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IMPACTS OF INCREASED GOODS VEHICLE WEIGHT LIMITS

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EXECUTIVE SUMMARY

On 1 January 1993 the maximum weights and dimensions of goods vehicles operating between European Community (EC) countries were harmonised. The United Kingdom has a derogation from some of the regulations (for example, the increase in the maximum permitted axle weight from 10.5 to 11.5 tonnes) until 1 January 1999. It is likely that United Kingdom domestic regulations will be brought into line with most of the EC limits.

Harmonisation will increase the maximum permitted weights in the United Kingdom for each type of heavy goods vehicle. (For example, from 1999 the weight limit for 5-axle artics will be increased from 38 tonnes to 40 tonnes.) This will affect the composition of the goods vehicle fleet, structural road wear, etc. In 1990 the Freight, Road Haulage and Taxation Policy Division of the Department of Transport commissioned TRL to investigate the likely impacts of the proposed changes in weight limits that come into effect in 1993 and 1999.

This report summarises two parts of the study:

- identification of the likely characteristics of vehicle operating at the heavier weight limits; and

- a questionnaire survey of goods vehicle operators to determine the use of vehicles at the heavier limits.

Two other reports cover a review of information on the impacts of heavy goods vehicles (Frith, 1993a) and trends in road goods transport between 1983 and 1991 (Frith, 1993b).

The characteristics of vehicles operating at the new weight limits were estimated from the characteristics of equivalent vehicles operating in 1991. The values for existing vehicles were based on data from the Department of Transport's Continuing Survey of Road Goods Transport and on data from TRL roadside surveys of goods vehicle weights and dimensions. The data were also used to estimate road wear factors for existing and heavier vehicles. (All the road wear calculations were based on the assumption that structural road wear is simply proportional to the fourth power of the static axle weight.)

In order to determine how goods vehicle operators would change their fleets in response to the changes in weight limits, questionnaires were sent to 248 goods vehicle operators. Since most operators have few vehicles it was decided to concentrate on operators with more than 25 vehicles. Both own account (move their own goods) and hire and reward (move goods that belong to others) operators were included in the sample. For each of the new weight limits, operators were asked whether they would use vehicles at the new limit and, if they would, how many they would use and which vehicles they would replace. Complete replies were received from 182 operators (73 per cent of all questionnaires).

The replies to the questionnaires were grossed-up to give estimates of the changes to the national fleet of goods vehicles. These estimates were made assuming that there would be no change in the overall amount of goods moved by road. The estimates also reflected the long term aspirations of operators - some vehicles could be upgraded to the new weight limits but other changes would occur as vehicles are replaced.

It was estimated that the 1993 (derogated) weight limits would lead to a 1 per cent decline in the number of heavy goods vehicles and annual goods vehicle travel and a 1 per cent increase in road wear factors. The introduction of the full EC weight limits (in 1999) would have a greater impact. It was estimated that it would lead to a 3 per cent decrease in the number of goods vehicles and a 4 per cent decrease in annual goods vehicle travel but an 8 per cent increase in road wear factors.

The operators were also asked if they would use 42 or 44 tonne artics. Few operators wished to use these vehicles if they could only be used for combined transport (moving unitised goods to and from a rail or barge terminal). However, many operators were interested in using these vehicles if there were to be no restriction in their use. It was estimated that the inclusion of 42 / 44 tonne 6-axle artics to either the 1993 or the 1999 scenario would further reduce the number of goods vehicles and annual goods vehicle travel by 1 to 2 per cent. It was also estimated that this change would lead to a reduction in road wear factors of 3 to 4 per cent. However, the addition of both 5 and 6-axle 44 tonne artics to the 1999 scenario was estimated to lead to an increase in road wear factors of about 3 per cent.

The accuracy of the results depended on a number of assumptions. These include the characteristics of the vehicles and assumptions about how the heavier vehicles would be operated. It should be noted that the questionnaire replies reflected the information available to the operators. Whilst some information on the characteristics of the vehicles was available, other factors, such as the level of Vehicle Excise Duty (VED) payable for the heavier vehicles, was not known. For example, after the questionnaire were returned it was announced that the VED rate for 35 tonne 4-axle artics operating in 1993 is £5,000 compared with £2,450 for existing 32.52 tonne 4-axle artics. The report includes analysis of the sensitivity of the results to some of the assumptions.

IMPACTS OF INCREASED GOODS VEHICLE WEIGHT LIMITS

ABSTRACT

The maximum weights of goods vehicles operating between European Community countries were harmonised on 1 January 1993 (the United Kingdom has a derogation from some of the regulations until 1 January 1999). This harmonisation will increase the maximum permitted weights in the United Kingdom for all types of heavy goods vehicle (rigid, articulated and drawbar) which will affect the composition of the vehicle fleet, structural road wear, etc. In order to estimate the impacts of these changes, TRL conducted a questionnaire survey of goods vehicle operators' responses to the new limits. The survey data were grossed-up to give estimates of the numbers of goods vehicles, amount of goods vehicle travel and overall road wear factors for the new weight limits. (For the purpose of the study it was assumed that there would be no change in the amount of goods moved by road.) The results indicated that full implementation of the European Community weight limits in the United Kingdom would lead to a reduction in the number of goods vehicles and annual goods vehicle travel and an increase in road wear.

1. INTRODUCTION

The maximum weights of goods vehicles operating between European Community (EC) countries were harmonised on 1 January 1993 (the United Kingdom has a derogation from some of the regulations until 1 January 1999). It is likely that most of the EC regulations will be extended to also cover goods vehicles operating solely within the United Kingdom. This harmonisation will increase the maximum permitted weights in the United Kingdom for all types of heavy goods vehicle (rigid, articulated and drawbar) which will affect the composition of the vehicle fleet, structural road wear, bridge loading, etc. In 1990 the Freight, Road Haulage and Taxation Policy Division of the Department of Transport commissioned TRL to investigate the likely impacts of the proposed changes in weight limits.

The project included identifying the likely characteristics of vehicles operating at the new weight limits and estimating the response of goods vehicle operators to the new limits. In order to determine the response of operators, questionnaires were sent to 248 goods vehicle operators in November 1991. A number of different scenarios were included in the questionnaires, including two scenarios covering the vehicles permitted in the United Kingdom in 1993 and 1999. Completed replies were returned by 182 operators. The data from the replies were then grossed-up to give estimates of the number of vehicles which would be operated in the United Kingdom at the heavier weight limits. Total goods vehicle travel and the effects of the heavier vehicles on road wear factors were also calculated. Other impacts of the heavier vehicles, on people, the environment, safety, etc are considered in a separate report (Frith, 1993a).

It will take several years for the changes in the goods vehicle fleet to be completed and, during this period, economic circumstances and the quantities of freight transported are likely to change. Since the purpose of this study was to examine some of the possible consequences of the changes in weight limits, it was assumed that the volume of freight to be moved for each scenario remained constant at the 1991 levels.

It was estimated that the increases in weight limits implemented in 1993 would lead to small (1 per cent) decreases in the number of goods vehicles and total travel by goods vehicles but a slight increase (1 per cent) in overall road wear factors. The increases in weight limits due to be implemented in 1999 would lead to larger decreases (3 - 4 per cent) in the number of goods vehicles and total travel by goods vehicles and a larger increase (8 per cent) in overall road wear factors.

In this report the maximum permitted gross weight of a goods vehicle is referred to as its Plated Gross Weight (PGW). The classification system for goods vehicles used in this report is based on the number of axles, the configuration of the vehicle (R- Rigid, A - Artic, D - Drawbar) and the number of tractive-unit and semi-trailer axles (where appropriate). For example, class 5A(2+3) refers to a 5-axle articulated vehicle with a 2-axle tractive-unit and a 3-axle semi-trailer.

2. GOODS VEHICLE WEIGHT LIMITS

The 'Construction and Use' regulations (Secretary of State for Transport, 1986) set weight limits for vehicles depending on the vehicle configuration, number of axles and wheelbases. The main configurations of goods vehicles are:

- Rigids (goods vehicles without any trailer);
- Artics (consisting of a tractive-unit which does not carry any goods and a semi-trailer part of whose weight is carried by the tractive-unit); and
- Drawbars (consisting of a rigid goods vehicle towing a trailer).

Weight limits are also specified for individual axles and for linked axles (bogies). The limits for bogies depend on the spacing between the axles and, for 3-axle bogies, the type of suspension.

EC directives set weight limits for goods vehicles used on journeys between member countries (see Appendix A). Most of these limits came into force on 1 January 1993. However, the United Kingdom and Ireland have derogations from some of the regulations until 1 January 1999. The 1992 United Kingdom weight limits, those which came into force in 1993 (Secretary of State for Transport, 1992) and those due to come into force in 1999 are summarised in Table 1.

In February 1993 the Department of Transport published a consultative document (Department of Transport, 1993) which proposed increasing the maximum permitted weight for 6-axle artics and drawbars on journeys to or from rail terminals from 38 to 44 tonnes. It also proposed increasing the maximum permitted weight for drawbars with 5 or more axles from 35 to 38 tonnes. If approved, these changes would be unlikely to come into effect until the beginning of 1994.

3. VEHICLE DESIGNS

The first stage of the project involved defining the likely characteristics of vehicles operating at the new weight limits. These were generally based on the characteristics of the equivalent vehicles operated in 1991. Data from the Department of Transport's Continuing Survey of Road Goods Transport (CSRGT) (Department of Transport, 1992) and TRL surveys of goods vehicle weights and

TABLE 1

Maximum permitted weights in the United Kingdom

Type of vehicle / axle		Weight limits (tonnes)		
		1992	*from 1.1.93 (derogated)*	*from 1.1.99 (full EC limits)*
Rigid:	2-axle	17.00	-	18.00
	3-axle	24.39	25.00 (26.00[1])	-
	4-axle	30.49	30.00 (32.00[2])	-
Artic:	3-axle	24.39	25.00 (26.00[1])	-
	4-axle	32.52	35.00[3]	36.00 (38.00[6])
	5/6-axle	38.00	-	40.00 (44.00[7])
Drawbar:	4-axle	32.52	35.00[3]	36.00
	5/6-axle	32.52	35.00[3]	40.00
Axles:	non-drive	10.17	-	10.00
	drive	10.50	-	11.50
Bogies:	2-axle on a vehicle	20.34	18.00 (19.00[4])	-
	2-axle on a trailer / semi-trailer	20.34	20.00[5]	-
	3-axle	22.50 (24.00 on air)	-	24.00

Notes: - limit unchanged;

1 if drive axle(s) fitted with twin tyres and air (or equivalent) suspension or axle weight does not exceed 9.5 tonnes, also the axle spread must be at least 5.2 metres;

2 if drive axle(s) fitted with twin tyres and air (or equivalent) suspension or axle weight does not exceed 9.5 tonnes, also not to exceed 5 tonnes PGW per metre of axle spread;

3 if drive axle fitted with twin tyres and air (or equivalent) suspension or on an international journey;

4 if drive axle(s) fitted with twin tyres and air (or equivalent) suspension or axle weight does not exceed 9.5 tonnes (existing vehicles will be permitted to continue at weights shown on their plates);

5 existing vehicles will be permitted to continue at weights shown on their plates;

6 if drive axle fitted with twin tyres and air (or equivalent) suspension (tractive-unit not to exceed 18 tonnes, semi-trailer not to exceed 20 tonnes);

7 for combined transport (specifically, the movement of 40 foot ISO containers as part of a combined road and rail / barge journey) provided that a 3-axle tractive-unit is used.

dimensions (Shane and Newton, 1988, Sommerville, 1990, Sommerville and Tarry, 1990 and Frith and Barbour, 1992) were used to calculate the typical characteristics of existing maximum weight vehicles. These included:

- Unladen weights / carrying capacities;
- Unladen axle weights;
- Axle weights when fully loaded;
- Typical patterns of loading / average loads;
- Types of commodity carried.

The values for the heavier vehicles were calculated using simple assumptions and with reference to the requirements set out in the relevant EC directives. For example, the unladen weights of heavier vehicles were based on the unladen weights of equivalent existing vehicles and the relationship between Plated Gross Weight and unladen weight for existing vehicles.

4. ROAD WEAR FACTORS

The structural road wear attributable to an axle is normally assumed to be proportional to the fourth power of the axle weight (Addis, 1992) (measured in terms of standard axles). In this report one standard axle is defined as the wear associated with a 10 tonne axle and the wearing power of a heavier or lighter axle was calculated as:

$$\text{Road wear factor (standard axles)} = \left(\frac{\text{axle weight}}{10}\right)^4$$

Examples of the calculation of road wear factors for three vehicles are shown in Table 2. (The axle weights were based on data from TRL surveys.) The overall road wear factors for the fully-loaded 38 tonne 5-axle artic (2+3) and 6-axle artic are lower than that for the 32.52 tonne 4-axle artic. When the increased carrying capacities of the 38 tonne vehicles are taken into account, the road wear benefits of using the 5 and 6-axle vehicles are even greater (road wear factors for fully-laden vehicles per 100 tonnes of carrying capacity of 10.0 for the 4-axle artic, 7.8 for the 5-axle artic and 4.7 for the 6-axle artic).

Road wear factors per 100 tonnes of goods carried were calculated for each type of vehicle using data on typical loading patterns from the CSRGT (these reflected the work that vehicles do). In Figure 1 the figures are shown for pre-1993 and heavier vehicles. (Detailed figures are given in Appendix B.) Generally the road wear factors per 100 tonnes of goods increased with increasing plated gross weight and decreased with increasing number of axles. The figures were lower for drawbars than for the equivalent artics (same plated gross weight and number of axles) because drawbars tend to be used to move lower density goods and therefore have lower average loads. The figures were particularly high for 18 tonne 2-axle rigids, 38 tonne 4-axle artics and 44 tonne 5-axle artics.

It is recognised that the assumption that road wear factors are simply proportional to the fourth power of the static axle load is a simplification. Work at the Technical University of Munich has led to a modification of the fourth power relationship to take into account the effect of suspension type, wheel configuration and contact pressure. The impact of using this relationship is discussed in a companion report (Frith, 1993a).

TABLE 2

Examples of the calculation of road wear factors

Type of vehicle	Axle						Total for vehicle
	1	*2*	*3*	*4*	*5*	*6*	
4-axle artic:							
Axle weights	5.94	9.48	8.55	8.55	-	-	32.52
Standard axles	0.12	0.81	0.53	0.53	-	-	2.00
5-axle artic:							
Axle weights	6.34	9.63	7.34	7.35	7.34	-	38.00
Standard axles	0.16	0.86	0.29	0.29	0.29	-	1.89
6-axle artic:							
Axle weights	5.70	4.56	7.40	6.78	6.78	6.78	38.00
Standard axles	0.11	0.04	0.30	0.21	0.21	0.21	1.08

Notes: 5-axle artic with 2-axle tractive-unit and 3-axle semi-trailer.
6-axle artic with one driven axle (third axle).

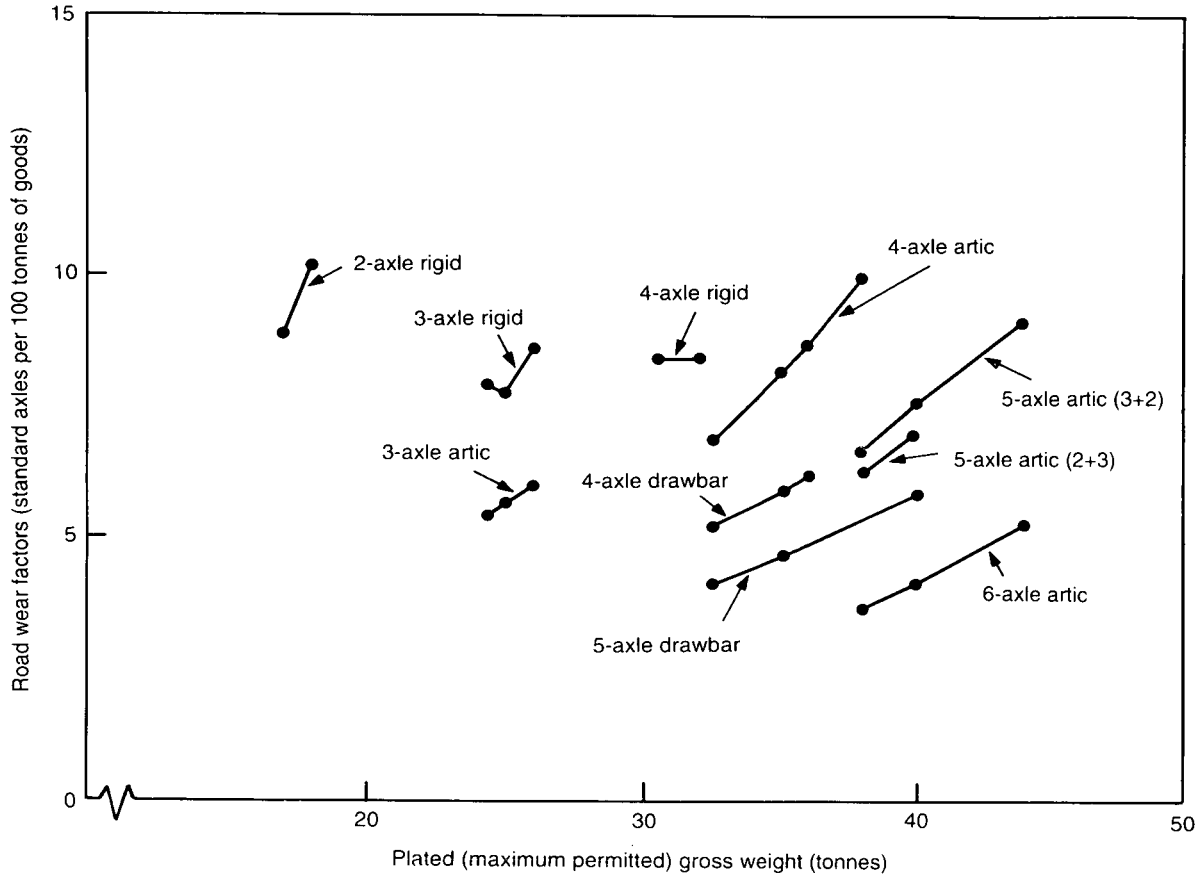

Fig.1 Road wear factors per 100 tonnes of goods (average loading patterns for type of vehicle)

5. QUESTIONNAIRE SURVEY

5.1 QUESTIONNAIRE DESIGN

In order to estimate how goods vehicle operators would change their fleets in response to the changes in weight limits, questionnaires were sent to a selection of operators. There were four main parts to the questionnaire:

1. Details of the operator. These included the name, address and phone number and whether the operation was mainly for hire and reward (moving goods that belong to others) or own account (moving their own goods);

2. Details of the goods loaded onto their vehicles in a typical week. The operators were asked to provide this information for four different types of goods vehicle and 13 different commodities;

3. Details of their existing fleet of vehicles (split into 17 different types of vehicle) and their estimates of how they would change their fleet given the proposed changes in weight limits. The changes in limits were split into two main scenarios reflecting the changes due in 1993 and 1999. For each of the new weight limits the operators were asked whether they would use vehicles at that limit and, if they would, how many they would use and which vehicles they would replace; and

4. Other factors. The operators were asked to comment on why they would, or would not, use heavier vehicles and on whether they would use 44 tonne artics for combined transport movements (for example, the movement of a container from a rail terminal).

5.2 RESPONSE TO THE SURVEY

In November 1991 questionnaires were sent to 248 goods vehicle operators. Since most operators have few vehicles it was decided to concentrate on larger operators (those with more than 25 vehicles). Both own account and hire and reward operators were included in the survey.

Complete replies were received from 182 operators (73 per cent of all questionnaires). Of these, 84 were own account operators and 98 were hire and reward operators. Overall they operated 27,567 vehicles which was equivalent to about 6 per cent of all goods vehicles over 3.5 tonnes PGW in Great Britain in 1991.

In the analysis the commodities carried by the operators were grouped into three classes:

- Food;
- Bulk goods (wood, fertilizer, ores, solid fuels, liquid fuels, chemicals, building materials and metals); and
- Other (fibres, machinery, clothing, other goods).

The commodities carried by the operators are shown in Table 3. Almost half of the own account operators specialised in carrying food (ie: food accounted for over 90 per cent of the weight of goods loaded onto their vehicles) and 90 per cent specialised in one of the three groups of commodities. In comparison, only 59 per cent of hire and reward operators specialised in one of the three groups of commodities.

5.3 CHANGES TO THE VEHICLE FLEETS

The replies to the questionnaires indicated the anticipated changes to the operators' fleets of vehicles. The changes were totalled for two scenarios:

- 1993 scenario: the changes which came into effect in 1993 (see Table 1);
- 1999 scenario: 1993 scenario plus the changes proposed for 1999 (see Table 1).

The questionnaire replies indicated the long-term fleet changes - the operators indicated the number of vehicles they would wish to replace but in practice it would take a number of years for all the vehicles to be replaced or upgraded. The results are summarised in Table 4.

The operators indicated that few (less than 8 per cent) of the lighter vehicles (2-axle rigids up to 15 tonnes, 3-axle artics and 4-axle artics and drawbars up to 30 tonnes) would be replaced by (or upgraded to) vehicles at the heavier weight limits. In comparison, if the full EC limits (1999 scenario) were available at least 60 per cent of the heavier vehicles (17 tonne 2-axle rigids, 3-axle rigids, 4-axle rigids, 5 and 6-axle artics and 32.52 tonne drawbars) would be replaced (or upgraded). In addition, about 30 per cent of 32.52 tonne 4-axle artics would be replaced (or upgraded).

The operators' most common policy was to replace existing vehicles with heavier vehicles of the same type (for example, 32.52 tonne 4-axle artics being replaced by 35, 36 or 38 tonne 4-axle artics). For 10 of the 14 types of vehicle shown in Table 4 no more than 3 per cent of vehicles would be replaced by vehicles of a different type. The exceptions were the 5 and 6-axle artics (8 to 10 per cent in the 1999 scenario being replaced by artics of a different axle configuration) and 5-axle drawbars (32 per cent replaced by a different type of vehicle). (The results for 5-axle drawbars were dominated by a small number of large operators.) Very few operators (3 of those covered by the survey) indicated that they would replace rigids or artics with drawbars.

5.4 COMMENTS MADE BY OPERATORS

Many of the operators commented on the reasons why they would, or would not, use the heavier vehicles. The main reason given for using the heavier vehicles was economic - the cost of moving goods per tonne of goods carried generally decreases with increasing vehicle weight. A number of public haulage operators commented that, as the haulage industry is very competitive, the savings in haulage costs tend to benefit the customer rather than the operator.

The main reason given for not using heavier vehicles was that the goods carried were of low density and filled the available volume without the vehicles reaching even the existing weight limits. For example, a number of operators moving food (other than drinks, canned or frozen food) came into this category. In other cases, the sizes of the consignments were limited by the size of the warehouse, the amount of goods that could be delivered in a shift or the rate of production or consumption of the goods.

TABLE 3

Questionnaire replies by type of commodity carried

Type of commodity	Number of replies		
	Own-account	*Hire & reward*	*Total*
Mainly food	39 (46%)	11 (11%)	50 (27%)
Mainly bulk	20 (24%)	20 (20%)	40 (22%)
Mainly other	17 (20%)	27 (28%)	44 (24%)
Mixed commodities	7 (8%)	36 (37%)	43 (24%)
Commodity not recorded	1 (1%)	4 (4%)	5 (3%)
Overall	84 (100%)	98 (100%)	182 (100%)

Note: mainly = the type of goods accounted for over 90 per cent of all goods loaded onto their vehicles.

TABLE 4

Questionnaire results

Type of vehicle	Proportion of vehicles (per cent) to be replaced					
	1993 scenario			1999 scenario		
	No change	*Heavier vehicles of same type*	*Different type of vehicle*	*No change*	*Heavier vehicles of same type*	*Different type of vehicle*
Rigids:						
2-axle 7.5t	100	0	0	100	0	0
2-axle 15t	99	0	1	94	5	1
2-axle 17t	98	0	2	31	66	3
3-axle	28	70	2	28	69	3
4-axle	34	64	2	34	64	2
Artics:						
3-axle	95	5	0	93	5	2
4-axle 30t	93	7	0	93	7	0
4-axle 32.52t	74	26	0	67	31	2
5-axle (2+3)	97	0	3	21	71	8
5-axle (3+2)	100	0	0	39	53	8
6-axle	98	0	2	16	74	10
Drawbars:						
4-axle 30t	99	1	0	99	1	0
4-axle 32.52t	51	49	0	40	58	2
5-axle	1	67	32	1	67	32

Note: t = tonnes (Plated Gross Weight).

Some operators were concerned that there would be little tolerance for miss-placed loads on some of the heavier vehicles. For example, the 38 tonne 4-axle artic would be limited to 18 tonnes on the tractive-unit and 20 tonnes on the semi-trailer bogie, giving no tolerance for poor positioning of the load. One operator wrote a separate letter expressing concern about the level of Vehicle Excise Duty proposed for the heavier vehicles (the levels for the 1993 scenario vehicles were announced in the 1992 budget which was after the questionnaires had been returned). For example, the rate for 35 tonne 4-axle artics was announced as £5,000 compared with £2,450 for 32.52 tonne 4-axle artics (an increase of 104 per cent).

Only 12 of the 182 operators (7 per cent) indicated that they would consider using 44 tonne artics for combined road / rail freight transport (for example, moving a container from a rail terminal). Of these, three already regularly carried containers.

6. GROSSED-UP RESULTS

6.1 CHANGES IN NATIONAL FLEET

The changes in the vehicle fleets indicated by the operators in the questionnaires were grossed-up to give an estimate of the changes at a national level. The 'base' scenario was calculated using figures from the CSRGT for 1991 (Department of Transport, 1992). Data from the questionnaires were used to estimate the numbers of vehicles, total vehicle travel and overall road wear factors for the 1993 weight limits (1993 scenario) and the 1999 weight limits (1999 scenario). The use of 42 or 44 tonne vehicles was disregarded in the main scenarios.

Since the purpose of the study was to examine some possible consequences of a change in maximum permitted gross weights rather than to forecast the future, it was assumed that the volume of goods moved and the operational requirements for moving goods remained at the 1991 level for each scenario.

In order to allow for changes in the types of goods carried by each type of vehicle (high density goods were most likely to be carried by the heavier vehicles), the data were analyzed separately for each of the three groups of commodities listed in Section 5.2. Where an operator carried more than one group of commodities, the anticipated changes in the fleet were applied in proportion to the weight of each group of commodities.

There were five main stages to the calculations:

1. The proportions of vehicles that would be replaced by each of the heavier types of vehicle were calculated from the responses to the questionnaires;
2. The proportions of vehicles were then multiplied by the corresponding amount of goods moved (in

tonne-kilometres) in 1991 to give the amount of goods moved using each of the new types of vehicle;

3. The total annual vehicle travel (in kilometres) for each type of vehicle was then calculated by dividing the amount of goods moved (in tonne-kilometres) by the average load (in tonnes). It was assumed that the average load factors (average load divided by the carrying capacity) for the heavier vehicles would be the same as those for the types of vehicle being replaced;

4. For each type of vehicle the number of vehicles was calculated by dividing the total annual travel by the assumed annual travel per vehicle (it was assumed that the average annual travel for each of the heavier vehicles would be the same as that for the type of vehicle being replaced); and

5. Overall road wear factors (in standard axle kilometres) were calculated by multiplying the amount of goods moved (in tonne-kilometres) for each type of vehicle by the appropriate road wear factor per tonne of goods carried (in standard axle kilometres - see Section 4).

The main results are summarised in Table 5.

It was estimated that, compared with the base scenario, annual travel would be 1.1 per cent lower for the 1993 scenario and 3.9 per cent lower for the 1999 scenario. The estimated reductions in the numbers of vehicles were smaller (1.0 per cent for the 1993 scenario and 3.0 per cent for the 1999 scenario). In comparison, it was estimated that the overall road wear factors would increase (by 0.9 per cent between the base and 1993 scenarios and by 7.7 per cent between the base and 1999 scenarios). This reflects the increases in Plated Gross Weights for each type of vehicle (see Figure 1).

Comparing the base and 1999 scenarios, it was estimated that annual travel by drawbars and 5-axle artics would decline by at least 10 per cent but that there would be increases in annual travel by 3 and 4-axle artics (by 0.2 per cent) and 6-axle artics (by 2.9 per cent). It was also estimated that road wear factors attributable to each of the types of vehicle shown in Table 5 would increase. These increases would be greatest for 3 and 4-axle artics (25.1 per cent), 6-axle artics (22.6 per cent) and drawbars (16.2 per cent).

TABLE 5

Grossed-up questionnaire results

Type of vehicle	Scenario (percentage change from base scenario in brackets)		
	Base (1991)	*1993 weight limits*	*1999 weight limits*
Annual travel (billion vehicle kilometres):			
Rigids	11.64	11.50 (-1.2%)	11.28 (-3.1%)
3 & 4-axle artics	2.77	2.79 (+0.7%)	2.77 (+0.2%)
5-axle artics	4.30	4.22 (-1.9%)	3.86 (-10.1%)
6-axle artics	1.31	1.31 (-)	1.35 (+2.9%)
Drawbars	0.43	0.41 (-5.8%)	0.38 (-10.9%)
Total	20.45	20.22 (-1.1%)	19.65 (-3.9%)
Number of goods vehicles (thousand):			
Rigids	336.6	333.5 (-0.9%)	328.5 (-2.4%)
3 & 4-axle artics	38.7	38.8 (+0.2%)	38.5 (-0.6%)
5-axle artics	48.6	47.7 (-1.9%)	43.7 (-10.0%)
6-axle artics	14.8	14.8 (-)	15.2 (+2.9%)
Drawbars	5.2	4.9 (-5.8%)	4.7 (-11.0%)
Total	443.8	439.6 (-1.0%)	430.5 (-3.0%)
Road wear factors (billion standard axle kilometres):			
Rigids	2.68	2.65 (-1.2%)	2.75 (+2.5%)
3 & 4-axle artics	1.20	1.35 (+12.9%)	1.50 (+25.1%)
5-axle artics	3.26	3.20 (-1.7%)	3.34 (+2.6%)
6-axle artics	0.59	0.59 (-)	0.72 (+22.6%)
Drawbars	0.10	0.10 (+6.8%)	0.11 (+16.2%)
Total	7.82	7.90 (+0.9%)	8.43 (+7.7%)

Note: Figures for road wear factors exclude non Heavy Goods Vehicles (such as buses and coaches).

6.2 42/44 TONNE VEHICLES

The operators were asked whether they would use 42 or 44 tonne artics if there were to be no restriction on their use. In the case of the 1993 scenario an option was presented of using 42 tonne 6-axle artics with one driven axle or 44 tonne 6-axle artics with two driven axles. In the case of the 1999 scenario the operators were presented with the options of 44 tonne 5-axle artics (3+2) or 6-axle artics. These responses were grossed-up and the results are shown in Table 6.

The inclusion of 42 or 44 tonne artics was estimated to lead to a further reduction in total goods vehicle travel (by between 1.5 and 2.1 per cent) and the number of goods vehicles (by between 0.7 and 1.1 per cent). In comparison, whilst the inclusion of 42 or 44 tonne 6-axle artics was estimated to lead to a reduction in road wear factors when compared with either the 1993 or the 1999 scenarios (by between 3.3 and 3.7 per cent), the inclusion of both 5-axle and 6-axle 44 tonne artics was estimated to lead to an increase in road wear factors of 3.2 per cent (compared with the 1999 scenario). This reflects the high value of the road wear factor per 100 tonnes of goods for 44 tonne 5-axle artics (see Figure 1).

7. SENSITIVITY OF THE ESTIMATES

The estimated changes in vehicle numbers, annual travel and road wear factors given in Section 6 were based on the replies to the questionnaire survey and on a number of assumptions about the operation of the heavier vehicles. In this section the sensitivity of the estimated changes to some of these assumptions is examined.

7.1 REPLACEMENT OF VEHICLES

The number of existing vehicles which would be replaced by heavier vehicles was obtained from the replies to the questionnaire survey. Operators may have over or under-estimated the number of vehicles they would replace. The sensitivity of the results to these possibilities were examined by assuming:

1. all the changes in vehicle numbers would be at twice the level indicated by the operators;

2. all the changes in vehicle numbers would be at half the level indicated by the operators;

3. replacement by drawbars would be at twice the level indicated by the operators; and

4. replacement by vehicles of the same type but with a higher plated gross weight would be at half the level indicated by the operators and replacement by vehicles with more axles would be twice the level indicated by the operators.

7.2 LOAD FACTORS

In the main analysis the average load factors and patterns of loading (the proportion of travel at each degree of loading) for the heavier vehicles were assumed to be the same as those for the vehicles they replaced. For the sensitivity analysis it was assumed that:

- the proportion of empty travel for the heavier vehicles would be the same as for the vehicles being replaced;

- the heavier vehicles would be fully loaded for 50 per cent of their annual loaded travel and 90 per cent full for the remaining annual loaded travel; and

TABLE 6

Unrestricted use of 42 and 44 tonne artics

	Annual travel (billion vehicle kilometres)	Number of goods vehicles (thousand)	Road wear factors (billion standard axle kilometres)
1993 scenario	20.22	439.6	7.90
Addition of 42 and 44 tonne 6-axle artics	19.80	434.9	7.64
(% change)	(-2.1%)	(-1.1%)	(-3.3%)
1999 scenario	19.65	430.5	8.43
Addition of 5 and 6-axle 44 tonne artics	19.33	426.9	8.69
(% change)	(-1.6%)	(-0.8%)	(+3.2%)
Addition of only 6-axle 44 tonne artics	19.36	427.3	8.11
(% change)	(-1.5%)	(-0.7%)	(-3.7%)

- the average load factors would be consistent with this assumed loading pattern.

7.3 ANNUAL TRAVEL

In the main analysis the average annual travel by each of the heavier vehicles was assumed to be the same as that for the vehicles being replaced. However, there is some evidence that vehicles with higher plated weights are used more intensively than lighter vehicles. Between 1983 (when 38 tonne plated weight vehicles were first permitted) and 1991 annual travel per vehicle for the heaviest vehicles increased from about 68,000 kilometres to about 89,000 kilometres, an increase of about 30 per cent (Frith, 1993b). In the sensitivity analysis it was assumed that the annual travel for the heavier vehicles would be 30 per cent higher than that for the vehicles they replaced.

7.4 LOAD POSITION

In the main analysis overall road wear (in standard axles) was calculated assuming that the centre of gravity of the loads were at the centres of the loading decks (assuming typical dimensions for vehicles and that, where possible, the heavier vehicles would have the same dimensions as the equivalent existing vehicles). In practice, loads may not be positioned centrally. The sensitivity of the estimated overall road wear to the position of the loads was calculated by assuming that the centre of gravity of all loads on the heavier vehicles were 1 metre forward, 0.5 metres forward, 0.5 metres back or 1 metre back from the centre of the loading deck.

7.5 RESULTS OF SENSITIVITY ANALYSIS

The results of the sensitivity analysis are shown in Table 7.

Generally, doubling the proportion of vehicles replaced by heavier vehicles increased the savings in annual travel and vehicle numbers by about 50 per cent and increased the estimated road wear (by about 150 per cent for the 1993 scenario and 50 per cent for the 1999 scenario). Conversely, halving the proportion of vehicles replaced halved the savings in annual travel and vehicle numbers and reduced the estimated increases in road wear (by 75 per cent for the 1993 scenario and 60 per cent for the 1999 scenario). Changing the proportion of non-drawbars replaced by drawbars had little impact on the figures and doubling the proportion of vehicles replaced by vehicles of a different class led to small decreases in annual travel and vehicle numbers and small increases in road wear factors.

Increasing the amount of travel at full load had a major impact of the estimates. The savings in annual travel and vehicle numbers were increased by between 200 and 350 per cent and the estimated increases in road wear

TABLE 7

Sensitivity of the results to changes in the assumptions

Change	Percentage change from base scenario					
	1993 weight limits			1999 weight limits		
	Annual travel	*Number of vehicles*	*Road wear factors*	*Annual travel*	*Number of vehicles*	*Road wear factors*
Basic assumptions.	-1.1%	-1.0%	+0.9%	-3.9%	-3.0%	+7.7%
Replacement of vehicles (see Section 7.1):						
Proportion replaced doubled.	-1.8%	-1.5%	+2.5%	-5.9%	-4.6%	+11.6%
Proportion replaced halved.	-0.6%	-0.5%	+0.2%	-2.0%	-1.5%	+3.2%
Proportion of non-drawbars replaced by drawbars doubled.	-1.1%	-1.0%	+0.9%	-4.0%	-3.0%	+7.7%
Proportion of vehicles replaced by vehicles of different type doubled.	-1.3%	-1.2%	+1.2%	-4.3%	-3.3%	+8.0%
Load factors and annual travel:						
50% of travel at full load (see Section 7.2).	-4.3%	-3.6%	+4.6%	-17.0%	-13.5%	+23.3%
Annual travel 30% higher (see Section 7.3).	-	-1.8%	-	-	-6.4%	-
Load position (see Section 7.4):						
Centre of gravity 1.0 metre forward	-	-	+4.5%	-	-	+21.8%
Centre of gravity 0.5 metre forward	-	-	+3.0%	-	-	+12.6%
Centre of gravity 0.5 metre backward	-	-	+3.7%	-	-	+12.1%
Centre of gravity 1.0 metre backward	-	-	+8.6%	-	-	+22.7%

factors were increased by 250 to 350 per cent. Changing the assumed annual travel per vehicle had no effect on the overall annual travel or road wear factors but roughly doubled the reduction in the number of vehicles.

Changing the assumed position of the centre of gravity of the load on the heavier vehicles had no effect of annual travel or the number of vehicles but had a major impact on the estimated road wear factors. All four alternative positions led to an increase in road wear factors, the increase becoming larger the further the centre of gravity of the load was moved from the centre of the load deck. The increase in road wear factors was increased by between 200 and 850 per cent for the 1993 scenario and between 50 and 200 per cent for the 1999 scenario.

8. DISCUSSION

8.1 ACCURACY OF RESULTS

The accuracy of the results depended on a number of factors. These include:

1. the sample of operators chosen for the questionnaire survey;
2. the method of grossing-up the questionnaire replies;
3. the assumed characteristics of the heavier vehicles;
4. the assumptions about goods vehicles operations (lading patterns and annual travel per vehicle); and
5. the method of estimating structural road wear.

The sample of operators was chosen randomly from lists of operators with fleets of more than 25 vehicles. This ensured that a significant proportion (about 6 per cent) of heavy goods vehicles operated in Great Britain were covered by the survey. In addition, the changes to the combined fleet of vehicles were used in the analysis, resulting in large operators having a greater influence than small operators. Hence it is possible that the changes are not representative of the whole industry. Also, whilst operators were aware of the general characteristics of the heavier vehicles, they were not aware of the environment in which they would operate (for example, the Vehicle Excise Duty rates were not known). Changes in the operating environment could have a major impact on the results. The sensitivity of the results to the choices made by the operators is considered in Section 7.

It was assumed that the lading patterns and annual travel per vehicle for the heavier vehicles would be the same as those for the vehicles they replaced (with changes in the movement of three classes of commodity being taken into account). The same basic assumptions were used by the Department of Transport to calculate the impact of introducing 38 tonne goods vehicles (Johnson and Wilding, 1986). When 38 tonne artics were compared with 32.52 tonne artics it was found that the average weight load factors for individual commodities (in 1984) were generally similar. It was also found that the annual travel per vehicle for young (less than two years old) 38 tonne artics (62,000 km) was similar to that for young 32.52 tonne artics (66,000 km). If the load factors for the heavier vehicles are assumed to be higher than those for existing vehicles, the savings in annual travel and vehicle numbers would be increased and the estimated road wear factors would also be increased (see Section 7).

The road wear factors were calculated on the assumption that road wear is proportional to the fourth power of the axle weight. This is recognised to be a simplification. In practice, other factors such as the number of tyres on the wheel, tyre contact pressure, axle spacing, type of suspension, types of road construction and vehicle speed are important. The implications of taking some of these factors into account when estimating road wear factors are examined in a companion report (Frith, 1993a)

8.2 42 AND 44 TONNE VEHICLES

The EC directives include a limit of 44 tonnes for certain artics used to carry 40 foot ISO containers as part of a combined transport movement (ie: to or from a rail or barge terminal). (The UK has a derogation from this regulation until 1999). Only 12 of the 182 operators who responded to the survey indicated that they would use 44 tonne artics if they could only be used for combined transport. Of these, 3 already carried ISO containers. Most of the other 9 operators indicated that their use of combined transport would depend on customer demand. It is unlikely that there will be major demand for the use of combined transport purely within the Great Britain. In comparison, there are likely to be significant combined transport flows between Great Britain and continental Europe through the Channel Tunnel. Permission to use 44 tonne vehicles on the road portions of combined transport journeys could be an incentive to increased use of combined transport (Sutcliffe and Plent, 1992).

It was estimated that the unrestricted use of 42 tonne or 44 tonne 6-axle artics would lead to a reduction in the number of vehicles, vehicle travel and road wear factors. The addition of the 42 and 44 tonne vehicles to the 1993 scenario led to an reduction in road wear factors of about 3 per cent. In comparison, the addition of both 5-axle and 6-axle 44 tonne artics to the 1999 scenario led to an increase in road wear factors of about a 3 per cent. However, if 6-axle 44 tonne artics had been used instead of 5-axle 44 tonne artics, the total road wear factors would have been reduced by about 4 per cent.

8.3 DRAWBARS

Whilst a number of existing drawbar operators indicated that they would replace existing drawbars with heavier drawbars, only three operators indicated that they would use drawbars to replace rigids or artics. In comparison, a study by the Transport Studies Group of the Polytechnic of Central London (Peters and Doganis, 1989) estimated that long term demand for drawbars would increase from 16,500 drawbars if the weight limit remained at 32.52 tonnes to 42,000 drawbars if the weight limit were to be increased to 38 tonnes.

9. CONCLUSIONS

In November 1991 questionnaires were sent to 248 goods vehicle operators asking them how they would react to changes in weight limits. Analysis of the 182 complete replies led to the following conclusions:

1. It was estimated that the increases in weight limits which came into operation in 1993 would, in the long term, lead to a decline of about 1 per cent in goods vehicle travel and the number of goods vehicles but an increase of about 1 per cent in road wear factors.

2. The increases in the weight limits due to be implemented in 1999 (including the increase in maximum permitted axle weight from 10.5 tonnes to 11.5 tonnes) were estimated to have greater impacts. These included a decline of 4 per cent in goods vehicle travel, a decline of 3 per cent in the number of goods vehicles and an increase in road wear factors of about 8 per cent.

3. A sensitivity analysis indicated that the estimated decreases in annual travel and vehicle numbers might be less if fewer vehicles are replaced by heavier types but could be much greater (up to 4 times those estimated) if the heavier vehicles were to be more fully loaded. Under these circumstances the increase in road wear factors could also be considerably higher than the main estimates.

4. The use of 42 or 44 tonne 6-axle artics would be likely to reduce overall road wear factors, whilst the use of 44 tonne 5-axle artics would be likely to increase overall road wear factors.

5. Few operators wished to use 42 or 44 tonne artics if they could only be used for combined transport (such as moving a container from a railhead).

6. Very few operators (only 3 of the 182 replies) wished to use heavier drawbars to replace rigid or articulated vehicles.

10. ACKNOWLEDGEMENTS

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APPENDIX A: SUMMARY OF EUROPEAN COMMUNITY DIRECTIVES ON VEHICLE WEIGHTS

The following information on maximum authorised weights was based on EC directive 85/3/EEC as amended by directives 86/360/EEC, 88/218/EEC, 89/338/EEC, 89/460/EEC, 89/461/EEC, 91/60/EEC and 92/7/EEC. The regulations apply to traffic between EC member states. The figures for the United Kingdom derogations (until 31 December 1998) are marked with an asterisk.

Rigid vehicles

2-axle rigids (17 tonnes *) 18 tonnes

3-axle rigids 25 tonnes (26 tonnes where the driving axle is fitted with twin tyres and air suspension or suspension recognised as being equivalent within the Community or where each driving axle is fitted with twin tyres and the maximum weight of each axle does not exceed 9.5 tonnes)

4-axle rigids with two steering axles (30 tonnes *) 32 tonnes (32 tonne limit applies where the driving axle is fitted with twin tyres and air suspension or suspension recognised as being equivalent within the Community or where each driving axle is fitted with twin tyres and the maximum weight of each axle does not exceed 9.5 tonnes)

Articulated vehicles

3-axle articulated buses (27 tonnes *) 28 tonnes

4-axle artics (2-axle rigid and 2-axle semi-trailer) (35 tonnes *) 36 tonnes + 2 tonnes of margin when the maximum weight of the motor vehicle (18 tonnes) and the maximum weight of the semi-trailer bogie (20 tonnes) are respected and the driving axle is fitted with twin tyres and air suspension or suspension recognized as being equivalent within the Community (does not apply in the United Kingdom until 31 December 1998)

5 and 6-axle artics (38 tonnes *) 40 tonnes

3-axle tractive-unit with 2 or 3-axle semi-trailer carrying a 40-foot ISO container as a combined transport operation (38 tonnes *) 44 tonnes

Drawbar combinations

4-axle drawbar combinations (2-axle rigid and 2-axle trailer) (35 tonnes *) 36 tonnes

5 and 6-axle drawbar combinations (35 tonnes *) 40 tonnes

Trailers

2-axle trailers 18 tonnes

3-axle trailers 24 tonnes

Single axles

Non-driving axles 10 tonnes

Driving axles (10.5 tonnes *) 11.5 tonnes

Bogies

2-axle bogies of motor vehicles18 tonnes (19 tonnes where the driving axle is fitted with twin tyres and air suspension or suspension recognized as being equivalent within the Community or where each driving axle is fitted with twin tyres and the maximum weight of each axle does not exceed 9.5 tonnes)

2-axle bogies of trailers and semi-trailers 20 tonnes

3-axle bogies of trailers and semi-trailers (22.5 tonnes *) 24 tonnes

Related characteristics of vehicles

All vehicles:
The weight borne by the driving axle or driving axles of a vehicle or combined vehicle must not be less than 25 per cent of the of the total laden weight of the vehicle or combined vehicle when used in international traffic

4-axle rigids:
The maximum authorized weight in tonnes of a 4-axle rigid vehicle may not exceed five times the distance in metres between the axes of the foremost and rearmost axles of the vehicle

APPENDIX B:
VEHICLE CHARACTERISTICS

TABLE B1

Vehicle characteristics

Vehicle type	Plated gross weight (tonnes)	Carrying capacity (tonnes)	Road wear factor for fully loaded vehicle (standard axles)	Wear factor per 100 tonnes of goods - average loading pattern
2-axle rigid	17.00	9.5	1.39	8.9
	18.00 **	10.4	1.86	10.2
3-axle rigid	24.39	15.1	1.55	7.9
	25.00 *	15.6	1.55	7.7
	26.00 *	16.6	1.87	8.6
4-axle rigid	30.49	19.4	1.85	8.4
	32.00 *	20.8	1.99	8.4
3-axle artic	24.39	14.6	1.77	5.4
	25.00 *	15.2	1.92	5.6
	26.00 *	16.1	2.25	6.0
4-axle artic	32.52	20.1	2.00	6.9
	35.00 *	22.4	2.73	8.1
	36.00 **	23.3	3.08	8.7
	38.00 **	25.1	3.90	10.0
5-axle artic (2+3)	38.00	24.2	1.89	6.2
	40.00 **	26.1	2.34	7.0
5-axle artic (3+2)	38.00	24.1	2.09	6.7
	40.00 **	26.0	2.61	7.6
	44.00 ***	29.6	3.65	9.2
6-axle artic	38.00	23.2	1.08	3.7
	40.00 **	25.1	1.34	4.2
	44.00 ***	28.8	1.99	5.2
4-axle drawbar	32.52	20.0	2.00	5.2
	35.00 *	22.3	2.72	5.9
	36.00 **	23.2	3.06	6.2
5-axle drawbar	32.52	19.1	1.11	4.2
	35.00 *	21.4	1.49	4.6
	40.00 **	26.0	2.56	5.8

Notes: * from 1.1.93
** from 1.1.99
*** from 1.1.99 (combined transport)
Values for existing vehicles based on survey data, values for heavier vehicles based on assumed characteristics and same loading patterns as for existing vehicles.
Road wear factors calculated using the fourth power relationship (10 tonne standard axles).

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