Impacts Of Increased Goods Vehicle Weight Limits: A European Case Study

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ABSTRACT

This paper reviews the effects of changes in the allowable weights and dimensions of goods vehicles on the composition of the United Kingdom goods vehicle fleet, and the carriage of goods by road. It then considers the effects of proposed changes on road wear, environmental impacts and operating costs. Individual heavier vehicles cause greater impacts and, for a given number of axles, more road wear. However, if higher weights are spread over more axles and fewer vehicles are needed, then road wear and total environmental impacts could be reduced.

A survey of goods vehicle operators indicates how operators in the UK would be likely to react to increases in allowable gross weights. Numbers of vehicles and vehicle km to move the same amount of goods are forecast to reduce.

INTRODUCTION

Since 1955 the maximum allowable weight of rigid and articulated Goods Vehicles in the United Kingdom has increased from 24.39 to 38 tonnes, and the total tonne km for freight moved by road has more than trebled (from 38 to 127×10^9 tonne km). Much of this increase has been due to longer trip lengths rather than an increase in the tonnage of goods lifted. The maximum weights of goods vehicles operating between European Community (EC) countries were harmonised on 1 January 1993, but the United Kingdom has a derogation from some of the regulations until 1 January 1999. By that date, it is likely that most of the EC regulations will be applied to goods vehicles operating wholly 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, fuel consumption, operating cost and environmental impact.

This paper briefly reviews the changes in goods vehicle weights and the use of road transport for freight transport in the United Kingdom up to 1992. It then summarises work done recently by TRL to investigate the likely impacts of the changes in weight limits that result from the recent EC harmonisation (Newton and Frith, 1993; Frith, 1993). This study identified the likely characteristics of goods vehicles at the new weight limits, and used a survey of goods vehicle operators to estimate the number of vehicles which would be operated in the United Kingdom for two scenarios covering the vehicles permitted in 1993 and 1999. Total goods vehicle travel and the effects of the heavier vehicles on road wear factors were also calculated. It is hoped that this analysis of the effects of changes in goods vehicle weights in the United Kingdom has lessons that are relevant to New Zealand, despite substantial differences in, for example, maximum allowable axle loads.

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.

TRENDS IN ROAD GOODS TRANSPORT

GOODS VEHICLE WEIGHTS AND FLEET COMPOSITION, 1955-1992

The main changes in the goods vehicle weight limits in the United Kingdom between 1955 and 1992 are summarised in Table 1. Between 1955 and 1968 weight and dimension limits changed substantially, particularly for 4 axle articulated goods vehicles (artics). After 1968, the sizes of the various classes of goods vehicle changed much less and the weight limit increased substantially for 5 axle artics. For example, the maximum length of an articulated goods vehicle was 10.67m in 1955, 13m in 1964, 15m in 1968,

Table 1: Principal changes in maximum plated gross weights 1955-1992

tonnes

Year	Rigids			Articulated		
	2-axle	3-axle	4-axle	3-axle	4-axle	5+ axle
1955	14.23	20.33	24.39	20.33	24.39	24.39
1964	16.26	22.36	28.45	22.36	32.52	32.52
1966	-	-	-	24.39	-	-
1972	-	24.39	30.49	-	-	-
1983	-	-	-	-	-	38.00
1988	17.00	-	-	-	-	-

15.5m in 1983 and 16.5m in 1992.

Drawbar units have been limited to 32.52 tonne since 1941, and had a speed limit of 30 mph (48 km/h) on all roads until 1984.

Over the same period the composition of the heavy goods vehicle fleet changed substantially, as is shown in Figure 1 (Department of Transport, 1993). After the weight changes in 1964 and the length increases in 1964 and 1968, the numbers of 4-axle articulated goods vehicles immediately began to increase. It took over a decade for the articulated vehicle to assume its present dominant position, in which artics are moving about 70 per cent of the total road freight tonne km (and 5-axle vehicles are moving 57 per cent of the total), perhaps because it was very different geometrically from the rigid vehicles it displaced, and thus often required modifications to operators' premises.

As the fleet composition changed, so the goods vehicle traffic and the tonne km of freight moved by the different types of vehicle also changed. Figure 2 shows the trends in the tonne km of freight moved in different classes of goods vehicle (Department of Transport, 1992b). It is striking the extent to which the heaviest articulated vehicles have become the work-horses of the road freight fleet.

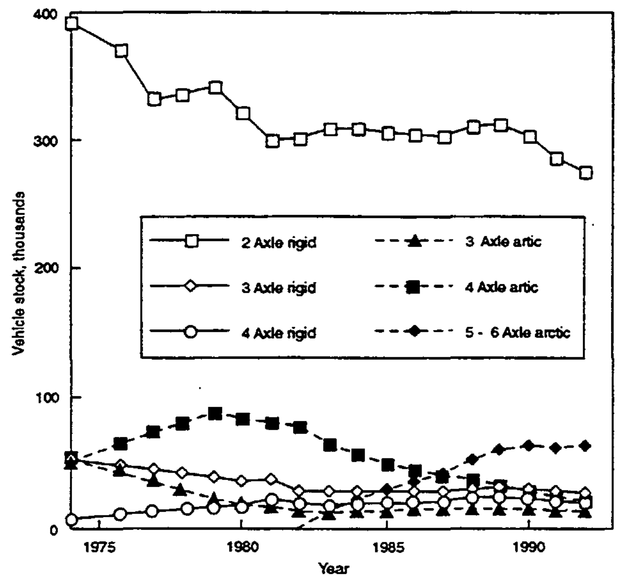


Fig 1 Heavy goods vehicle stock
(Gross weights > 31/2 tonnes)

EUROPEAN COMMUNITY HARMONISATION OF GOODS VEHICLE WEIGHT LIMITS

European Community (EC) directives set weight limits for goods vehicles used on journeys between member countries. 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 2.

In September 1993 the Department of Transport published draft regulations increasing the maximum permitted weight for 6-axle artics and drawbars on journeys to or from rail terminals from 38 to 44 tonnes, and the maximum permitted weight for other drawbars with 5 or more axles from 35 to 38 tonnes.

VEHICLE DESIGNS

The first stage of the TRL study involved defining the likely characteristics of vehicles operating at the new EC 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, 1992a) and TRL surveys of goods vehicle weights and dimensions (Shane and Newton, 1988) 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.

Table 2: Maximum permitted weights in the European Union and in the United Kingdom under EC harmonisation - international traffic

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

Notes:

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;

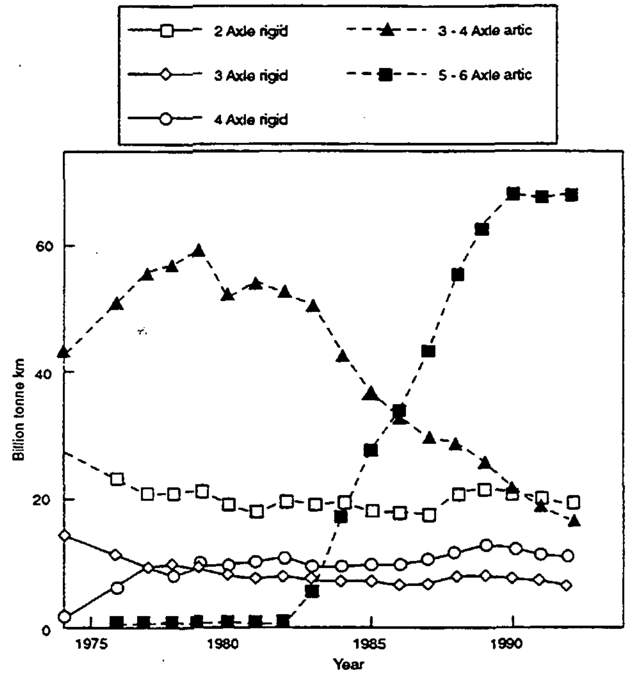
6 if drive axle fitted with twin tyres and air (or equivalent) suspension (tractive-unit not to exceed 18 tonnes, semi-trailer not to exceed 20 tonnes);

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.

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.

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). It is conventional to express the road wear factor in terms of standard axles, with one standard axle defined as the wear associated with a 10 tonne



Note:

Rigid goods vehicles: 3½-17 tonne; 2 axle; 17-25 tonne; 3 axle: 25+ axle
Artic goods vehicles: 3½-33 tonne; 3-4 axle: 33+ tonne; 5-6 axle

Fig 2 Goods moved by road
(Source: Department of Transport, 1992b)

axle, and the wearing power of a heavier or lighter axle calculated as:

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

Examples of the calculation of road wear factors for three vehicles are shown in Table 3. (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 3 the figures are shown for pre-1993 and heavier vehicles. 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. This is discussed in the next section, and in more detail in Frith, 1993.

EFFECTS OF TYRES AND SUSPENSIONS ON ROAD WEAR

The principal modes of deterioration of flexible road pavements in the UK are rutting and cracking of the surface. Rutting is associated with deformation in the road subgrade due to vertical strains. Cracking, which is considered to determine the long term durability of the road (Powell et al, 1984) is associated with horizontal strain at the underside of the road base. Both modes are induced by the wheel loads of vehicles travelling along the road. In situations where axles are closely grouped (bogies, tandem and tri-axle trailers) the strains induced in the road interact.

The main determinant of road wear is the static axle load, as described above. Other relevant factors are the number and type of tyres on an axle, the axle arrangement, the surface contact pressure of the tyres and the type of suspension system. Theoretical work at TRL (Addis and Whitmarsh, 1979) concluded that, for most road design and maintenance purposes, the fourth power law is robust as a measure of road wear. Recent research (OECD, 1991) has studied the relative wear for 10 and 11.5 tonne axles. The conclusions were that where cracking is the principal form of deterioration, the fourth power law is robust but where rutting is the principal form, the exponent in the power law depends on pavement strength (5.7 for thin bituminous pavements, 2.9 for thick bituminous pavements, and 1.5 for cement treated pavements).

The effect of axle configuration and wheel type on road wear has been investigated at TRL. Indications are that the fatigue effect (cracking) due to grouped axles is less than the effect of the same number of widely spaced single axles.

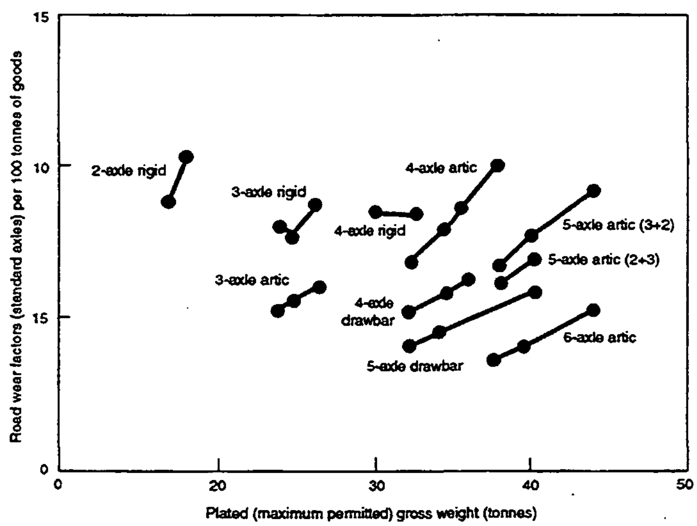


Fig.3 Road wear factors per 100 tonnes of goods (average loading patterns for type of vehicle)

Table 3: Examples of the calculation of road wear factors

Axle weights (tonnes) and standard axles ($tonnes^4/10^4$)

Type of vehicle	Axle						Total for vehicle	Max. Payload
	1	2	3	4	5	6		
4-axle artic:								
Axle weights (t)	5.94	9.48	8.55	8.55	-	-	32.52	
Road wear factor	0.12	0.81	0.53	0.53	-	-	2.00	20.07
5-axle artic:								
Axle weights (t)	6.34	9.63	7.34	7.35	7.34	-	38.00	
Road wear factor	0.16	0.86	0.29	0.29	0.29	-	1.89	24.23
6-axle artic:								
Axle weights (t)	5.70	4.56	7.40	6.78	6.78	6.78	38.00	
Road Wear Factor	0.11	0.04	0.30	0.21	0.21	0.21	1.08	23.23

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

The effect is particularly marked for close spaced tandem and triple axles (1.3 metres spacing). The order of magnitude of the effect, which is the subject of current research at TRL, is that the fatigue wear of tandem bogies is about 50 per cent of the fatigue wear of two widely spaced axles and the fatigue wear of triple bogies is 35 per cent of the fatigue wear of three widely spaced axles. Research indicates that the deformation (rutting) effect is more for triple axles than for three single axles and a little more for tandem axles than two single axles.

The effect of contact pressure (applied load per contact area) has also been studied at TRL. The results suggest that strains (which cause cracking in the road pavement) are higher for single wheels (super singles) than for dual wheels carrying the same weight by a factor between 1.53 and 2.05 depending on pavement thickness (Addis, 1992). The tyre pressure can also affect road wear. A 40 psi increase in tyre pressure, in the range 60 - 140 psi, has been found to increase fatigue wear by a factor of 1.26 (Addis, 1992). Work in Germany (Eisenmann et al, 1986) showed that for single axles in the range 5 to 13 tonnes the strain in the road was proportional to the instantaneous load (dynamic load) of the axle. Under the assumption that road wear is approximately proportional to the fourth power of the strain, a formula was derived relating road wear to a number of factors:

$$\text{Road wear} = (1+6(DLC)^2 + 3(DLC)^4) \times (WC \times CP \times S)^4$$

where

S = Static wheel load.

DLC = the dynamic load coefficient (the coefficient of variation of the ratio of dynamic to static load).

WC = wheel configuration: 1.0 for wheels with single tyres; 0.9 for wheels with twin tyres.

CP = contact pressure: 1.1 for pressure 0.9 N/mm^2
1.0 for pressure 0.7 N/mm^2
0.9 for pressure 0.5 N/mm^2

The quantity $(1 + 6(DLC)^2 + 3(DLC)^4)$ is known as the dynamic wear factor (DWF) and has been shown to be lower for axles and bogies equipped with air suspension than for those equipped with steel suspension (Mitchell and Gyenes, 1989). Table 4 shows TRL estimates of the DWF for a number of classes of vehicle travelling at between 50 and 60 mile/h on an average of medium and smooth surfaces (equivalent to an average motorway/trunk road).

Table 5 shows the estimated relative road wear per 100 tonnes of carrying capacity for fully loaded rigids, relative to the estimated road wear for a fully loaded 2-axle rigid (17 tonnes PGW) with steel suspension and double rear tyres. The estimated relative road wear (using either the fourth power or Eisenmann formula) is below unity for 3 and 4-axle vehicles but is above unity for 2-axle rigids weighing 18 tonnes, even with air suspension.

Using the Eisenmann formula, the relative road wear for 3-axle rigids is lower for vehicles weighing 26 tonnes with air suspension than for vehicles weighing 24.39 tonnes with steel suspension. Similarly, the relative road wear is lower for 4-axle rigids weighing 32 tonnes with air suspension than for 30.49 tonne vehicles with steel suspension.

Table 4: Estimated dynamic wear factors at 50/60 mile/h on an average motorway/trunk road

Vehicle type	Axle	Suspension type	
		Steel	Air
Rigid	Steering	1.04	-
	Drive	1.10	1.04
Artic	Steering	1.04	-
	Drive	1.07	1.04
	Semi-trailer bogie	1.11	1.04

Source: TRL tests with instrumented vehicles

Table 5: Estimated relative road wear for rigid heavy goods vehicles

Vehicle class	PGW (tonnes)	Drive axle suspension#	Relative road wear for fully loaded vehicle per 100 tonnes of carrying capacity *	
			Fourth power	Eisenmann
2-axle rigid	17.00	steel	1.00	1.00
	18.00	steel	1.21	1.20
	18.00	air	1.20	1.15
3-axle rigid	24.39	steel	0.70	0.69
	25.00	steel	0.68	0.69
	26.00	air	0.77	0.66
4-axle rigid	30.49	steel	0.65	0.65
	32.00	air	0.65	0.64

Notes: static axle weights within the bogies of the 3 and 4 axle vehicles is assumed the same for air and steel suspensions

* relative to a the estimated road wear for a fully loaded 17 tonne PGW 2-axle rigid with steel suspension and double rear tyres

\# all drive axles have double tyres and non-drive axles have steel suspension and single tyres

OTHER IMPACTS

ENERGY EFFICIENCY

In 1991 goods transport by road consumed about 11 per cent of the petroleum used in the UK (Department of Transport, 1992b). Over 90 per cent of 2-axle rigids and 99 per cent of other goods vehicle use diesel fuel. The fuel consumption of a goods vehicle depends on a large number of factors including operating conditions, driving style, configuration, total weight, engine type, number of driven axles and cab / body aerodynamics.

Considerable fuel savings (up to 18 per cent at 80 km/h) can be achieved by using seals between the body and cab, front and rear mouldings, side skirts and shaped mirrors (Williams et al, 1981). Lowering vehicle speeds also results in lower fuel consumption. In tests with a 32.52 tonne 4-axle artic at steady speeds, a 14 per cent fuel saving was achieved by reducing the speed from 96 to 80 km/h (Williams et al, 1981). Improvements in engine design, weight reduction, aerodynamics and electronic engine management are expected to result in considerable fuel savings. Martin (1989) suggests that goods vehicles in the year 2000 are expected to consume 20 to 30 per cent less fuel than current vehicles.

Latham and Tonkin (1988) expect reductions in fuel consumption to be much less than that, in part because of the introduction of more stringent limits for noise and emissions.

In studies of the effect of vehicle plated weights between 32.52 and 40 tonnes on fuel consumption (Gyenes, 1980), with a constant power to weight ratio of 5 kW/tonne, the fuel utilization, per payload tonne km, was least for the 40 tonne vehicle (see Table 6).

OTHER ENVIRONMENTAL EFFECTS

Vehicle noise partly depends on engine size and load. Increasing vehicle weights will increase the use of vehicles with the most powerful engines. However, all vehicles will

Table 6: Estimated fuel consumption for articulated heavy goods vehicles

Plated Gross Weight (tonnes)	32.52	35	38	40
Fuel consumption for average load (litres/100 km)	41.1	43.1	46.2	47.3
Average fuel utilization (litres/100 tonne-km)	3.57	3.37	3.30	3.17

Source: (Gyenes, 1980) Note: Turbocharged engines with charge cooling.

have to comply with future noise limits of 80 dB(A), which may be introduced in 1995/6. The new limits will mean that the proposed heavier goods vehicles will be quieter than existing vehicles. Air-borne vibration is related to noise and is expected to decrease in line with noise level reduction. Ground-borne vibration increases with vehicle speed but is not strongly dependent on vehicle weight and is not simply related to axle weights (Watts, 1988).

Individual heavier vehicles with larger engines produce more pollutants. However, when the emissions per tonne of carrying capacity are considered, the level is likely to be lower for the heavier vehicles than for pre-1993 vehicles. Emissions will also be reduced by changes in EC regulations. The net effect of all these changes should be a reduction in smoke and fumes.

The effect of heavier vehicles on congestion is likely to be beneficial due to the reduction in total vehicle kilometres.

OPERATING COSTS

The cost of operating goods vehicles can be broken down into standing costs, incurred irrespective of whether the vehicle is operating, and running costs, only incurred when the vehicle is operating. Table 7 shows a summary of the main components of standing and running costs expressed as a percentage of total annual operating costs. The figures were taken from tables of operating costs published by Commercial Motor (Commercial Motor, 1991).

Table 7 shows that standing costs, as a proportion of total operating costs, decline with increasing vehicle weight, largely due to the higher annual travel of the heavier vehicles. The major components of operating costs are wages, interest charges, maintenance, fuel and depreciation.

The licence fee (vehicle excise duty) is only a minor component (at most 6 per cent), particularly for the heavier vehicles.

The variation with carrying capacity in operating cost per tonne km moved was calculated by Newton (1985) and is shown in Figure 4 (the absolute values for operating costs are not comparable between the table and the figure). Both Table 7 and Figure 4 show that the cost per tonne km falls rapidly with increases in vehicle gross weight or payload capacity up to a vehicle weight of about the current maximum allowable. There would be further reductions in operating cost per tonne km for further increases in allowable gross weight, but these would be progressively smaller for further increases in weight.

OPERATORS PREDICTED USE OF HEAVIER VEHICLES

SURVEY OF OPERATORS

In order to estimate how goods vehicle operators would change their fleets in response to the changes in weight limits, questionnaires were sent to 248 operators. There were four main parts to the questionnaire:

1. Details of the operator.

2. Details of the goods loaded onto their vehicles in a typical week.

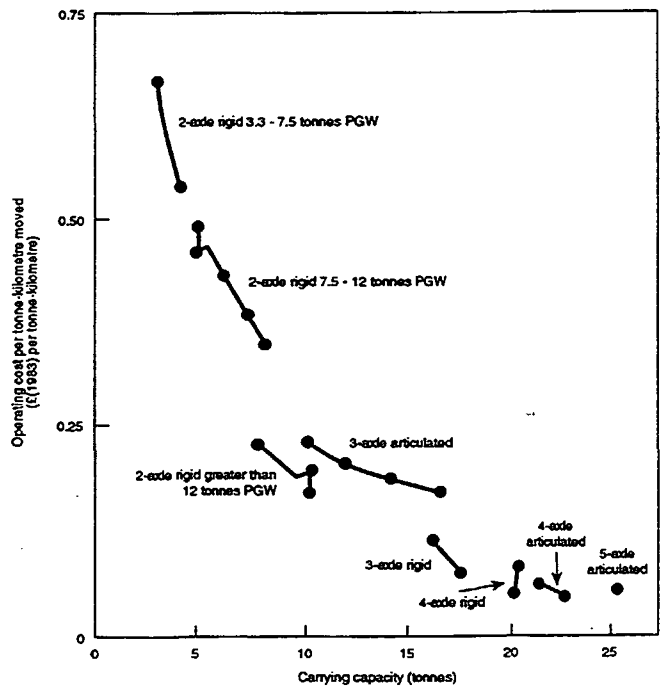


Fig.4 Operating cost per tonne-kilometre of goods moved
(Sources: Commercial motor tables of operating costs 1983-4 and CSRGT (Department of Transport, 1992a)

Table 7: Components of vehicle operating costs (per cent) in 1991

	2-axle rigid 17 tonnes PGW	3-axle rigid 24.39 tonnes PGW	4-axle rigid 30.52 tonnes PGW	4-axle draw-bar 32.52 tonnes PGW	4-axle artic 32.52 tonnes PGW	5-axle artic (2+3) 38 tonnes PGW	5-axle artic (3+2) 38 tonnes PGW	6-axle artic 38 tonnes PGW
Wages	44	37	26	28	29	24	24	23
Interest	12	15	15	15	12	10	11	11
Other	13	14	12	12	7	6	6	6
Standing costs	69	66	53	55	55	47	47	45
Maintenance	9	8	9	10	12	12	12	13
Fuel	9	9	11	13	15	18	18	18
Depreciation	10	13	23	17	13	14	16	16
Tyres & lubricants	3	4	4	4	4	9	7	8
Running costs	31	34	47	45	45	53	53	55
Assumed annual kilometres x 10^3	39.0	41.0	57.0	69.0	69.0	88.0	88.0	88.0
Annual cost (£1991)	32253	38668	54228	58876	56773	71364	72417	73592
Cost per km (£1991)	75	85	95	77	75	81	82	84
Cost per tonne km (£1991)	0.25	0.14	0.10	0.16	0.09	0.07	0.07	0.07

Source: Commercial motor tables of operating costs

3. Details of their existing fleet of vehicles 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.

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.

Complete replies were received from 182 operators (73 per cent of all questionnaires). Overall they operated 27,567 vehicles which was equivalent to about 6 per cent of all goods vehicles over 3.5 tonnes Plated Gross Weight in Great Britain in 1991.

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 the 1993 and 1999 scenarios. 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 operators indicated that, even if the full EC limits (1999 scenario) were available, 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, 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 considered, 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). Very few operators (3 of those covered by the survey) indicated that they would replace rigids or artics with drawbars.

Table 8: Grossed-up questionnaire results

Type of vehicle	Scenario (percentage change from base scenario in brackets)		
	Base (1991)	Weight limits 1993	Weight limits 1999
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 vehicles other than Heavy Goods Vehicles (such as buses and coaches).

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.

Some operators were concerned that there would be little tolerance for misplaced 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.

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.

GROSSED-UP RESULTS - 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. The main results are summarised in Table 8.

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 3).

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 8 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).

42/44 TONNE VEHICLES

The operators were asked whether they would use 42 or 44 tonne artics if there were 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 (3+2) or 6-axle artics.

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). But whilst the inclusion of only 6-axle 42 or 44 tonne artics was estimated to lead to a reduction in road wear, the inclusion of both 5-axle and 6-axle 44 tonne artics was estimated to lead to an increase in road wear 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 3).

DRAWBARS

Whilst a number of existing drawbar operators indicated that they would replace existing drawbars with heavier drawbars, thus reducing the number of vehicles needed to move the same amount of goods, only three operators indicated that they would use drawbars to replace rigids or artics. In contrast, 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. There is so little experience of drawbars in the UK that any forecasts concerning them must be regarded as tentative.

CONCLUSIONS

In the United Kingdom, changes in permitted weights and dimensions for goods vehicles have lead to changes in the composition of the goods vehicle fleet. In particular, changes in 1964 and 1968 in the weight and overall length of articulated vehicles led to the 4-axle articulated goods vehicle becoming the dominant mover of road freight between the early 1970s and the mid-1980s. Subsequent changes in 1983 in the maximum weight for 5-axle artics led to their current dominant role. Restrictions in the weight and allowable speed for drawbar units restricted their use relative to many other European countries.

The impact of heavier vehicles on road wear will almost certainly be adverse if the maximum weights are increased without a change of vehicle configuration. But an analysis of further weight increases for goods vehicles has shown that gross weights could be increased with no additional road wear if the weight is spread over more axles. In some cases, air suspensions allow vehicles to operate at higher gross weights while causing the same or less road wear.

Individually, the heavier vehicles will cause greater nuisance to people than lighter vehicles. But overall, the increase in weight limits should lead to a reduction in exposure to heavy vehicles (reduction in vehicle travel). The implementation of safety features, reduced noise levels, lower levels of smoke and fumes and reduced speeds, which are not related to the introduction of heavier vehicles, will mean that goods vehicles operating in the future should cause less nuisance to people than current vehicles. Higher gross weights would reduce the total fuel used by road freight and the total emissions and noise from goods vehicles.

A survey of 248 goods vehicle operators, asking them how they would react to changes in weight limits, 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 and a decline of 3 per cent in the number of goods vehicles, but an increase in road wear factors of about 8 per cent.

3. 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).

ACKNOWLEDGEMENTS

The work described in this report was carried out by the Environment Centre of TRL, and the paper is published by permission of the Chief Executive, TRL. The authors would like to thank the Statistics Transport 'D' Division of the Department of Transport for providing data from the Continuing Survey of Road Goods Transport and the goods vehicle operators who assisted with the survey. The studies of the impacts of heavier goods vehicles were carried out for the Freight and Road Haulage Division of the Department of Transport, and form part of the research programme of the Transport Research Laboratory.

Any views expressed in this paper are not necessarily those of the Department of Transport.

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