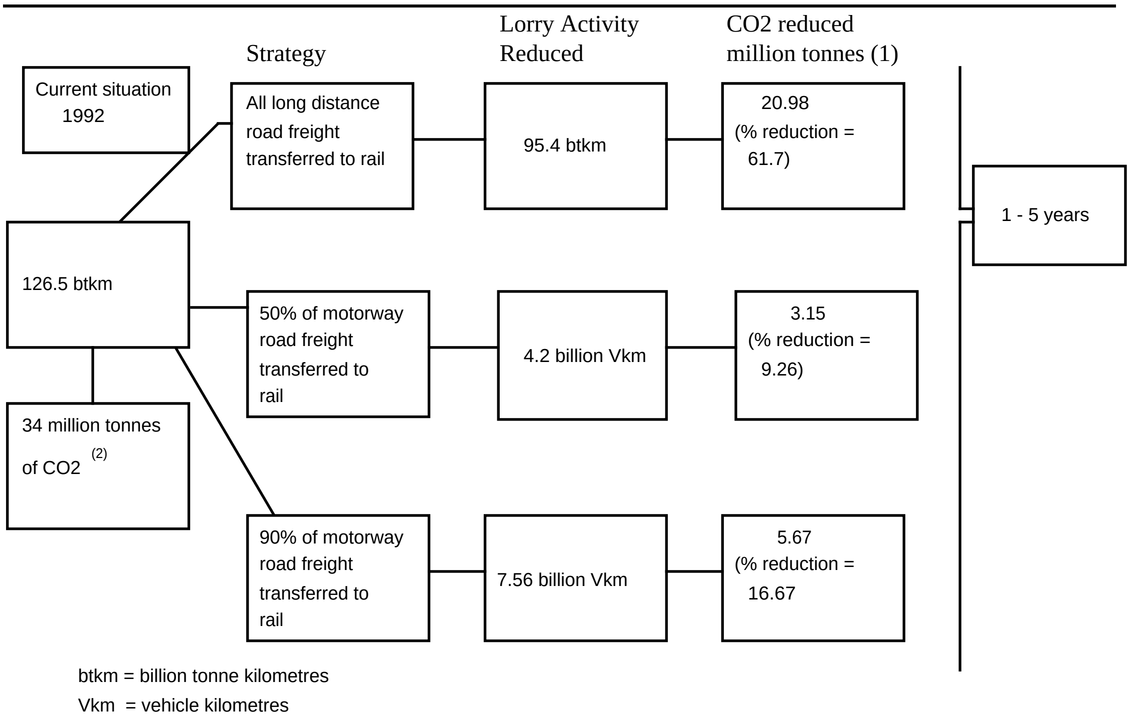
1 Utilising rail/road intermodalism and transferring 50-90% of motorway road freight onto the railways
2 Utilising port and waterway capacity to achieve higher levels of transfer away from road freight
3 Reconstructing logistics and advancing the idea of regional production systems to minimise distance travelled by goods.

Each stage is associated with a time scale for implementation.

Table 26 summarises stage 1 and reveals a potential reduction of CO2 of 16.67%. It is assumed that this can be achieved in 1-5 years. This reduction is approximately equal to the growth in road freight by the year 2000 (Table 22). The net effect therefore in the absence of other measures would be to wipe out this reduction and "buy" about five years grace in the growth of CO2 emissions in this sector. This underlines the importance of approaches that go far beyond modal transfer from road to rail. Put more bluntly a sustainable freight transport system cannot be built on shifting freight from road to rail.

Table 26

The potential for road/rail intermodalism (Stage 1)



(1) Emission factors are 750gms per vehicle kilometre (Tanja, 1993) and 220 gms per tonne-kilometre (Table 1)
(2) Taylor & Fergusson (1993)

Equally the forecasts demonstrate that a functioning freight transport system cannot be based on the existing road system. Just-in-time transport rapidly loses its appeal if reliability levels drop. A sustainable freight transport system is one that can guarantee to maintain reliability and quality in a way that the present approach cannot.

Stage 2 is constructed on the longer time horizon of 5-10 years. This stage takes the findings in Maritime Studies (1994) as its starting point. The UK port system is operating at 50% of its capacity and with 300 ports there are very few parts of Britain not served in some way by a commercial port. The population centres in the Leeds, Doncaster and Sheffield area are in their turn well served by inland waterways (see Figure 18).

It is not possible to make precise estimates of the likely transfer of freight from road to the port system for coastwise traffic or to the port system for international traffic. It is possible, however, to work to targets over a 5-10 year planning period and given a 50% estimate of spare capacity we propose that ports and inland waterways in combination with other segments of intermodal transport take up 10% of the total vehicle kilometres currently accounted for by goods vehicles. Table 27 summarises the impact of a 10% transfer from road freight to shipping and inland waterways.

Table 27

Transfer of road freight to shipping and inland waterways

Vehicle kilometres by road (1992) Billion	28.4
10% transfer	2.84
CO2 reduction (million tonnes)	2.13

A reduction of 2.13 million tonnes of CO2 represents only 6.26% of the 1992 CO2 production in road freight. This contribution is, however, only a modest beginning. Ports and inland waterways can offer spare capacity for utilisation on a 5-10 year time scale (and in some cases immediately). They also have much greater potential if regional production systems (Holzapfel, 1995) and lean production (Strutynski, 1994) become the norm.

Stage 3 takes freight transport into the area of "strong" sustainability. "Strong" sustainability is defined here as the adoption of very clear strategies to resolve fundamental problems of growth and environmental impact. We categorise modal transfer as "weak" sustainability. This is because it does not tackle the well spring of growth pressure in the increasing amounts of distance intensity and freight movement which is characteristic of contemporary European economies. Modal transfer does provide relief and is important. It will for example completely remove the perceived pressure for new road capacity across the Pennines. It will, however, only "buy" time and it cannot in itself dampen down the growth in tonne-kilometres moved.

"Strong" sustainability involves a more ambitious strategy to reduce the distances over which freight is moved by fundamentally altering the spatial relationships in production and consumption. It is designed to eliminate the illogicalities of logistics and substitute "near" for "far" wherever possible in the sourcing and production links of manufacturing, storage and distribution systems.

Holzapfel (1995) has calculated the potential for one category of food product and his results show that 67% of the vehicle kilometres can be eliminated by using local/regional sources of inputs into the manufacture of yoghurt rather than more distant sources. Strutynski (1994) supports this view with a case study in the field of motor vehicle manufacturing.

Clearly more work is needed on a range of products to test the sensitivity of these percentage reductions but the principle is well established.

Stage 3 assumes that 50% of the vehicle kilometres can be eliminated by removing geographical illogicalities in the distribution chain and by substituting "near" for "far" in sourcing decisions. For the purposes of this analysis a 50% reduction in vehicle kilometres will be equated with a 50% reduction in CO2 to be achieved by 2025.

Figure 19 graphs the progressive implementation of the three stage reduction in CO_2 and the forecast of road freight to the year 2025 (business as usual scenario, Table 4.8 Transport Statistics Great Britain, 1993).

The final reduction in CO_2 in figure 19 is 60% of the 1992 figure. This brings road freight very much into line with what is required of CO_2 reductions from all sectors. The International Panel on Climate Change (WMO/UNEP, 1990) concluded that 60-80% cuts in current emissions of CO_2 and other long-lived greenhouse gases are necessary merely to stabilise their concentrations in the atmosphere at 1990 levels.

The 60% reduction implied by the strong sustainability scenario in Figure 19 would in practice be reduced in size by the robustness of the existing trajectory even if measures were adopted to implement the shift. No attempt has been made to superimpose the timing of reductions in the 'strong' sustainability scenario on the timing of the growth in road freight.

EXECUTIVE SUMMARY

The analysis of road freight transport and the potential of alternative modes of transport has shown that at least 50% of the road freight on motorways can be transferred to rail and combined transport within a time scale of less than five years and at a cost which is less than the current road building programme.

The detailed analysis of the West Coast Main Line based on the work of the Piggyback Consortium (PBC, 1994) has shown that the capacity exists on the UK rail system to take this additional freight. The conventional wisdom that a doubling of rail freight would only remove 4% of road freight (Prognos, 1989) is based on a misunderstanding of the structure of road freight. The rail system can easily remove 50% of the long distance motorway based road freight. This has important implications for reducing CO2, reducing the demand for motorway widening and new road construction and improving the economics of the rail system.

On specific corridors under severe stress combined transport based on rail and utilising the German "Rollende Landstrasse" technology can remove over 90% of the lorries. On the M62 and adjacent Trans-Pennine highways combined transport has the potential to remove 20,000-25,000 lorries per day completely eliminating any "need" for new highway capacity. Other corridors experiencing similar stress include the M6 around Birmingham and the M2/M20 through Kent.

At least four waterway systems have the capacity to remove over 500,000 tones and 50,000 lorries each per annum from the road system.

The UK port system has enormous capacity to substitute sea miles for road miles and represents one of the densest and most underutilised transport systems in Europe. It can function for import/export traffic reducing the road mileage involved in long hauls from the north of England and Scotland to Channel ports and East Anglian ports and it can handle coastal traffic within the UK.

The potential for reducing lorry activity by modest transfers to environmentally better modes of transport is large in scale and modest in investment requirements. Such transfers would not, however, solve the fundamental problem of increasingly distance intensive production/distribution systems. The transfers would buy time during which more fundamental solutions aimed at sustainable freight transport would be engineered and put into place.

Eliminating circuitous freight flows dictated by the size and location of distribution centres and manufacturing sites rather than geographical logic would reduce tonne-km dramatically. Substituting "near" for "far" in the sourcing of manufactured products, inputs and intermediate products and in the consumption of final products has the potential to reduce vehicle kilometres by over 60% (Holzapfel, 1995).

An approach to sustainability is developed using modal transfers in the short to medium term and more fundamental restructuring of the locational and production/distribution systems to reduce distances over which freight is moved in the longer term. This is described as "strong" sustainability and has the potential to reduce CO2 from the road freight sector by 60% over the period 1992-2025.

The current pattern of dependence on distance intensive modes of production and on road transport cannot be maintained into the medium term future. There is insufficient highway capacity and rising congestion from both lorries and cars builds in increasing amounts of uncertainty and higher probabilities of economic failure and loss of competitiveness.

A sustainable transport policy based on short term modal transfers, greater use of combined transport including lorries for local trips and longer term demand reduction offers environmental gains and guarantees welfare benefits from a functioning economy. There is no conflict between the environmental and economic imperatives. Lorry dependency contains the seeds of its own destruction whereas a broad spread of demand through a number of modes operating in combination and regionalised production and consumption wherever this is possible offers environmental gains, economic stability and the achievement of sustainability.

Actions which could be taken to move freight transport in the direction of sustainable development are summarised below:

ACTIONS NEEDED TO PRODUCE SUSTAINABLE FREIGHT TRANSPORT

ACTION	LEVEL	COMMENTS
1 All transport modes to pay full external costs	EU	Agreed in principle
2 Introduce CO2/energy tax	EU/MS	In disarray, UK opposed
3 Shift resources from road building to less polluting modes	EU/MS	EU commitment to TERN[1] has major implications for boosting road freight and CO2
4 Introduce specific weight/distance tax for lorries	EU/MS	Supported by T & E[2]. Already in place in some countries outside of EU
5 Utilise potential of technology to track lorries, limit speed, limit access to specific areas	EU/MS/LA	Technology exists, political will does not. Major gains for safety and environment can be obtained.
6 Establish system for recording lorry illegalities and banning firms who break the law	MS/LA	Current levels of policing inadequate. "Cowboy" operators are a problem for the industry, for public safety and for the environment.
7 Exploit city-logistic concepts	MS/LA	Lorries above a certain weight (eg 7.5 tonnes) to be excluded from urban areas. New intermodal centres established at edge of cities and final delivery by smaller/less polluting vehicles.
8 Application of IT to encourage local production - consumption linkages	EU/MS/LA	EU has large funds for IT projects. Can reduce lorry mileage, strengthen local economies
9 Establish regional, national and corridor strategies for freight and modal split	MS	Britain has under-utilised ports, coastal shipping, rail and inland water and over-utilised roads
10 Land use planning to minimise impact of lorries	LA	Industrial estates and lorry traffic generators should be located in such a way as to keep lorries away from sensitive areas.
11 Establish investment strategies and funding mechanisms for rail, coastal shipping and inland water	MS	Large economic benefits for industry if there is a real choice between a number of high quality options.

Notes:

EU = European Union MS = Member State LA = Local Authority

1. TERN is the EU Trans-European Road Network which intends to develop 12000 Km of new roads in the EU at a cost of over 100 billion ECU.
2 T & E is the European Federation for Transport and the Environment which has produced a scheme for a weight distance tax.

CONCLUSION

The analysis has shown that the potential for reducing the number of lorry movements in Britain is very large and much larger than previously recognised. This reduction can be achieved in part by transferring freight from road to rail, inland waterway, coastal shipping and all these modes in combination. It is clear, however that a transfer of this kind cannot represent a fundamental solution to the problems of rising tonne-km of road freight. The environmentally high performing modes cannot adequately deal with the problems of local freight (short journeys) and if average length of haul continues to rise and the demand for freight transport continues to rise there will come a point where environmental impacts from rail freight and from new rail infrastructure are unacceptable.

We have shown how the demand for transport can be reduced by substituting "near" for "far" in the supply and logistics chain and that sustainability concerns go much deeper than modal transfer. Sustainability implies a different organisational system , one that can still satisfy the need for ordinary items of consumption, but one that is not oriented towards global and trans-European supply patterns. The 5th Environmental action programme asserts the importance of resolving environmental problems at source and not after the problem has been well-established. Freight transport offers a number of attractive options for building alternatives. Establishing the importance of regional and local production/consumption links and reducing the basic demand for freight transport is one of these alternatives.

The Royal Commission on Environmental Pollution in its 1994 report on transport and the environment was very clear on the non-sustainability of current trends in road freight transport. The advantages of moving to lower level of tonne-km are wide ranging. This report has concentrated on carbon dioxide emissions as an important indicator of sustainablity but this does not mean that other aspects of road freight are unimportant or less relevant. Lower levels of tonne-km will deliver significant gains in the reduction of road traffic noise and vibration. Reductions in road traffic accidents involving heavy goods vehicles can be expected from reduced lorry activity as can significant gains in health as a result of much lowered emissions of particulates. Local economies will benefit from the increased range of opportunities associated with local production and consumption links and an important source of the pressure for new highway construction will be reduced or removed. The case for the Birmingham Northern Relief Road, for example, would be seriously weakened by a coherent policy for modal transfer and reduction in demand for road freight.

Britain is a small country with intensive pressures on green belt and protected landscapes. In urban areas the demand for car and lorry parking makes its contribution to loss of valuable amenity land and actual or potential green land. Reducing the demands on land take from the road transport system is as important an objective as reducing emissions and is intimately bound up with maintaining biodiversity and enhancing quality of life in urban areas.

The case for fundamental demand reduction in road freight transport is a strong one and the time has arrived when continuing to develop along the same path as the last 20 years is no longer acceptable and is in clear conflict with sustainable development objectives. There is a way forward and sustainable development is a stimulus to innovation and experimentation that will chart a new course

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APPENDIX 1

CASE STUDIES

The 3 case studies are:

1. A combined transport link along the west coast main line (WCML) from London to Manchester. The analysis uses the CSRGT 1991 data of goods lifted from the North West and West Midlands regions to the South East and Greater London area as a basis for the calculations. It omits international road freight travelling along this route as finding suitable data that could be objectively evaluated was difficult.
2. A Trans-Pennine combined transport link from Immingham dock on the Humber estuary to Seaforth dock at Liverpool. The analysis considers both international road haulage and domestic goods moved along this route as it was possible to estimate the share of this volume of traffic.
3. An inland waterway connecting the Manchester Ship Canal (MSC) to the Yorkshire broad gauge canal system at Rotherham. Estimates of potential traffic using this mode of transport was calculated from the data already collected for the Trans-Pennine combined transport route.

The studies consider the potential volume of traffic that could transfer from road to these alternatives. Furthermore the estimated market shares represent levels which are achievable and economically viable. It is realised however that without a proper feasibility study that includes a commercial evaluation of the routes the figures here remain very broad estimates. In spite of this, costing of the routes, especially for the combined transport routes are based on data published in the Final Report by the Piggyback Consortium, PBC (1994) into the feasibility of a much larger WCML combined transport linking Glasgow and an Irish Sea port to London and the Channel Tunnel. Accordingly, costs are current and have been agreed between Railtrack and the consortium.

Typical HGV loading factors
The case studies are attempting to quantify the possibility of inducing a modal shift away from road freight i.e lorries. It is necessary, therefore, to estimate an average value for a lorry's payload. Simons (1994 pp51) calculates that one lorry carries approx 20t of goods. This is higher than other estimates and may be due to mainland European weights which are higher than the UK (typically 44 tonne compared to 38 tonne in the UK).

Environmental Resource Management (1994) in the PBC final report works on a load factor of 12t per HGV. Fergusson (1993) states that the average load for articulated vehicles >33t GVW is 15.26t within a range 11t - 24t. This study therefore uses the Environmental Resource Management/PBC value of 12t loading factor in all of the calculations for rail wagon capacity.

CASE STUDY NO.1: WCML COMBINED TRANSPORT ROUTE

CSRGT 1991 data (Department of Transport, 1992) show that the volumes of goods lifted moving between NW, W Midlands, SE and Greater London are:

Table 1

	G. London	S. East	Total
N. West	3	10	13
W. Mids	5	13	18
Total	8	23	31

Millions of tonnes

Further, CSRGT, 1991 also shows that national figures for goods lifted by vehicle type are (millions of tonnes):

Table 2

	Rigid				Artic	
GVW(t)	3.5-7.5	7.5-17	17-25	>25	3.5-33	>33
t lifted	75	256	236	289	165	484
%	4.98	17	15.7	19.2	10.9	32.2

Assuming that traffic moving between the origin and destination is in the same proportion as above (by vehicle type), then it is conceivable that the market potential for combined transport would possibly be that proportion which currently travels by lorry over 25 GVW (both rigid and artic). CSRGT shows that these vehicles account for 927million tonnes of the total 1505 million tonnes goods lifted (62%).
If we multiply Table 2 by 0.62 we arrive at an estimate of potential combined transport goods moving between destinations.

Table 3

	G. London	S. East	Total
N. West	1.83	6.1	7.93
W. Midlands	3.05	7.93	10.98
Total	4.88	14.03	18.91

Millions of tonnes

According to Toubol (ECMT 1993 pp40) certain goods are not suited to combined transport. These goods are NST categories 1,3,8,9,10,11,15,16. These are: live animals, sugar beet, solid mineral fuels, crude oil, petrol and petroleum products, iron scrap, blast furnace dust, natural & manufactured fertilisers. These commodities must be excluded from Table 3 Also it is assumed that the combined transport market is only interested in goods travelling >200km. Therefore this factor must be accounted for in the calculation. These factors were calculated by using CSRGT Table 14 data: "Goods lifted by commodity & length of haul".

Table 4

Goods excluded

	million tonnes
Agri products	15
Coal & coke	5
Petrol & Petrol products	3
Ores	2
Other crude materials	6
Fertilisers	3
Total	34

However, CSRGT also shows that all commodities moving >200km equals 187mt.
Therefore combined transport market is: 187 - 34 = 153 mt: or, 82% of total goods lifted. Now, assuming that national conditions apply on the route being assessed the values in Table 4 can be multiplied by 0.82 to arrive at the actual potential combined transport market for goods lifted moving between NW, W. mids, and SE and London.

Table 5

	G. London	**S. East**	**Total**
N. West	1.5006	5.002	6.5026
W. Midlands	2.501	6.502	9.003
Total	4.0016	11.504	15.506

million tonnes

In terms of lorry loads this tonnage of goods suitable for combined transport would fill the following number of lorries (assuming a 12t load factor).

Table 6

	G. London	S. East	Total
N. West	125050	416833	541883
W. Midlands	208416	541833	750249
Total	333466	958666	1292132

number of lorries

In terms of vehicles per day, assuming a 6 day working week and 4 weeks holiday pa, the number of working days pa = 288, therefore number of vehicles day equals:

Table 7

	G. London	S. East	Total
N. West	434	1447	1881
W. Midlands	723	1881	2605
Total	1157	3328	4486

Vehicles per day

The figures above can be directly transposed into rail wagons per day. If the UK government allows an increase in HGV size to 44t GVW and assuming a load factor of 20 t the above figures should be reduced by 40%.

Market share
These data underestimate the potential market share for combined transport. Combined transport can operate over distances of less than 200km. Figures from the PBC (summary pp26) estimate that for international traffic travelling the same route they would expect to capture 9% of the market by the end of the century (service opening in 1998). On the Continent (again for international trade) Toubol (1993 pp55) estimates approximately 8% of the market by 2005.

Engels (1993 pp41) says that on hauls over 500 km combined transport is estimated to have already captured 13.4% of market. And through the Alps between 9-23% Van Zijst (ECMT 1993 pp88) writes that within the current non-user group in the Netherlands, carriers engaged in volume transportation estimated that maximum share of the market for them using combined transport could be up to about 20%.

From the studies above it can be seen that a realistic estimate of market share for combined transport (under existing policies towards road and rail freight) lies between 10-20%. Accordingly the estimated wagons per day figure should be adjusted to suit.

Table 8

10% Market Share

	G. London	S. East	Total
N. West	44	145	189
W. Midlands	72	188	260
Total	116	333	449

Wagons per day

Table 9

20% Market Share

	G. London	S. East	Total
N. West	88	290	378
W. Midlands	144	376	520
Total	232	666	898

Wagons per day

Assuming that each train will pull 30 wagons, then the data above mean that the number of trains operating per day will be:

10% market share
NW to SE & London: 6 trains / day (3 each way)
W. Midlands to SE & London 8 trains / day (4 each way)

20% market share
NW to SE & London: 12 trains / day (6 each way)
W. Midlands to SE & London 16 trains / day (8 each way)

CASE STUDY NO. 2: TRANS-PENNINE COMBINED TRANSPORT ROUTE

Much of the combined transport literature suggests that it is not economically viable below about 500km distance. For example, Carpenter (1994) reports that in the Financial Times (6.11.90) BR stated that "with exceptions rail freight transport over less than 200 miles (320km) is uneconomic". Exceptions are more than likely to be 'merry-go-round' bulk goods movement between coal mines and power stations. More specifically BR Railfreight (Hansford 1990) has estimated that the break-even distance at which rail freight of a single unit becomes economic is 250 - 300 miles (400-480km). Seymer (1992) reports that some continental railway operators claim that 600km is minimum distance over which rail can compete with road for container traffic. This figure may represent the movement of modest amounts of traffic, or that the O & D of cargo is relatively remote (Carpenter 1994)

However, others such as Kilvington (1990) have calculated that the majority of goods can be moved more economically by rail than road at 300km. Also, Runge (1989) has shown that in Germany combined transport ("Rollende Landstaße" or rolling road & piggyback) may present alternatives to direct road transport at distances down to 200km but Carpenter (1994) suggests that this may be an isolated case peculiar to Germany because of the regulatory system that controls journeys by permit. The experience in Germany and Switzerland shows that on heavily trafficked corridors lorries can be carried 'piggy-back' on trains (Rollende Landstraße) over distances of 100 - 200km.

1989 data for international road haulage (IRH) travelling between GB regions shows that total annual goods lifted (both inward and outward journeys) between NW and the Continent was only 635,000 tonnes or approx 52,918 lorries assuming 12t load factor. Obviously all this will not travel through the Humber ports. A conversion of this figure into vehicles per day will show that this is insufficient to support a combined transport system; assuming a 20% market penetration = 36 lorries per day or about 1 train per day (half train per day each way)

52,916 lorry p.a. = 184 per day

This is clearly not economically viable. Therefore, to increase the potential marketability of a combined transport link across the Pennines one must also consider the volume of goods moving between the Irish Republic and continental Europe. Currently road traffic operating between these destinations will either arrive in GB at the South or East coast ports and travel by road to NW, W coast ports (Liverpool, Holyhead, Heysham etc). For a Trans-Pennine combined transport route to be viable it is **imperative that a signifcant proportion of this traffic must be captured.**

According to PBC (section 6 final report) 1992 estimates of trailer movements between NW, Scottish and N Wales ports to Ireland are:

Dublin Bay - Holyhead / Liverpool	*14000
NI - Stranrear	*17000
From NI	*18000
To Rosslare	7000
To Dyfed	14000
Total	49000

Those marked with * are potential combined transport Trans-Pennine traffic and adds up to 49,000 trailers (70% of total).

Also, PBC (pp84) estimates that container movement between the Republic/Northern Ireland and Continent is approximately 164,000 p.a. Assuming the same 70% share moving between NW, Scottish and N.Wales ports, then the potential market is 115000 containers. This gives an aggregate figure for unitised traffic of 164,000 per year. Further PBC (pp97) estimates that a 15% market share of units moved is feasible, therefore possible Trans-Pennine combined transport traffic equals:

> 164,000 x 0.15 = 24,600 units per year
> or 332,100 tonnes (PBC assume 13.5 tonne loading factor here!)

This is a substantial amount of goods lifted and would make a Trans-Pennine combined transport route economically viable.
What proportion of domestic IRH traffic travelling to the NW could possibly use the combined transport alternative?

> IRH to / from NW = 635,000 tonnes

This however includes existing Irish traffic. According to Transport Statistics Great Britain (1989) this accounts for 1.6% of all IRH (124,000 tonnes).
It is reasonable to assume that this trade is not evenly distributed across England, Scotland and Wales, and that proportionately the NW region's share will be greater because of its closer location and hence lower transport costs. This traffic would not therefore need to use a Trans-Pennine combined transport route.
So, assuming that the NW has approximately 15% of this market this would reduce total trade with Ireland by 18,600 tonnes. Also, all the traffic does not travel between the Humber ports and NW - although it is the shortest and cheapest route in terms of road costs - and in an economically rational world would be the most cost effective route.

What proportion of IRH travelling from/to NW uses the Humber ports? Again this data is not available for analysis. However, if the ratio of goods lifted between the NW, Yorkshire and Humberside and SE is any indicator of this split then it would suggest than NW hauliers use the Humber ports twice as much as the SE coast, i.e a ratio of 2:1 in favour of the Humber. Using this figure we can estimate that 66% of NW IRH passes through the Humber ports. In actual tonnage the figures for domestic traffic are:

IRH to / from NW			=	635000 t
minus Irish goods moving from NW			=	(18600)
				616400
minus 33% to SE ports =				(203412)
				412988 t
10% market share	=	41299		
Irish traffic	=	332100		
Total		**373399**		
20% market share	=	82598		
Irish traffic	=	332100		
Total		**414698**		

In terms of vehicles/wagons (12t loading factor) = 31,116 to 34,558 per year.
Assuming 288 working days per year then this equals: 108 to 120 wagons per day.

This is equal to approx 4 trains per day (2 each way) with 30 wagons per train.

CASE STUDY NO. 3: TRANS-PENNINE INLAND WATERWAY

A freight goods system using this mode is not feasible on a national scale due to a lack of suitable waterways. For example:

- Navigable rivers and principal canals are shown in Figure 18.
- Physical location means that there is only a limited potential market.
- Navigable river lengths are minimal.
- Canal widths and depths constrain the size and DWT of shipping. With the exception of the Manchester Ship Canal and Gloucester and Severn Canal from Gloucester to the River Severn, UK inland waterways are typically restricted to approximately 700DWT.

This study will therefore concentrate on the viability of a Trans-Pennine route connecting the Manchester Ship Canal with the Yorkshire broad gauge canals and the Humber Estuary as presented by Transpennine Waterway Interest Group (TWIG) co-ordinated by Keith Ingham, Consultant Artchitect and Designer, Manchester.

TWIG suggests a route from the MSC through the disused Woodhead rail tunnel to Sheffield, Rotherham and the Sheffield & South Yorkshire Navigation (S & SYN). This would connect into the existing Yorkshire canals and the River Ouse and Humber Estuary.

A canal able to take 1350 tonne Eurobarges (Class IV) would need to be a minimum 25m wide, 3m deep with approximately 6m clearance. The 32-64km of new canal would then link all of Europe (Ireland to the Black Sea) with a transport system that in principle would need no transhipment of goods. The canal would offer the lowest possible line-haul costs over an approximate 3200km route.

Civil engineering problems are well within known practice. The recently constructed Rhine-Danube canal was similarly over a watershed. The Manchester Ship Canal/Sheffield and South Yorkshire Navigation link would require a lift of no more than 260m with the use of the Woodhead tunnel avoiding the need to cross over the moor tops. Boat lifts (not locks) with no water loss are expected to be used (6-10 east from Manchester and 3 down to Sheffield).

Cost estimates suggest £300-400M plus land costs. Transit time would be about 3 days mid-UK to mid-Europe. Total costs including upgrading of existing navigations and port facilities would be under £1bn.

Volume of Traffic and Viability

The type of goods carried would, of course, be in direct competition with that carried by other modes. Waterways are better suited to bulk goods/low value goods and standard container traffic. In practice rail and inland waterways would serve different markets. If we assume that the weight of a standard conainer is approximately 2-3 tonnes and add to this an 18-22 tonne load factor we arrive at a total unit weight of approximately 22 tonnes. This means that a 1350dwt vessel will carry approximately 60 lorry load equivalents in containers.

Potential Irish-Continental Traffic using a Trans-Pennine Waterway

Using the 332100 tonnes of goods lifted as a starting point, and assuming that due to other factors such as slow movement by water etc. 50% of this traffic is not suitable, the possible total of tonnes lifted is approximately 166050 tonnes p.a. moving between Ireland and Continent. Add to this goods not suitable for combined transport mode. PBC (pp91) estimates that liner tonnage to/from Republic and Continent of some goods are (all figures in tonnes):

Peat	120,000
Urea	131,000
Natural Fertilizers	98,000
Other Fertilizers	65,000
TOTAL	**414,000**

Again assuming that the same conditions apply as for combined transport route (70% of goods lifted move through NW ports) we arrive at a figure of 289,800 tonnes pa. Now, due to the very low transport costs and lack of the need for transhipment between Ireland and Continent, the route is considered to be very attractive to hauliers and captures 25% of the market. Then the final estimate of "other goods" tonnage is 72450t.

Total potential market is therefore (tonnes):

166,050
72,450
238,500

Domestic Traffic
It is very difficult to estimate the potential share of these goods lifted that might use an inland waterway link across the Pennines. Due to the short distance being travelled and high terminal costs it is possible that the route would only capture a very small proportion of the goods moved between NW and Yorkshire & Humberside. That is not to say that when a system is in operation and cost/tonne-kilometre data are avaible for inspection by hauliers that there will not be some cross over especially for those involved in moving bulk materials such as coal, coke, building materials, fertilisers or chemicals. Clearly then for this system to operate profitably the need to capture a regular clientele i.e. Irish Continental traffic is important (as with the combined transport route). If this can be achieved then there is perhaps considerable scope for "piggybacking" of small loads by domestic hauliers on the strength of the regular movements of Irish traffic. The table below shows the type of commodites that are currently moved by water on a selection of canals and waterways.

Goods moved on Humber, Trent Ouse, Aire and Calder Navigation, Sheffield/South Yorkshire Navigation:

Coal	To Ferrybridge Power Station
Petrol/Oil	On much of the system
Aggregate	On much of the system
Sludge	Goole to Leeds
Paper	To York
Fluorspar	To Rotherham

Goods moved on Thames & Medway:

Refuse	
Grain	From Tilbury
Aggregate	From Medway to Thames
Orimulsion	To Richborough Power Station

Goods moved on Mersey, Manchester Ship Canal, Weaver

Grain	From Seaforth
Orimulsion	To Ince Power Station
Chemicals	On much of the system
Oil	On much of the system

(Source: F.W. Andrews (no date) "Freight on Inland Waterways - a way ahead" in TWIG paper.

The table shows that there is a market, but quantifying its extent is difficult due to a lack of statistics. All that is possible therefore is to make simple estimates based on current road movements of goods lifted between NW and Yorkshire & Humberside (Y & H). The CSRGT (1991) data shows that there were 21 million tonnes of goods lifted transported between the two destinations. Of this, 9 million tonnes was from NW to Y & H, and 12 million tonnes from Y&H to NW.

Even if the canal was able to capture just 1% of this traffic it would represent some 210,000t of goods lifted or 17,500 lorry load equivalents assuming 12 load factor. 3% and 5% figures would be:

3% of road goods lifted = 630,000 tonnes or 52,500 lorry equivalents

5% of road goods lifted = 1,050,000 tonnes or 87,500 lorry equivalents
Add to this the Irish traffic (table below)

Table 10

Domestic	Irish	Total	Vessels	Vessels/week
210 (1%)	238.5	448.5	332 (pa)	7
630 (3%)	238.5	868.5	643 (pa)	13
1050 (5%)	238.5	1288.5	954 (pa)	20

Figures in '000 tonnes

At 3% share of domestic road haulage goods lifted plus Irish goods lifted the viability of the Trans-Pennine waterway looks feasible, being able to offer (in theory at least) 1 vessel each way on 6 days per week (assuming the same 288 working days per year). At 5% the viability is even stronger; not only because of an increase in tonnage but also because the operators may be able to offer greater flexibility and variation; for example, smaller minimum loads or even cheaper rates.

Infrastructure costs

How do the costs of providing these alternatives compare with current motorway and widening scheme costs?

In Trunk Roads England in the 1990s (HMSO 1990), slightly modified in 1994, the Government sets out the current road building programme and its costs.

Road building	**£(million)**
- 14.4km urban motorway: Greater Manchester western / Northern bypass	159 (11.04 / km)
- 7.5km M40 near Oxford	22.4 (2.94 / km)
- 20km M40: Waterslack to Wendlebury	77.2 (3.83 / km)
- 9km Lancaster Western Bypass	81.0 (9.04 / km)
- 21km M65 Blackburn Southern / Western Bypass	93.0 (4.47 / km)
Widening	
- 146km M1 junction 15 - 30	794 (5.45 / km)
- 11km M6 junction 30 - 32	56 (5.0 / km)
- 52km M6 junction 11 - 16	280 (5.38 / km)
- 171km M25	1000 (5.84 / km)

From these figures the average cost of building a dual 3 lane motorway is therefore £6.26m per kilometre. For widening (to 4 lanes per carriageway) the average cost is £5.41m per kilometre. The widening of 63km of the M6 as outlined above will cost £336m. At these rates (1989/90 prices) it is estimated that the widening of the whole motorway link between London and Glasgow (M1 junction 1, M6, A74, M74 junction2: 658km) would cost in the region of £3.5bn.

In comparison the much needed upgrading of the WCML is already budgeted at one seventh of this, a meagre £500m (approximately 800km @ £0.625 million per kilometre). Further, PBC estimated that the cost of upgrading the WCML to take combined transport (ensuring that the loading gauge -height of bridges and tunnels is large enough etc.) would cost approximately £45m (PBC Summary pp22). The exact wording of the paragraph is:

> *"Based on unit costs agreed with railtrack, the cost of providing piggyback from Glasgow and an Irish Sea port to the channel tunnel has been estimated at £45m including allowance for fees, land purchase and disturbance to passenger services. Even allowing for a 50% over-run a piggyback route would be achieved for under £70m." para. 4.13*

In addition to these costs, for a combined transport service to be operational one must also consider other infrastructure costs such as that for terminals and rolling stock. PBC estimates that that the price of wagons to take 38.5gvw trailers is between £40 -65K for lots of 100-500 Loco costs are estimated by PBC to be approximately £1.4m each. PBC estimates the cost of a "regional" combined transport terminal to be £10.92m which includes all new tracks, cranes, yard tractors and shunting equipment. However, on the WCML, the PBC is of the opinion that currently capacity could be handled by existing freight terminals at Manchester, London and Birmingham but in the medium term additional capacity will be necessary especially in the London area.

On the Trans-Pennine route existing facilties at Seaforth and Immingham could be utilitised but upgrading may be necessary.

Using these figures one can therefore estimate the total capital costs of providing a combined transport link on the WCML and across the Pennines.

Trans-Pennine combined transport Route Capital Costs	**£ (millions)**
Upgrading Liverpool-Immingham link: 239km @ £0.625M/km	149.375
Upgrading to piggyback loading gauge: 239km @ £0.076/km	18.160
Allowance for new terminals: 2 No. @ £10.92M each	21.840
120 Wagons @ (avg) £0.0525M each	6.300
4 No. heavy duty diesel locos @ £1.4M each	5.600
TOTAL	**£201.275**

WCML combined transport Route Capital Costs	£ (millions)
Upgrading London - Manchester Link: 310km @ £0.625M/km	193.750
Upgrading to piggyback loading gauge 310km @ £0.076/km	23,590
Allowance for new London Terminals 1 No. @ £16.11M each	16.110
540 Wagons @ (avg) £0.0525M each	28.350
18 No. heavy duty diesel locos @ £1.4M each	25.200
TOTAL	**£287.000**
Price per km = £0.925M	

The cost of these projects are 5 - 6 times cheaper per kilometre than for widening of existing motorways.

Trans-Pennine Inland Waterway

Building canals is the most expensive option !

Details of costs of recently built inland waterways on the Continent are outlined below.

Rhine-Main-Danube (RMD) canal: Germany
Length: 171km, 16 locks.
Width: 40m (55m @ surface) x 4m deep
Cost: DM 2679m for 64 km of the most difficult section between Nurnberg and Kelheim.

(Waterways News 4/82)

River Saar: River Mosel to Saarbrucken: Germany
Upgrading of river to take 2000dwt vessels
Length: 85km
Cost: £250m

(Waterways World 3/80)

Rhine-Rhone link: France
River Saone: 217km. 5 locks, and, Canal du Rhine au Rhone, 230km 24 locks.
Cost: River Saone: 340m FF
Canal du Rhine au Rhone: 1400m FF
Macon diversion: 100m FF

(1982 prices)

TWIG estimates the capital costs of this link to be:

MSC to Sheffield: 75km @ £4M/km =	300M
Sheffield to Rotherham: 13km @ £2M/km =	26M
Rotherham to River Trent: 50km @ £0.8M/km =	40M
	366M

Clearly this is an expensive option (average cost £2.6m per km excluding other infrastructure such as barges and port facilities). However, if the PBC study is any guideline, then the costs of these would not significantly add to the cost per kilometre. Accordingly, this scheme would still be cheaper than road widening of the M62 at £5.41m per km. Further, as the estimated emissions calculation shows this mode of transport produces the greatest reductions.