SOME TRAFFIC SAFETY IMPLICATIONS OF MOVEMENT OF GOODS BY ROAD

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To help to reduce the numbers killed, disabled or injured in road traffic accidents, all kinds of road use need to be examined for their traffic safety implications, and movement of goods by road and other uses of goods vehicles are no exception. Recent published data for Great Britain and counterpart data for Hong Kong are used in an exploratory study of the pattern of casualties in road accidents involving goods vehicles The use of goods vehicles is shown not to be unduly hazardous compared with other use of motor vehicles in terms of aggregate risk, but in accidents involving goods vehicles, the numbers of casualties to other kinds of road user are substantially greater than those to the goods vehicle users themselves. Some issues arising for road safety policy and for those sectors of business that make use of goods vehicles are discussed. Suggestions for further research are made.

KEYWORDS: Goods movement, road safety, light goods vehicles, heavy goods vehicles, Great Britain, Hong Kong

1. INTRODUCTION

Movement of goods by road in vehicles ranging from light vans and pickups to the largest lorries permitted by local regulations, and the use of light vans for delivery of a vast range of services, are indispensable to modern industry and commerce. Like all uses of the roads, the use of goods vehicles of all sizes contributes to the risk of death, disablement, injury and material damage in road traffic accidents. These consequences of road traffic accidents have been a matter of concern throughout the history of motor transport, but in recent years there has been in the industrialised countries an increasing realisation of the disproportionately high levels of risk of death and injury in using the roads. This is leading to increasingly systematic efforts to reduce these levels of risk and the consequent numbers of people killed, disabled or injured in road traffic accidents. For this purpose, all kinds of use of the roads need to be examined for their traffic safety implications, and movement of goods by road and other uses of goods vehicles are no exception.

This paper uses readily available published data for Great Britain in the year 2000 and counterpart data for Hong Kong in 2000 and 2001 as the basis for an exploratory study of the pattern of casualties in road traffic accidents involving goods vehicles and discussion of some issues that arise for road safety policy and for those sectors of business that make use of goods vehicles. The results provide a number of strong pointers, but coming from an exploratory study they can only be indicative, and the paper concludes by outlining further work that is required to establish definitive conclusions.

The results also inevitably indicate similarities and differences between some aspects of road accident occurrence in Hong Kong and in Great Britain, but no attempt is made to discuss these systematically here. To do so would require consideration of many other aspects of transport and society in Hong Kong and Great Britain, and would go beyond the stated purpose of this study.

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Focussing upon accidents involving goods vehicles is in no way intended to imply that use of such vehicles is in general unduly hazardous compared with use of other motor vehicles – on the contrary, the next section of the paper shows that this is not the case. It is simply intended to point to particular ways in which attention to the accidents in which these vehicles are involved can contribute to wider efforts to reduce risk on the roads.

2. DATA

In both Hong Kong and Great Britain, official statistics of road traffic accidents are based on information recorded by the police about those accidents on public roads that they attend or which are reported to them and which involve one or more vehicles and personal injury to one or more road users. In these data goods vehicles are categorised as *light*, *medium* or *heavy* in Hong Kong and *light* or *heavy* in Great Britain. Light goods vehicles (LGV) are mainly vans and pickups constructed on car or similar-sized chassis. In this paper, the medium and heavy categories for Hong Kong are considered together as medium and heavy goods vehicles (M&HGV), and this term is also used to refer to the heavy category for Great Britain.

In both systems, casualties are recorded as killed if they die within 30 days of the accident as a result of injuries sustained in it. Other casualties are recorded as seriously injured in Hong Kong if they are detained in hospital for more than 12 hours, and in Great Britain if they are detained in hospital overnight or suffer one of a short list of specific injuries such as broken bones; otherwise they are recorded as slightly injured. In this paper, numbers of those killed or seriously injured (KSI) are combined for purposes of analysis, to avoid dealing with small numbers subject to wide statistical variation. In both systems, accidents are categorised as fatal, serious or slight according to the severity of the most severely injured casualty in the accident.

The data used here are taken from the relevant annual government publications, (Transport Department, 2001, 2002; Department for Transport, Local Government and the Regions, 2001) together with tables kindly extracted for the author by the Transport Department of the Government of the Hong Kong Special Administrative Region to match data in the goods vehicle rows and columns of Table 23 (*Accidents, vehicle user and pedestrian casualties: by combination of vehicles involved*) of the British annual publication.

Readers who may wish to use findings reported here as pointers towards comparisons between Hong Kong and Great Britain in respect of road accident occurrence and its consequences should bear in mind that Hong Kong is largely urban, with only an inextensive network of interurban and rural roads, whereas Great Britain has in addition to a number of large conurbations an extensive interurban and rural road network. Moreover, largely for reasons of space, policy in Hong Kong has led to lower car ownership relative to income than in Great Britain, so that the compositions of the two vehicle fleets differ greatly. In particular, the LGV plays a much more prominent role in traffic in Hong Kong than in Great Britain.

3. OVERALL LEVELS OF RISK

Numbers of recorded injury accidents involving all motor vehicles, numbers involving LGV and numbers involving M&HGV, and numbers of KSI and slight casualties in these accidents for two recent years in Hong Kong and one recent year in Great Britain

are used in Table 1 together with amounts of vehicle-distance travelled, as estimated from systematic traffic censuses in Hong Kong and Great Britain, to calculate a number of ratios which help to indicate how the use of goods vehicles contributes to overall risk on the roads. These are

- the number of accidents per million vehicle-km as an indicator of the risk of injury-producing events,
- the number of casualties per accident as an indicator of the number of people injured per incident,
- the proportion of casualties KSI as an indicator of severity of the resulting range of injury,
- the number of casualties per million vehicle-km as an indicator of the risk of injury of any kind, and
- the number KSI per million vehicle-km as an indicator of the risk of death or serious injury.

TABLE 1: Indicators of overall levels of risk from all motor vehicles, from LGV and from M&HGV in Hong Kong and Great Britain

Numbers and indicators	All motor vehicles	Light goods vehicles	Medium and heavy goods vehicles
Hong Kong 2000 & 2001			
Vehicle-km (millions)	23 148	4 692	2 714
Number of accidents	28 584	5 654	2 086
Number of casualties	39 747	*8 511	*3 507
of which KSI	7 016	*1 475	*604
Accidents/million vehicle-km	1.235	1.205	0.769
Casualties/accident	1.391	*1.505	*1.681
Proportion KSI	0.177	*0.173	*0.172
Casualties/million vehicle-km	1.717	*1.814	*1.292
KSI/million vehicle-km	0.303	*0.314	*0.223
Great Britain 2000			
Vehicle-km (millions)	467 700	50 500	29 300
Number of accidents	232 858	16 860	13 894
Number of casualties	319 317	*25 843	*21 836
of which KSI	41 287	*3 203	*3 459
Accidents/million vehicle-km	0.498	0.333	0.474
Casualties/accident	1.371	*1.533	*1.572
Proportion KSI	0.129	*0.124	*0.158
Casualties/million vehicle-km	0.683	*0.512	*0.745
KSI/million vehicle-km	0.088	*0.063	*0.118

*Numbers of casualties and ratios based on them are estimated – see Section 4 and Appendix

The numbers of accidents and numbers of casualties in accidents to all motor vehicles are taken directly from the published data. The numbers of casualties in accidents involving the two categories of goods vehicle are not included in published tables and have been estimated for the purposes of this study as described in Section 4 and the Appendix. Exact numbers could be extracted from the data sources for a more definitive analysis, but the author did not feel justified in requesting such extractions for this exploratory study.

For LGV in Hong Kong, the values of the indicators of overall risk are all broadly similar to those for all motor vehicles. For M&HGV in Hong Kong the accident involvement rate is less than two-thirds of the rate for all motor vehicles but the number

of casualties per accident is about one-seventh higher, and the proportion KSI about the same, leading to risks of injury and of being KSI about 30 per cent lower than those for all motor vehicles.

In Great Britain, however, it is for LGV that the accident involvement rate is only two-thirds the rate for all motor vehicles, and as for the M&HGV in Hong Kong, this is partly offset by a higher number of casualties per accident, in this case about one-eighth higher. With a proportion of KSI about the same as for all motor vehicles, this leads to risks of injury and of being KSI about 25 per cent lower than for all motor vehicles. M&HGV in Great Britain have an accident involvement rate similar to that for all motor vehicles, but about one-seventh more casualties per accident and a proportion KSI about one-fifth higher, leading to a risk of injury about 10 per cent higher and a risk of being KSI about 30 per cent higher than for all motor vehicles

The overall risk of injury from the use of goods vehicles in Hong Kong is therefore somewhat lower than from use of motor vehicles in general because of the lower risk from M&HGV, whereas in Great Britain a lower risk from use of LGV is somewhat more than offset by a higher risk from M&HGV – having regard to the fact that the value attached to prevention of a death or serious injury in Great Britain is about 20 times the value attached to prevention of a slight injury (Department for Transport, Local Government and the Regions, 2001).

4. DISTRIBUTION OF RISK

Within the overall levels of risk examined in Section 3, it is important to consider the distribution of this risk over the various kinds of road user. In the context of road safety policy this is true of risk for each substantial type of use of the roads, but in the case of risk from the use of goods vehicles, the distribution of risk is also relevant to policy for the regulation of industry and commerce in relation to principles concerning the bearing by sectors of business of the costs that their activities impose on society.

The distribution of risk from the use of goods vehicles is examined here in terms of the distribution of injury among the main kinds of road user, and the severity of injury incurred by each kind of road user.

For accidents involving either category of goods vehicle, the published data used by the author for Great Britain and the counterpart data for Hong Kong supplied by the Transport Department give the numbers of each main kind of road user KSI or slightly injured in single-vehicle and two-vehicle accidents. They also give the numbers of pedestrians and users of that category of goods vehicle KSI or slightly injured in accidents involving 3 or more vehicles, one of which is a goods vehicle of the category being considered – but not the numbers of road users of other kinds injured in such accidents. The author has used these data to estimate the numbers of road users of each of the other main kinds injured in relevant accidents involving 3 or more vehicles. The method of estimation is described in the Appendix. The estimates made represent between about one-quarter and one-third of the corresponding total numbers of casualties, so that errors of estimation may have affected details of the results, but are unlikely to affect the broad conclusions. As mentioned previously, exact numbers could be extracted from the source data for a more definitive analysis.

Table 2 shows for Hong Kong how the estimated numbers of casualties over two recent years are distributed by road user type and indicates for each type and each level of severity what percentage the casualties in accidents involving the relevant category of goods vehicle form of all casualties to that type of road user in all traffic accidents in

Hong Kong. It also shows the corresponding proportions of casualties that were KSI, and these proportions as percentages of the corresponding proportions for all traffic accidents in Hong Kong. Counterpart data for Great Britain in one recent year are shown in Table 3.

TABLE 2: Distribution of estimated numbers of casualties in accidents involving goods vehicles in Hong Kong (HK) 2000 & 2001 (two years)

Type of road user	Casualties in accidents involving LGV			Casualties in accidents involving M&HGV		
	KSI	Slight	Proportion KSI	KSI	Slight	Proportion KSI
Pedestrian: number	567	1250	.312	114	215	.347
percentage of HK figure	20.9	17.7	112.4	4.2	3.0	124.8
Pedal cyclist: number	80	171	.319	22	40	.355
percentage of HK figure	18.8	9.6	165.0	5.2	2.2	183.7
Motorcyclist: number	126	537	.190	60	138	.303
percentage of HK figure	10.9	11.9	93.3	5.2	3.1	148.8
Car or taxi occupant: number	241	2037	.106	133	945	.123
percentage of HK figure	16.8	19.4	87.9	9.3	9.0	102.5
*PLB occupant: number	37	411	.083	35	244	.125
percentage of HK figure	22.8	25.7	89.3	21.6	15.4	135.6
**Bus occupant: number	28	532	.050	15	456	.032
percentage of HK figure	8.0	14.0	58.5	4.3	12.2	37.2
Total non-GV occupant	1079	4938	.179	379	2038	.157
percentage of HK figure	17.3	16.9	101.7	6.1	7.0	89.0
LGV occupant: number	383	2048	.158	89	415	.177
percentage of HK figure	100.0	100.0	100.0	23.3	20.2	112.5
M&HGV occupant: number	13	50	.206	136	450	.232
percentage of HK figure	9.5	10.9	89.6	100.0	100.0	100.0

* Public Light Bus   ** including tram and light rail vehicle occupants

In both Hong Kong and Great Britain, comparison of the numbers of casualties shown in the last 3 rows of the LGV columns of these tables shows that accidents involving LGV result in about 2½ times as many casualties to other kinds of road user as to users of goods vehicles, and among the latter, the great majority of the resulting casualties are to users of the LGV. The percentages of the HK and GB figures for proportion KSI show that the average severity of the casualties among users of buses, and in Great Britain among users of M&HGV, in accidents involving LGV is substantially lower than the averages for such casualties in all accidents, and for cyclists in Hong Kong it is substantially higher, but for other kinds of road user, the average severities of casualties in accidents involving LGV are broadly similar to those in all accidents. The percentages of the HK and GB figures for numbers of casualties to particular types of road user show that in Hong Kong, between about 10 and 20 per cent (25 per cent for occupants of Public Light Buses) of casualties to other kinds of road user occur in accidents involving LGV, whereas in Great Britain the corresponding percentages range from about 4 to 8, but a large part of this difference is accounted for by the fact that LGV form about 20 per cent of all motor traffic in Hong Kong, but only about 10 per cent in Great Britain – as shown by the vehicle-km figures in Table 1. Among these casualties to other kinds of

road user in Hong Kong, comparison of these percentages with the corresponding percentages for all non-GV occupant casualties indicates that pedestrians and occupants of Public Light Buses are clearly overrepresented, occupants of cars or taxis are slightly overrepresented, and pedal cyclists, motorcyclists and bus occupants are clearly underrepresented, compared with their involvement as casualties in all traffic accidents in Hong Kong. In Great Britain, it is pedal cyclists and motorcyclists who are overrepresented, whereas pedestrians and bus or coach occupants are underrepresented. Casualties to M&HGV occupants are clearly underrepresented in Hong Kong and somewhat underrepresented in Great Britain.

TABLE 3: Distribution of estimated numbers of casualties in accidents involving goods vehicles in Great Britain (GB) 2000 (one year)

Type of road user	Casualties in accidents involving LGV			Casualties in accidents involving M&HGV		
	KSI	Slight	Proportion KSI	KSI	Slight	Proportion KSI
Pedestrian: number	429	1374	.238	307	540	.363
percentage of GB figure	4.5	4.2	105.3	3.2	1.7	160.4
Pedal cyclist: number	220	1268	.148	240	610	.282
percentage of GB figure	7.9	7.1	110.0	8.7	3.4	210.1
Motorcyclist: number	436	1485	.227	338	609	.357
percentage of GB figure	5.9	7.1	86.8	4.6	2.9	136.5
Car or taxi occupant: number	1248	11501	.098	1766	11892	.129
percentage of GB figure	6.3	6.1	102.7	9.0	6.4	135.3
Bus or coach occupant: number	22	537	.039	59	879	.063
percentage of GB figure	3.8	5.6	68.8	10.2	9.2	109.8
Other vehicle user: number	15	116	.115	34	207	.141
percentage of GB figure	6.2	6.8	91.9	14.1	12.2	113.3
Total non-GV occupant	2370	16281	.127	2744	14737	.157
percentage of GB figure	5.9	6.0	98.0	6.8	5.5	121.0
LGV occupant: number	813	6194	.116	144	614	.190
percentage of GB figure	100.0	100.0	100.0	17.7	9.9	163.8
M&HGV occupant: number	20	165	.108	571	3026	.159
percentage of GB figure	3.5	5.5	68.1	100.0	100.0	100.0

Corresponding comparisons in the M&HGV columns of Tables 2 and 3 show that although M&HGV also form about twice as large a proportion of all motor traffic in Hong Kong as in Great Britain (about 12 per cent compared with about 6 per cent – as shown by the vehicle-km figures in Table 1), the percentages of casualties to other kinds of road user that occur in accidents involving M&HGV differ less. They range from about 3 to about 12 in each case (16 per cent for occupants of Public Light Buses in Hong Kong). But in other respects there are considerable differences between Hong Kong and Great Britain in the patterns of occurrence of casualties in accidents involving M&HGV. In Hong Kong there are nearly as many casualties to LGV users as to M&HGV users in such accidents, compared with fewer than a quarter as many in Great Britain, and only about twice as many casualties to other kinds of road user as to users of goods vehicles, compared with four times as many in Great Britain. In both cases the average severities of injury to pedestrians, cyclists and motorcyclists is substantially

higher in accidents involving M&HGV than in all accidents. In Hong Kong the same is true for occupants of Public Light Buses, and in Great Britain for occupants of cars and taxis and of LGV, and to a lesser degree for occupants of buses, whereas in Hong Kong the reverse is true for occupants of cars and taxis and of buses, and there is little difference in average severity for occupants of LGV. The upshot is that for all kinds of road user other than goods vehicle occupants, the average severity of casualties is substantially higher in Great Britain, but somewhat lower in Hong Kong, in accidents involving M&HGV than in all accidents. In accidents involving M&HGV in Hong Kong, casualties to Public Light Bus occupants are substantially overrepresented, and both there and in Great Britain those to occupants of LGV, cars or taxis and buses are clearly overrepresented while those to pedestrians, cyclists and motorcyclists are clearly underrepresented compared with their involvement as casualties in all traffic accidents.

A recent study of casualties in accidents involving goods vehicles in Greater London in 2002 (London Road Safety Unit, 2004), which does not distinguish between LGV and M&HGV, gives a broadly similar picture to that presented for Great Britain in Table 3, except that the proportions of casualties formed by pedestrians, cyclists and motorcyclists are somewhat higher, and the proportions KSI for other road user types are somewhat lower, in Greater London than in the whole of Great Britain. This is understandable because most roads in Greater London are urban roads.

5. DISCUSSION

In considering consequences of accidents involving goods vehicles as part of the cost of moving goods by road, it has first to be asked how many of these accidents would be prevented if the goods vehicles ceased to operate. It is reasonable to suppose that all accidents involving goods vehicles only (i.e. involving neither any vehicle of another kind nor a pedestrian) would be prevented. But of those accidents involving a single goods vehicle and a pedestrian, not all would be prevented, because, for example, some pedestrians stepping carelessly into the road and being struck by a goods vehicle would have been struck by another vehicle instead if the goods vehicle had not been there. Similarly, some two-vehicle accidents involving just one goods vehicle would still have taken place, involving another vehicle instead, if the goods vehicle had not been there, and so on for multi-vehicle accidents. In such cases the goods vehicle occupant casualties would be replaced by casualties among occupants of other kinds of vehicle. The published accident data give no information as to the proportion of accidents that would still have taken place.

However, a very broad indication of how much the total number of casualties might be reduced if, quite hypothetically, all goods vehicles ceased to operate can be obtained by combining the method described in the Appendix for estimating numbers of casualties in accidents involving 3 or more vehicles with the suppositions that the number of casualties would be reduced by

- the number of non-pedestrian casualties in accidents involving only goods vehicles, plus
- half the number of pedestrian casualties in accidents involving goods vehicles, plus
- half the number of other casualties in 2-vehicle accidents involving one goods vehicle, plus
- one-third of the number of other casualties in goods vehicle accidents involving 3 or more vehicles.

Under these suppositions, in Hong Kong in 2000 and 2001 the numbers of KSI and slight casualties would have been reduced by about 1000 and 4000 respectively, out of the totals of about 2000 and 9000 occurring in accidents involving goods vehicles. The corresponding figures for Great Britain in 2000 are about 3000 and 18500 out of about 6500 and 41000 respectively. These numbers give a broad indication of the cost in death and injury of the use of goods vehicles.

In relation to the sectors of business that make use of goods vehicles, death and injury to those goods vehicle occupants who are personnel of the businesses concerned are an internal cost. The larger amounts of death and injury among other types of road user are an external cost, some of which is borne by those sectors through insurance which compensates the victims and their families and through that part of the taxes they pay that is spent on dealing with the consequences of these deaths and injuries.

In principle, it could be arranged for the cost to society of these deaths and injuries to be borne wholly by the relevant business sectors by adjusting the requirements for and levels of insurance and the levels of taxation imposed. But even if this could be achieved to a reasonable degree of approximation in practice, it would still be preferable to prevent deaths and injuries than to compensate for their occurrence, to the extent that means of prevention were cost-effective, having regard to the value attached by society to prevention of death and injury in road accidents.

Within this constraint of cost-effectiveness, therefore, it seems reasonable to require these business sectors to implement preventive measures. In doing so the need has to be recognised for ways of imposing these requirements both upon operators of large or small fleets of vehicles driven by employees and upon self-employed operators of just one, or one or two, vehicles which they drive themselves. Such measures include

- high and certified standards of driver training,
- high and certified standards of vehicle maintenance,
- high and audited levels of availability and use of safety equipment,
- high and audited standards of equipment and procedures for securing loads,
- comprehensive and audited systems for recording incidents, their investigation, and steps taken to reduce the risk of recurrence, and
- high levels of underrun protection on goods vehicles whose construction would otherwise allow pedestrians and cyclists to fall under them, or cars in collision with them to make initial contact at a height above the road surface greater than that of their inbuilt crash protection.

Note: No mention is made of precautions concerning the carriage of hazardous goods, because that is not a matter of traffic safety, but of materials handling and associated risk management.

The last of these measures can be expected to help to reduce the excess severity of injury to other types of road user in accidents involving M&HGV, but in respect of collisions with cars and other light vehicles, a fundamental difficulty remains. The high ratios of the masses of M&HGV to those of cars means that occupants of cars colliding with M&HGV experience velocity change approximately equal to the closing speed, and twice what they would experience in a similar collision with another car. This is a fact of physics which cannot be altered. The injurious effect of a given velocity change is, however, determined by the associated deceleration, which is in turn determined largely by the distance travelled by the light vehicle occupant relative to the rigid structure of the heavy vehicle during deceleration. At present this comprises in a frontal impact the amount by which the seatbelt stretches plus the amount by which the front of the car

crushes, and in a rear-end impact, the amount by which the rear of the car crushes. In each case this distance could be increased by adding across the width of the front and rear of M&HGV a structure shaped in side view like the bonnet or boot of a car and with similar crushing characteristics. The benefit of this would be a function of the crushing distance. The capital cost would be small in relation to the initial cost of the heavy vehicle; the main cost to the user of the vehicle would be in terms of loss of payload within the maximum permitted vehicle-length. Research would be required to determine whether the fitting of such crushable ends to M&HGV would be cost-effective, and if so, what length of crushable structure would maximise its cost-effectiveness.

6. FURTHER RESEARCH

This exploratory study indicates scope for further research in a number of areas:

- Replacement of the estimated numbers of casualties used here by actual numbers extracted from the source data.
- Extension of the analysis for Hong Kong to include more years of data to reduce the possible effect of random variation in casualty numbers on the conclusions.
- Investigation of the possible effect on the conclusions of non-commercial use of LGV – which would probably require collection of special data about both accidents and vehicle use.
- Investigation of the cost-effectiveness of the various preventive measures.

ACKNOWLEDGEMENTS

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APPENDIX. ESTIMATION OF NUMBERS OF CASUALTIES TO USERS OF VARIOUS TYPES OF VEHICLE IN ACCIDENTS INVOLVING 3 OR MORE VEHICLES INCLUDING AT LEAST ONE GOODS VEHICLE

The method is described for accidents involving LGV; for those involving M&HGV, the two types are interchanged. Of the recorded 2-vehicle accidents involving LGV, let the proportion involving 2 LGV be p and the proportion involving both LGV and M&HGV be q. Let C and c denote the number of road users of a particular type KSI and slightly injured respectively per accident within a particular category of accident. The

values of *p* and *q* and of *C* and *c* for the various road user types and accident categories mentioned below can be calculated from the available data.

Among the known number *N* of accidents involving 3 or more vehicles including at least one LGV, suppose that $2Np$ involve at least 2 LGV, of which Np^2 involve 3 LGV and $2Npq$ involve M&HGV, and $2Nq$ involve M&HGV, of which Nq^2 involve 2 M&HGV. Suppose that the remainder *R* of these *N* accidents involve no other goods vehicle.

Then if each of these *N* accidents involved just 3 vehicles, the numbers of M&HGV and non-goods vehicles involved would be $M = 2Nq(1+q)$ and $V = 2R + 2N(p+q)(1–p–q)$ respectively, each to second order in *p* and *q*, both of which are quite small.

The numbers of LGV occupant casualties in the *N* accidents are known from the data. To estimate the numbers of M&HGV occupants KSI and slightly injured in the *N* accidents, *M* was multiplied by the values of *C* and *c* respectively for M&HGV occupants in 2-vehicle accidents involving one goods vehicle of each type. For each other type of vehicle occupant or user, the numbers KSI and slightly injured were estimated by multiplying *V* by the values of *C* and *c* respectively for that road user type in all 2-vehicle accidents involving one LGV and one non-goods vehicle. This neglects both casualties in fourth and subsequent vehicles and any tendency for numbers of casualties per vehicle involved to be lower in accidents involving more vehicles, approximations whose effects are likely partially to offset one another.

As a check in the case of accidents involving LGV, the already known numbers of LGV occupant casualties in such accidents involving 3 or more vehicles were estimated in the same way and the results compared with the known numbers. They were found to match well. The same check cannot be applied to the numbers of M&HGV occupant casualties in accidents involving 3 or more vehicles including at least one M&HGV because of the disproportionate concentration of such casualties in accidents involving more than one M&HGV.