THE ROLE OF DRIVER FATIGUE IN COMMERCIAL ROAD TRANSPORT CRASHES

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The Council brings together experts of international reputation on its Working Parties, and representatives of a wide range of national and international organisations with transport safety interests and Parliamentarians of all parties on its Main Council to exchange experience and knowledge and to identify and promote research-based contributions to transport safety.

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- The most important factor that will ensure safety is to effectively implement and enforce regulation.
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- The framework for the regulation of working and driving time needs to be broadened to cover complementary measures including training for drivers and operators.
- A co-ordinated programme of research is needed to address knowledge gaps and to evaluate the effectiveness of regulation.

Introduction

Although the trend is towards fewer fatalities in road crashes, the annual rate of decline is levelling off and still more than 42,000 people are killed each year on EU roads. A comprehensive, road safety strategy, guided by numerical targets, is needed to address this large public health problem. Reducing injuries by driver impairment is an important part of that activity.

The role of driver fatigue in driving safety is a complex one. Within commercial road transport (which is the focus of this review), the core issue is one of working time and the opportunity this offers for rest and recuperation from work, together with the possibility of presenting for work unimpaired by fatigue and loss of sleep. However, powerful economic and social forces influence and control the normative pattern of work of commercial drivers. Working time is, after all, one of the basic economic inputs to production and transport. Consequently, the safety argument too often has been brushed aside in the face of a commercial logic that requires flexible and on-time transportation of goods and passengers, in many cases spanning the 24-hour cycle. The customer, the consumer and new modes of production require this – and in some respects, the working conditions of many drivers have become harsher and more demanding over the last 30 years. For these reasons, it is of particular importance to restate the safety case for controlling more effectively the factors that give rise to fatigue. In the European context, the dialogue between the social partners through which regulation is framed has to move beyond the balancing of economic factors and social conditions of work to fully encompass the critical role working time plays in road transport safety.

The most comprehensive research undertaken into the effects of driver fatigue has been carried out in the USA. A series of studies by the National Transportation Safety Board (NTSB) have pointed to the significance of sleepiness as a factor in accidents involving heavy vehicles. The NTSB came to the conclusion that 52 per cent of 107 single-vehicle accidents involving heavy trucks were fatigue-related; in nearly 18 per cent of the cases, the driver admitted to falling asleep. Summarising the US Department of Transportation's investigations into fatigue in the 1990s, the extent of fatigue-related fatal accidents is estimated to be around 30%.

In Europe, the evidence is less comprehensive, and often involves retrospective accounts of fatigue involvement which are likely to underestimate its impact. Research undertaken in some Member States indicates that driver fatigue is a significant factor in approximately 20% of commercial transport crashes. The results from various surveys carried out at different times, show over 50% of long-haul drivers have at some time fallen asleep at the wheel.

The most conspicuous observation concerning the causes of all fatigue-related accidents is that peak levels at night are often 10 times higher than daytime levels. French research into lorry driver working times and habits showed that risk levels vary with three key factors as regards the general problem of fatigue. There is an increased risk of accidents at night, an increased risk the greater the length of the working day, and also with irregular working hours.

Over the thirty-year period since EC Regulation 543/69, initiatives to regulate drivers' hours have failed to implement the stated objective of reducing the impact of fatigue on driving safety. A whole generation of professional drivers, as well as the travelling public, have had neither the protection of regulations that control the most important factors contributing to fatigue, nor of regulations that have been consistently or effectively enforced. The current proposal to extend the Working Time Directive to road transport and the revision to the regulations on recording devices should have provided the opportunity to recreate a framework of regulations which can achieve two objectives:

- to better control those factors, associated with fatigue, which have been shown to influence road safety; and
- to provide a mechanism for the effective implementation and enforcement of these control measures.

The amended proposed extension of the Working Time Directive to road transport (COM (2000) 754) is welcome in that it addresses some issues.

– It extends coverage to all road transport workers (including, after three years*, self-employed drivers), whereas Regulation 3820/85 restricts its scope to certain categories of driver.
– It stipulates a maximum weekly working limit of 60 hours with a maximum average of 48 hours over four months. While these proposals do address part of the safety issue, they are unlikely to be effective because where drivers respect

* The Council of Minister's recently adopted common position amends the clause by providing that the Commission following an impact assessment of that exclusion, *"may propose conditions under which self-employed drivers would be subject to the Directive".* These provisions would require new negociations in the Council.

and work to the limits of driving time in Regulation 3820/85 (which is in principle easier to enforce) they will in the great majority of cases, exceed the working time limits. Both working time and driving time need to be addressed in the same regulation.

– It restricts the duration of daily work for nightworkers to an average of 8 hours with an absolute maximum of 10 hours.
– Rest periods are more or less in line with Regulation 3820/85, although it does allow a working span of six hours before a break, which is somewhat high.

There is a fundamental contradiction in European policy for regulating time at work and driving in road transport. European Regulation EEC 3820/85 permits drivers to drive up to an average of 45 hours, and up to 56 hours one week in two. Driving up to this limit will almost inevitably mean having an average work span of 13 hours or more, during that week. The accident risk data demonstrate that after 11 hours of work span the risk of being involved in an accident doubles. Regulations based on extending the Working Time Directive to road transport workers are unlikely to have any effect to reduce the risk of excessive work spans, unless there is an effective means of control of both working and driving time in the same regulation. It is essential to reduce permissible driving time to an extent that will bring total working time within acceptable limits.

The proposed extension to the Working Time Directive is severely deficient in another area. It does not address enforcement beyond stipulating requirements to display information and keep records, and requiring Member States to determine a range of penalties and to take steps to enforce the regulations. The Commission should consider in much greater detail how this proposed Directive might be enforced; otherwise, its provisions (even if enacted) are likely to remain an aspiration.

While, internationally, there has been a lot of research on fatigue and safety, in Europe there has not been the concerted effort to provide a strong and œherent research basis for the development of policy. Thus while quite a lot is known about the physiology of sleep and waking (particularly over cycles of no more than 24 hours) and a certain amount about the risks associated with the various parameters of working time, knowledge of the actual working hours (and how they are distributed) is limited to certain countries.

There is a whole set of issues which requires focused research effort if there is to be a sustained and balanced programme of regulation that has a realistic chance of achieving specified safety objectives. These include:

- The economic and social determinants of working time. If measures to regulate working and driving time are to be fully effective, it is important that they are based on a comprehensive understanding of the economics of working in different sectors of commercial transport, and of sociological factors that may influence changed patterns of work.
- The social and economic costs of accidents associated with fatigue and working hours. It should be borne in mind that, because of their sheer mass, heavy commercial vehicles involved in multiple vehicle accidents cause very high rates of death and injury to other road users. It has been estimated that approximately 60% of the total costs of traffic accidents involving for-hire commercial cargo

carrying trucks in the USA are borne by society rather than the truck operator. It is important therefore to establish a framework of data and evidence about these issues to enable a sound estimation of the benefits and costs of interventions to improve safety.

- The evaluation of a range of countermeasures. Regulation is one of a number of measures that can help to reduce the incidence of fatigue. It is important to evaluate both the implementation and effectiveness of these measures systematically.
- The establishment and monitoring of safety targets. Better quantification of the extent of the influence of fatigue on road safety should make it possible to establish realistic safety targets which can be achieved by the implementation of appropriate measures.

Conclusions and recommendations

There are three main areas of policy which need to be addressed if there is to be a chance of overcoming the limitations of current policy and successfully reducing the influence of fatigue on safety. These are the overall framework of regulation and enforcement, the specific provisions for hours of work and rest, and the co-ordination of research that would support and develop this policy.

The framework of regulation and enforcement

The framework for the regulation of working and driving time needs to be broadened to include a range of complementary measures which are specifically designed to improve the safety of road transport operations.

- Safety management. It is the responsibility of the transport operator to manage the operation safely, and of the driver to drive safely and only when in a fit condition to do so. These responsibilities should be the starting point for a framework regulation for the safe management of working time for all operators irrespective of size.
- Code of practice. A code of good practice for effective fatigue management in road transport should be promulgated and promoted by the relevant authorities on the basis of input from impartial expertise.
- Contracts. The contractual relationship between shippers/freight forwarders/prime contractors and sub-contractors should be regulated through the adoption of obligatory contracts allowing verification of compliance with labour laws and operator and traffic regulations.
- Auditing, monitoring and inspection. The implementation of all the above should be subject to systematic auditing and monitoring at the level at which responsibility rests for compliance with the requirements. This should be complemented by an improved, standardised system of roadside inspection that ensures a high probability of detection of non-compliance. A new generation of digital tachographs is essential to effective monitoring.
- Enforcement. There needs to be a consistent level of enforcement across the Community, with penalties designed to strongly influence behaviour towards compliance. Consideration should be given to measures which would support and encourage small operators with few management resources to develop more effective management of their operation.

- Training. Managing fatigue and alertness should be an essential component of a curriculum for the professional training of drivers and should be incorporated in the new European Directive on driver training.
- Management and operator qualifications. Managing working time in order to ameliorate fatigue should be an essential part of mandatory qualification standards for transport operators.

Hours of work and rest

The framework of hours limitations should explicitly take account of the scientific evidence concerning fatigue and the risk of accident. In particular:

- Daily and weekly rest. Sufficient time for daily rest and recuperation needs to be guaranteed. Where this cannot be taken at physiologically appropriate times of the day or in adequate facilities, adequate time for full recuperation on a weekly (or shorter) basis must be ensured.
- Night-work. Permissible working hours during the hours of circadian low activation should be substantially fewer than those permitted during the day.
- Working and driving time. There should be a co-ordinated approach to regulating driving and working time to ensure that permissible driving times do not inevitably lead to unacceptably high working times.
- Rest-breaks. Adequate time and facilities should be ensured for rest, meal-breaks and naps.

Intensification of research

A co-ordinated programme of research is needed to address some of the gaps in the evidence. In particular it should seek to:

- Quantify more precisely and routinely (e.g. in official road accident statistics) the role of fatigue in road safety.
- Extend our knowledge of the parameters that govern the influence of fatigue, especially those factors which span over several days or longer.
- Identify the social and commercial costs associated with fatigue related accidents.
- Evaluate the effectiveness of regulatory interventions and other counter-measures in reducing fatigue-related accidents.

1. INTRODUCTION

Although the trend is towards fewer fatalities in road crashes, the annual rate of decline is levelling off and still more than 42,000 people are killed each year on EU roads. A comprehensive, road safety strategy, guided by numerical targets, is needed to address this large public health problem. Reducing injuries by driver impairment is an important part of that activity.

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What is fatigue?

Fatigue, or tiredness, concerns the inability or disinclination to continue an activity, generally because the activity has been going on for “too long". There are different kinds, such as local physical fatigue (e.g. in a skeletal or ocular muscle), general physical fatigue (following heavy manual labour) or “central nervous” fatigue (sleepiness). The last of these is mental fatigue – not “having the energy” to do anything. Sleepiness is a particularly important form of fatigue related to the level of brain stimulation and the structures that regulate it (Åkerstedt and Kecklund, 2000).

In behavioural terms, there are four levels of sleep:

a) Completely awake;
b) Moderate sleepiness when the central nervous system maintains an adequate pattern but functions more slowly than normal (Angus and Heslegrave, 1985);
c) Severe sleepiness, where the individual is repeatedly overcome by fatigue and interruptions occur interactively with the surroundings and performance becomes irregular and fitful. This characterises such disorders as narcolepsy (Valley and Broughton, 1983),as well as totally healthy, but exhausted, individuals (Torsvall and Åkerstedt, 1987); and
d) Sleep, where there is no longer any interaction with the surrounding environment.

The level of fatigue or sleepiness is a function of the amount of activity (for example, the number of hours awake) in relation to the brain’s physiological waking capacity. Several factors can influence this physiological waking capacity and hence lower the

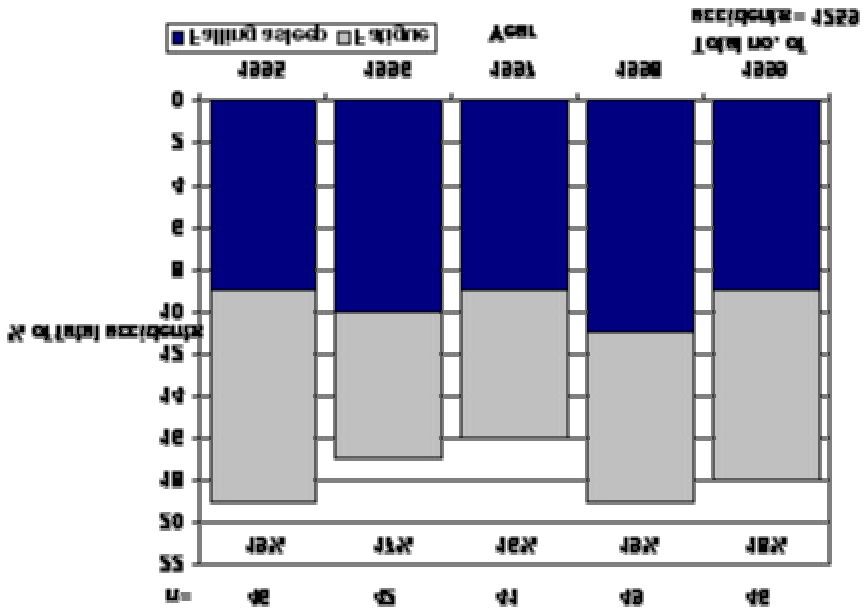
fatigue threshold. For example, disturbed sleep, the low point in the circadian rhythm (time of day), and alcohol and drugs. These factors are independent of the activity being undertaken, but result in the fatigue effect of that activity appearing more quickly. Thus fatigue cannot be seen simply as a function of the duration of time engaged in work (or any other activity). Furthermore, where there is a lack of sufficient restorative sleep, the fatigue threshold may be affected over a period of days or weeks.

How important is fatigue in road safety?

Fatigue is not normally referred to on road accident report forms. This means that, in general, no reliable official statistics exist for the frequency of fatigue-related road accidents. The data that do exist mostly originate from studies that estimate the extent of fatigue from other variables (for example, characteristics of accidents), or from specially constructed studies collecting new material on the incidence of tiredness in relation to accidents. Thus, while the typical representation of fatigue in official road accident statistics may be around 3% or less (slightly more for fatal accidents), the actual contribution of fatigue is hidden by systematic under-reporting. This is demonstrated in a wide range of reliable studies, a few of which are mentioned below.

In Finland, all fatal road accidents are investigated in-depth by multidisciplinary investigation teams. Figure 1 shows the percentage of fatal accidents involving fatigue or falling asleep between 1995 and 1999 (Hantula, 2000). This fluctuates between 16-19%. In a UK survey, "tiredness" was reported by the drivers questioned as being a factor in 7.3 % of the accidents they had been involved in during the three years preceding the study (Maycock, 1995). This figure is similar to a German study (7%) although this work focused on lorry and bus drivers (Garo et al, 1997). A Bavarian study found that 24% of the fatal accidents (irrespective of road users categories) that had occurred on motorways in 1991 (204 in total) were the result of sleepiness at the wheel (Langwieder and Sporner, 1994). A later UK study found that sleep-related accidents accounted for 16% of all vehicle accidents occurring in Devon and Cornwall counties between 1987 and 1992 and 23% of all accidents to which the Midlands counties police forces were called (Horne and Reyner 1995).

Figure 1: Falling asleep or fatigue as a risk factor in fatal accidents



The studies cited above serve to illustrate the significant role of fatigue in road accidents. Comparison between them is difficult. Some studies are regional while others are national. Some concentrate on a particular accident severity while others consider all types of road accidents. Some focus on a particular type of road user/vehicle while others encompass all driver categories.

However, it is clear that “official” figures of 1-3 % are too low and that the correct figure is probably considerably higher - 10-20 % is probably a conservative estimate. Furthermore, their incidence increases with the degree of seriousness of the accident. Fatigue is disproportionately represented in single-vehicle accidents (perhaps 25% of such accidents) but head-on collisions could also be fatigue-related to a far greater extent than other types of accident.

2. FATIGUE IN COMMERCIAL ROAD TRANSPORT

In the case of heavy vehicles, the figures are rather higher than for non-commercial traffic. The most comprehensive research undertaken into the effects of driver fatigue has been carried out in the USA. A series of studies by the National Transportation Safety Board (NTSB) have pointed to the significance of sleepiness as a factor in accidents involving heavy vehicles (NTSB, 1990 and 1995; Wang and Knipling, 1994). The NTSB came to the conclusion that 52 per cent of 107 one-vehicle accidents involving heavy trucks were fatigue related; in nearly 18 per cent of the cases, the driver admitted to falling asleep. In a new report published by NTSB (NTSB, 1999), summarising the US Department of Transport’s investigations into fatigue in the 1990s, the extent of fatigue-related fatal accidents is estimated to be around 30 %. Fatigue is considered the most important road safety factor for large trucks (FHWA, 1995).

In Europe, the evidence is less comprehensive, and often involves retrospective accounts of fatigue involvement which are likely to underestimate its impact. A Dutch survey found that 7% of HGV drivers attributed their accident involvement to having fallen asleep at the wheel (van Ouwerkerk, 1987). A more recent French study showed that 10.5% of HGV drivers stated that fatigue had contributed to their road crash involvement (Monfrin et al, 1996). Langwieder and Sporner (1994) found that for commercial vehicles, the rate varied according to the weight of the vehicle identified as being mainly responsible for the accident: 26% for HGVs of more than 7.5 tonnes GVW and 35.7% for light vehicles under 7.5 tonnes GVW, both figures being more in line with the US results.

Posing the question in another way – what proportion of drivers report having fallen asleep at the wheel? As the results of different surveys carried out at different times show, over 50% of long-haul drivers have at some time fallen asleep at the wheel.

Table 1: Dozing at the wheel (source: Hamelin, 2000)

Drowsiness at the wheel	**Yes**
Hamelin, FRANCE, 1993 and 1999: "have you ever during your career blanked-out or dropped off for a moment?"	
- Long-haul lorry drivers employed by haulage firms (N = 345) in 1999	62%
- Long-haul lorry drivers employed by haulage firms (N = 212) in 1993	58%
Van Ouwerkerk et al, HOLLAND, (N = 650) in 1986	60%
Fuller, IRELAND, (n=44) in 1978	45%
Linklater, AUSTRALIA, (n=615) in 1977	60%
Tilley, the USA, (n=1500) in 1973	64%

While, internationally, there has been a lot of research on fatigue and safety, in Europe there has not been the concerted effort to provide a strong and coherent research basis for the development of policy. Thus while quite a lot is known about the physiology of sleep and waking (particularly over cycles of no more than 24 hours) and a certain amount about the risks associated with the various parameters of working time, knowledge of the actual working hours (and how they are distributed) is limited to certain countries.

There is a whole set of issues which requires focused research effort if there is to be a sustained and balanced programme of regulation that has a realistic chance of achieving specified safety objectives. These include:

- The economic and social determinants of working time. If measures to regulate working and driving time are to be fully effective, it is important that they are based on a comprehensive understanding of the economics of working in different sectors of commercial transport, and of sociological factors that may influence changed patterns of work (Hamelin, 1999).
- The social and economic costs of accidents associated with fatigue and working hours. It should be borne in mind that, because of their sheer mass, heavy commercial vehicles involved in multiple vehicle accidents cause very high rates

of death and injury to other road users. It has been estimated that approximately 60% of the total costs of traffic accidents involving for-hire commercial cargo carrying trucks in the USA are borne by society rather than the truck operator (Morris, 1996). It is important therefore to establish a framework of data and evidence about these issues to enable a sound estimation of the benefits and costs of interventions to improve safety.

- The evaluation of a range of countermeasures. Regulation is one of a number of measures that can help to reduce the incidence of fatigue. It is important to evaluate both the implementation and effectiveness of these measures systematically.
- The establishment and monitoring of safety targets. Better quantification of the extent of the influence of fatigue on road safety should make it possible to establish realistic safety targets which can be achieved by the implementation of appropriate measures.

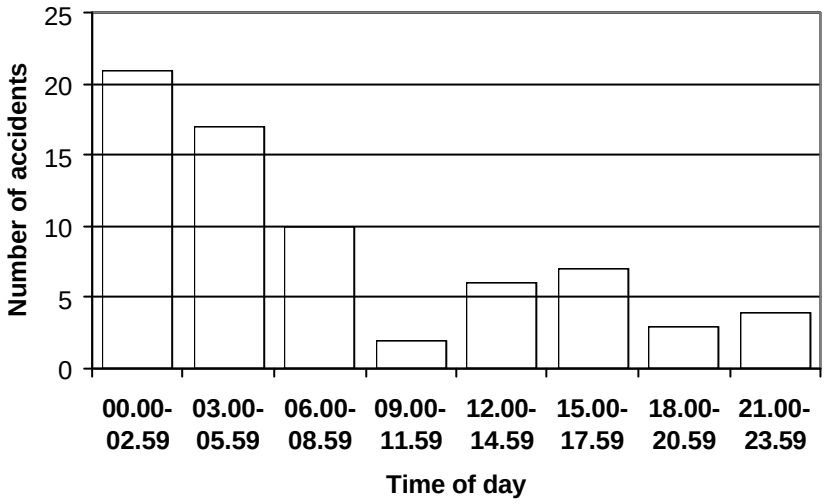
This official neglect compares most unfavourably with both the United States and Australia (Commonwealth of Australia, 2000), where there have been serious and concerted activities by the responsible government agencies to establish a sound basis for effective policy making to tackle the problem of fatigue in different transport modes.

3. FACTORS WHICH INFLUENCE RISK

The time of day during which driving or work occurs.

The most conspicuous observation concerning the causes of all fatigue-related accidents is the extremely pronounced effect of the circadian rhythm (Langois et al, 1985; Lavie et al, 1987; Horne and Reyner, 1995; Pack et al, 1995; Hantula, 2000). A recurring feature is that the maximum accident level occurs between 2.00 a.m. and 5.00 a.m., with a secondary and rather lower peak level at around 3.00 to 4.00 p.m. (see figure 2). The peak levels at night are often 10 or even more times higher than daytime levels.

Figure 2. Sleep related accidents and time of day (Horne and Rayner, 1995)



The mechanism behind fatigue-related road accidents is closely linked to the underlying biological factors controlling sleep/wakefulness. The biological clock drives human physiology in a constant undulating flow between high metabolic rates during the day and low ones at night. Changing the timing of activities to the night hours means being subject to the reduced functional capability due to a lowered metabolic rate, and, during the subsequent (daytime) sleep, being exposed to the high metabolic rates that disturb sleep. Furthermore, how long a person is awake is equally important, which means that late at night and early in the morning will be a double burden on people who drive at night.

Sleep deficit

The duration and quality of sleep have a direct effect on the level of alertness and the ability to drive a vehicle safely. Setting off in the vehicle in the early hours of the morning means, for instance, that a person is combining driving at the low point in the circadian rhythm with a greatly shortened period of sleep. Fragmented sleep, characteristic of a sleep disorder called sleep apnoea, can in serious cases have no recuperative value whatsoever with an accompanying high risk of falling asleep at the wheel. Any cumulative sleep debt, which has built up over several days, will also adversely affect performance. Such a sleep debt needs to be dissipated over successive nights of good sleep that include the time window of the circadian low point. Some evidence suggests that following severe sleep restriction, recovery of

performance may not be complete even after three nights of recovery sleep (Balkin et al, 2000).

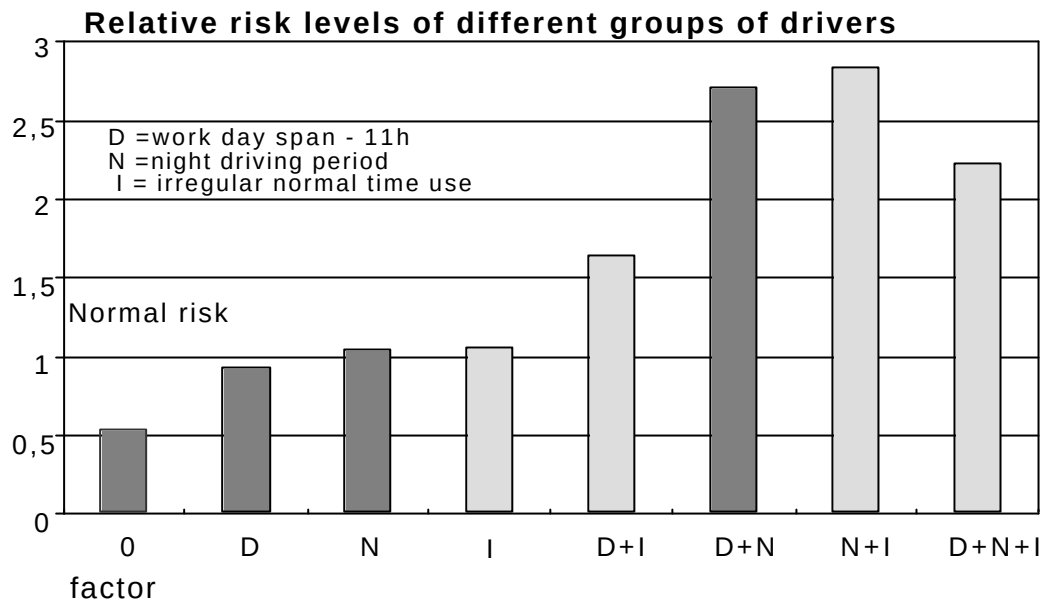
The NTSB's in-depth study of single-vehicle accidents involving large trucks (NTSB, 1995), concluded that the most important factors behind the 58 per cent of fatigue-related accidents were the duration of the driver's last period of sleep, the total number of hours of sleep during the past 24-hour period, and fragmented sleeping patterns (several short periods of sleep). The period of sleep starts to be negatively affected if this daily rest falls below 12 to 14 hours (Kurumatani et al, 1994; Kecklund and Åkerstedt, 1995; Wylie et al, 1996; Mitler et al, 1997; Hantula, 2000).

The duration of and pattern of work.
Driving time is only a part of the total working time for commercial drivers, who have many more tasks than the job of driving (see section 4). Many of the above studies sometimes provide information about the effects of the duration of the trip. Most show that it takes around nine or ten hours of driving, or eleven hours of work, before accident risk starts to rise (Mackie and Miller, 1978; Hamelin, 1987). Hamelin found that after 11 hours of work span the risk of being involved in an accident doubles.

However it should be borne in mind that this effect is practically always mixed up with the effects of the time of day and sometimes also with the length of time awake and previous lack of sleep. It may well be that the duration of a trip is not of great importance in itself – many fatigue-related accidents occur very soon after the start of the trip. The effect of duration of driving is likely to be very small for normal durations, while in the case of long trips it is generally compounded with other, more potent causes such as lack of sleep and night-time driving. However, the length of time driving can have a considerable indirect effect, in that long hours at the wheel deprive motorists of the sleep they need.

Hamelin's data demonstrates very clearly this interaction (see Figure 3). Risk levels vary with three key factors as regards the general problem of fatigue. There is an increased risk of impaired function and drowsiness at night, an increased risk the greater the length of the working day, and irregular working hours also seem to lead to sleep/alertness problems. How does that affect the level of the accident risk ratio?

Figure 3 - Level of risk and attributes of drivers' hours of service (Hamelin, 1987)



The light-coloured bars relate to transport sector drivers while the dark bars represent drivers for private-carrier industrial and commercial firms.

These factors (long hours, night work, and irregular hours) are present singly or in combination. Where one factor is present, the risk level is similar to the exposure level and the time factor does not influence the level of risk. By contrast, where two factors are present, the risk level is at least 3 times higher than the lowest relative risk value. The risk among transport sector drivers is higher than among their counterparts in other sectors. Road haulage firm's drivers differ significantly from their colleagues working in industrial and commercial firms in terms of hours of service, work content and tempo. The long hours and irregular work tempos of transport sector drivers contrast with the shorter more regular working hours of the drivers for industrial and commercial firms. It is not the same job and they do not have the same career profiles (Hamelin, 2000).

Repeated days of prolonged work activity may be associated with a cumulative decrement of performance, though the evidence for this is less substantial. Linklater (1980) found that average weekly driving hours, as reported by the driver, was a good discriminator of probable crash involvement. When exposure to risk (in terms of working hours) was taken into account the accident peak came in working weeks of over 55 hours.

A pattern of work which requires several successive nights away from home tends to mean heavier working weeks for commercial drivers (Hamelin, 1975, 1983, 1993, 1999; Garo et al., 1997). In the latter study, average weekly hours were 64.3 hours for those absent 4 nights a week from home or more against 53.3 hours for drivers back home every night. The more nights commercial drivers spent away from home per week, the higher was the reported frequency of near misses associated with being tired or asleep at the wheel. 63% of the drivers who spend 4 nights and more away from their homes admitted to having fallen asleep at the wheel while it only

concerned 33% of those who return to their home base every evening (Garo et al, 1997). Sleep tends to be less restorative when taken “on the road” due to the lack of adequate rest areas (Kiegeland et al, 1999).

Age and experience
Drivers with more than 10 years driving experience or over thirty years of age have a consistently lower accident risk than their younger or less experienced colleagues. (Lin et al, 1994; Hamelin, 1987). However, while older drivers have a lower overall accident risk they appear to be more susceptible to fatigue (Harris et al, 1972; Hamelin, 1987).

4. THE CURRENT SITUATION IN EU COMMERCIAL ROAD TRANSPORT

30 years of ineffective legislation
Over the thirty-year period since EC Regulation 543/69, initiatives to regulate drivers’ hours have never effectively addressed the stated objective of reducing the impact of fatigue on driving safety. A whole generation of professional drivers, as well as the travelling public, have had neither the protection of regulations that control the most important factors contributing to fatigue, nor of regulations that have been consistently or effectively enforced. The current proposal to extend the Working Time Directive to road transport and the revision to the regulations on recording devices should have provided the opportunity to recreate a framework of regulations which can achieve two objectives:

- to better control those factors, associated with fatigue, which have been shown to influence road safety; and
- to provide a mechanism for the effective implementation and enforcement of these control measures.

Hours currently worked in European transport
The number of hours worked in European commercial road transport varies strongly according to the transport category worked in goods transport for hire or for reward (TFH/GT), own account goods transport, (OAT/GT); short-distance passenger transport (SD-PT) or long-distance passenger transport (LD-PT) as shown in Table 2 below.

Table 2. Mean working time in hours* by category of transport

Driver Categories	N = 206	Daily Working Time	Weekly Working Time
TFH/GT	N = 79	**11.0**	**60.5**
OA/GT	N = 31	9.2	50.5
SD/PT	N = 53	7.2	39.5
LD/PT	N = 43	9.3	51.5

* number of days worked per week on average = 5.5. Source: Garo et al, 1999, p. 156

HGV drivers engaged in transport operations for hire work the longest whereas, not surprisingly, bus drivers in short-distance public transport have the shortest weeks

of all. The country worked in does not appear to make a great difference to the hours worked (see Table 3).

Table 3 - Comparison of the working times of road transport drivers, international drivers (Holland), long-haul drivers (France) and mixed (Germany). (Hamelin, 2000)

	France 1975 Hamelin	Netherlands 1986 Ouwerkerk	France 1983 Hamelin	France 1993 Hamelin	Germany 1996/7 Garo	France 1999 Hamelin
driving time	7h25	7h	7h35	7h35	7h05	7h40
waiting time	1h45	1h30	1h10	0h55	0h55	0h58
loading/unloading	2h15	2h50	2h30	2h25	2h25	2h10
other tasks	0h25	0h50	0h30	0h30	n.a.	0h24
total work time	11h50	12h10	11h45	11h25	11h00	11h12
days worked/week	5.5	5.8	5.2	5.2	5.5	5.1
number of drivers	54	650	235	315	79	345
scope of the survey	long and short haul drivers in the transport sector n=140	international drivers in the transport sector n=650	long and short haul drivers in all sectors, plus in 1993, drivers of cross-country coaches n(83)=940 n(93)=1250		lorry drivers in all sectors plus coach and city bus drivers n=206	as 1993 French survey - 1006 HGV 500 coach n=1506
data collection method	interview with sample of HGV drivers (selected by group: A knows B who knows C…. across France) plus worktime log kept chronologically for two weeks unit: 0h15	interview with drivers at Dutch border on previous day's work (previous day's tachograph reading at least - more if possible)	interviews with drivers from a representative sample of all commercial drivers (HGV in 1983, HGV and coaches in 1993), plus worktime log completed chronologically for 2 weeks. unit: 0h15		interviews based on master questionnaire plus worktime logbook kept chronologically for a week unit: 0h15	as 1983/93 French survey

Driving and working time

While driving is the principal activity of commercial drivers' working time (averaging approximately two thirds of the total working time duration in for-hire or for-reward goods transport) it is not the only task this category of driver has to perform. One third of their time or more is spent waiting, loading or unloading the vehicle or on other tasks. This is of prime importance when a limitation to working time in commercial road transport is contemplated, since those other tasks are multiple and rarely "compressible", as they strongly depend on the driving assignment itself.

Thus, driving time is linked with working time. For example, on average, long distance truck drivers (who are away from home two days or more) work 55.3 hours and drive only 38 hours a week (Hamelin, 2000). The following table demonstrates this linkage between driving hours and work spans and is based on a survey of a representative sample of 1000 truck drivers, filling in log books during two weeks, in autumn 1999.

Table 4: Driving and working hours (Hamelin, 2001)

Drivers grouped according to driving hours:	**Average working hours of these drivers**	**Percentage of these drivers working longer than 48 hrs**	**Percentage of drivers who have work spans greater than 12 hours**
less than 30,01 h	45,9h	39%	43 %
30,01 to 35h	51,4h	68%	49 %
		Percentage of these drivers working 56 hrs or longer	
35,01 to 40h	54,7h	37%	65 %
40,01 to 45h	58,0h	71%	75 %
		Percentage of these drivers working 60 hrs or longer	**Percentage of drivers who have work spans greater than 13 hours**
45,01 to 50h	63,5h	77%	67 %
=50h	70,9h	89%	79 %

This demonstrates a fundamental contradiction in European policy for regulating time at work and driving in road transport. European Regulation EEC 3820/85 permits drivers to drive up to an average of 45 hours, and up to 56 hours one week in two. Driving up to this limit will almost inevitably mean having an average work span of 13 hours or more, during that week. The accident risk data demonstrate that after 11 hours of work span the risk of being involved in an accident doubles. Regulations based on extending the Working Time Directive to road transport workers are unlikely to have any effect to reduce the risk of excessive work spans, unless there is an effective means of control of both working and driving time in the same regulation. It is essential to reduce permissible driving time to an extent that will bring total working time within acceptable limits.

Enforcement activities

'Lack of enforcement of regulations is perhaps the single greatest problem facing the sector' (Bayliss and Coleman, 1994). Consistently, surveys have shown that drivers' hours regulations have been routinely flouted (for example, Germain, 1988; van Ouwerkerk, 1989). Van Ouwerkerk found that 84% of 650 international truck drivers from a variety of European countries were in violation of drivers' hours regulations, in particular driving time, length of daily rest and daily work time. The level of inspection is reported to be very low. Hamelin (1989) estimated the risk of a control inspection of work time to be of the order of nine per thousand working days (the risk of a sanction at two per ten thousand days). In 1988, the European Council introduced minimum requirements on monitoring compliance (checks must cover at least 1% of days worked per year, not less than 15% of the days checked at the roadside and not less than 25% at the workplace). However, the impact of this requirement on the industry is by no means clear. A joint study by the Committee of Transport Workers' Unions in the European Community and the International Road Transport Union failed to elicit any significant information about enforcement of regulations from 30 trade union and 36 employer organisations in the Union (O'Brien et al, 1995). Furthermore, enforcement of the regulations (Council Regulation 3820/85) has been hampered by legal challenges to its interpretation (European Court of Justice 1992).

There is no consistent enforcement strategy across the Union. Thus, for example, the competent agencies responsible for enforcement vary in different Member States. The level of sanctions also varies considerably between different Member States (Gugenheim, 1989). It is accepted that the level of enforcement in total must be increased to ensure better compliance with the Regulation. This is also the conclusion of the 19th report from the commission on the implementation in 1995-96 of Regulation (EEC) 3820/85 on the harmonization of certain social legislation relating to road transport (CEC, 2000a). In general, there appears to be an overall increase in offences detected throughout the EU. An intensification or reduction in the number of checks does not lead to a corresponding rise or fall in the number of offences detected. While this may in some instances reflect the preventive effect of more frequent enforcement activities; it is apparent that in a large proportion of Member States increased enforcement activity is merely showing a growing problem.

A further issue is that of accountability – who should be held liable for violations? Council Regulation 3820/85 places an obligation on transport undertakings to organise drivers' work in such a way that drivers are able to comply with the relevant provisions, to check compliance periodically and to prevent repetition of any breaches found. It is not clear how this provision has either been interpreted or applied. Certainly there is little evidence in Europe of the kind of auditing activity ('Safety Review' audits) undertaken by the US Federal Highway Administration since the 1984 Motor Carrier Safety Act (Moses and Savage, 1994). Contractual relationships between firms are not covered in the EU regulations. Nevertheless, freight forwarders and prime contractors are frequently blamed for setting targets which require subcontractors to operate illegally (Bayliss and Coleman, 1994).

Enforcement is commonly held to depend on the ability to detect and deter infractions by both high probabilities of detection and adequate penalties. European regulation manifestly fails to meet these criteria.

Tachographs

Since the introduction of the mechanical tachograph as a recorder for working, driving and rest hours, it has been shown that drivers can tamper with these devices. This has partly undermined its role as a device to control and enforce the Community regulations.

On the 24 September 1998, the Council adopted EC regulation 2135/98- OJEC No L274, amending Council Regulation (EEC) No 3821/85 and Council Directive 88/599/EEC on recording equipment in road transport (tachograph). The starting date of the introduction of the digital tachograph in July 2000 was not met. At the time of writing, the introduction of the digital tachograph is expected to take effect at the end of 2002/beginning of 2003. This means that there will be a temporary co-existence of the two types of tachograph, the mechanical and digital tachograph. The transition period may be between 5 and 10 years.

If and when the necessary technical improvements can be met, it may be possible to realise a tamperproof device. The tachograph and ultimately the digital tachograph have an important part to play in enabling enforcement of the regulation, insofar as when controlling driving time the working time of drivers is also controlled.

Other technology-based interventions

A variety of technologies offer some promise to assist in the detection of fatigue or excessive working hours. These technologies can play a variety of roles: they can assist the enforcement agencies in detecting infringements, they can warn drivers of the onset of fatigue, or they can assist companies in managing the work of drivers in a more cost effective manner.

Tachographs are increasingly complemented by other technological systems for recording the location and movement of vehicles. The commercial role of such technologies is to increase the efficiency of the utilisation of vehicles and their drivers. They have the potential to offer some protection to the driver insofar as these systems can be used to help manage working time in conformance with the physiological requirements for rest and recovery. However, where this protection is not forthcoming, the role of the technology is only to reduce what little flexibility the driver has to manage his or her working rhythm so as to ameliorate the effects of fatigue.

Computer-based scheduling and roster-management tools are being developed which incorporate fatigue-management principles. European research in this area is directed towards the aviation industry. The use of such tools requires a management willing and able to use them effectively.

Various fatigue-warning devices have been proposed. However, unless there is a rigorous framework of enforcement of hours limitations, the use of driver warning devices is likely to encourage drivers to keep going to the limit prescribed by the device and then some more, as the driver attempts to 'take extra care' in driving following the warning.

For some time efforts have been made to develop a reliable and valid device for measuring driver fatigue and it has been suggested that performance impairment due to driving fatigue is analogous to impairments due to alcohol. (Williamson et al, 2000a). The validity and practical utility of these devices needs to be fully demonstrated if they are to become part of a more effective enforcement strategy.

Thus, while it is clear that a number of technological advances could help in the detection and management of fatigue or excessive hours of work, none of these is a substitute for a rigorous regime of enforcement of an appropriate framework of hours regulations.

Training

In most EU-countries the qualification required to operate as a "professional road driver" is merely obtaining the driving licences required for driving such vehicles, through a driving school. This can include a 'theory test' of knowledge of the regulations. Up until now only France and the Netherlands have made basic vocational training for professional drivers compulsory. In Germany, there is a further official vocational training for professional drivers set out in Reg. 26.10.73. The present duration of training is two years at the end of which there is a final examination where the skills (e.g. ability to complete the entrusted transport mission safely), know-how (e.g. basic vehicle maintenance/repairs) and knowledge (e.g.

international road transport legislation in the neighbouring countries) of course attendees are tested. Both trade unions and employers' organisations have agreed to a 3-year-training model due to be introduced in Germany in 2001. While the topic of fatigue and its effects is not explicitly mentioned, working time aspects, driving and rest times regulations as well as the proper use of tachographs are already part of the current syllabus, and the new proposed syllabus includes rostering and trip planning. Drivers can further qualify in a range of related courses and can complete further education courses leading to upward mobility in 'Goods or passenger transport master craftsman' or 'Logistician', for example (Garo, 2001).

The European Commission has recently adopted a proposal for a Directive setting obligatory basic and continuous training for professional drivers transporting goods or passengers by road (CEC, 2001). The management of fatigue and working time should be an essential part of the syllabus for this training.

The changing structure of the road transport industry

The commercial road transport sector in Europe has undergone considerable expansion and structural change over the last few decades (Bayliss and Coleman, 1994). Some of these changes have been associated with the deregulation of the industry in the late 1980s. There has been an increased number and size of road haulage firms. These are predominantly, but by no means exclusively, small firms servicing local markets. At the same time there is considerable concentration of the haulage fleet in large enterprises. Increased size of haulage companies implies an increased use of logistics governing operations and this in turn permits greater routinisation of transport operations. Accompanying these changes is a move from 'own account' to contracting out from professional haulage companies. Furthermore, this has led to new patterns of relationships between companies (haulage companies, shippers, forwarders and their clients). In particular, there has been a growth both in strategic alliances between enterprises with complementary roles and in subcontracting. Formal and more long-term contracts are becoming increasingly common. Within such arrangements there is usually a hierarchical pecking order with subcontractors taking the least profitable and the least regular business. As a result of intense competition and falling prices, the working hours for many drivers actually increased in the years following deregulation.

Thus it is important to stress that the regulation of conditions of work does not occur in a vacuum. The strength of enforcement of hours regulation has to be sufficient to counteract the tendency of the market to push working hours of drivers ever closer to the limit of endurance. The costs of non-compliance need to be greater than the potential commercial gain from violating the regulation.

These findings suggest that the relationship between shippers/freight forwarders/prime contractors and sub-contractors should be regulated through the adoption of obligatory contracts allowing verification of compliance with labour laws and operator and traffic regulations.

5. A NEW FRAMEWORK FOR REGULATION

Effective measures to control the social aspects of road transport require the setting of numerical limitations on the number of hours of work, driving and rest. However, regulations need to go beyond this. If the management of working time is to be effective in preventing fatigue, then it also has to be sensitive to broader criteria for ensuring that, within the limits set, the pattern of work permits adequate recuperation from work and provides some flexibility for individual needs. This requires an approach based on a code of best practice in the management of working time. In order to ensure the effective implementation of the regulation and code of practice, additional measures need to address:

- The professional training and career structure of drivers and operators.
- The monitoring of health and safety.
- The auditing of enterprises and of the contractual relationships between them.

Regulation

The regulatory system for working time in road transport should be based on three specifications:

1. The duties of the major actors of the system. These are the driver, the operator, the prime contractor, the national authority, and the European authority. These duties are complementary and reciprocal.
2. The means of compliance - how these duties are to be exercised. This is expressed below in the envelope of permissible hours of work and rest, a code of practice, and procedures for allowing flexibility.
3. The standard of safety - how compliance is to be assessed and enforced.

Duties and Obligations

Ultimately any satisfactory scheme to regulate the working hours of commercial drivers should be built on mutual obligations or requirements.

a) The duty of drivers to manage their own sleep and alertness in order to ensure their own fitness for duty. This might best be expressed in a professional code of practice.
b) The duty of the operator to manage rostering and dispatch to comply with human requirements to ensure that drivers can fulfil (a). This requires the effective management of safety in every transport enterprise. Obviously the sophistication and scope of safety management has to be appropriate to the size of the enterprise.
c) The obligation on those who contract commercial transport services to ensure that these contractual arrangements are compatible with (a) and (b). Such contracts should be transparent and allow verification and enforcement.
d) The duty of the regulator to ensure that (a), (b) and (c) are complied with according to the prescribed standards. This requires effective auditing, inspection and enforcement.

Permissible hours of work and rest

The core of a regulation to manage working time and fatigue is a set of mandatory limits prescribing minimum rest periods and maximum periods of driving and working time. What principles should govern the setting of numerical limits for hours of work, driving and rest?

Daily rest
The first requirement is to provide for sufficient time for daily rest. This should include the opportunity for a minimum of eight hours of sleep plus time for the requirements of food and hygiene. This would suggest a minimum of 11 hours, though the evidence that sleep starts to be negatively affected if this daily rest falls below 12 to 14 hours, should be noted.

Weekly rest
Weekly rest should guarantee two nights sleep at home to ensure adequate recovery, and to ensure that the next week's work starts without a substantial debt of fatigue or sleep loss. Where working time is reasonably regular daytime work this indicates a 36-hour minimum period. Where work is irregular in its pattern throughout the 24 hour cycle or includes nightwork, the weekly rest should be extended to 48 hours to ensure the opportunity for sleep periods when the body is physiologically adjusted for sleep, on two consecutive days.

Working and driving time
The most important principle for the regulation of daily working time is to ensure the limitation of periods of driving and work during the night time hours so that they are substantially lower than those permitted during the day. Working during a period of low circadian activation involves an increased risk of fatigue in itself and displaces the time of sleep to the day when high levels of circadian activation make it difficult to achieve a good quality of sleep. Nine hours is considered to be a reasonable maximum limit for work periods, which include some or all of the period of circadian low. The number of successive night shifts should also be limited in order to prevent the accumulation of fatigue.

Working and driving times, which do not impinge on the window of circadian low, also need to be regulated in the light of the increasing risk during the later part of driving shifts (particularly from the eighth hour of driving on), and when working time exceeds eleven hours. If any flexibility is permitted beyond these limits then this should be compensated for very rapidly (within a day or two) in order to prevent the build-up of cumulative fatigue over several days. It is therefore important to strictly limit the weekly maximum working time. One reference point for that is the evidence of increased risk following 55 hours of work.

Working time (which often governs the time since the last major sleep) is more critical to fatigue than driving time itself. Moreover, the relationship between driving and working time is fairly stable – on average 70% of working time is spent driving. It is therefore very important to ensure that the same regulation governs driving time and working time and to avoid the situation where following the driving time limits will inevitably lead to consequential violations of working time regulations.

Rest Breaks
The evidence clearly demonstrates the necessity for ensuring a meal or rest break during a work shift after a period of continuous work or activity of no more than 4.5 – 5 hours.

A simple regulation

Even though a range of factors have to be taken into account in framing a regulation on times of work, driving and rest, it is of great importance to keep the regulation simple, because it has to be enforced routinely, day after day.

The amended proposed extension of the Working Time Directive to road transport (CEC, 2000b) is welcome in that it addresses a number of these issues.

- It extends coverage to all road transport workers (including, after three years* self-employed drivers), whereas Regulation 3820/85 restricts its scope to certain categories of driver.
- It stipulates a maximum weekly working limit of 60 hours with a maximum average of 48 hours over four months. While these proposals do address part of the safety issue, they are unlikely to be effective because where drivers respect and work to the limits of driving time in Regulation 3820/85 (which is in principle easier to enforce) they will in the great majority of cases, exceed the working time limits (see Table 4). Both working time and driving time need to be addressed in the same regulation.
- It restricts the duration of daily work for nightworkers to an average of 8 hours with an absolute maximum of 10 hours.
- Rest periods are more or less in line with Regulation 3820/85, although it does allow a working span of six hours before a break, which is somewhat high.

Code of Practice

Good roster management accepts that if you have a 24 hour requirement for service, some fatigue and sleep loss is inevitable, but this is mitigated as far as possible by balancing different requirements. The limits on drivers' hours which are codified in the regulation should be those within which this compensation and balancing can occur without causing serious concerns about safety. A Code of Practice can help ensure that, within the framework of regulations, fatigue is managed effectively. Such a Code of Practice can assist in the dissemination of information about the management of fatigue and should form an important component of the training of drivers and operators.

Some of the principles of good roster management can be encompassed under the following headings.

- where possible preserve the opportunity for regular sleep including normally adjusted night sleep
- limit the duration of work to prevent the build up of fatigue
- preserve regularity in the 24 hour cycle
- allow for regular nutrition and hygiene requirements (e.g. rest breaks)
- provide weekly rest to prevent the accumulation of fatigue
- short term compensation is better than long term to prevent the accumulation of fatigue and sleep loss
- provide notice and predictability in roster patterns

* The Council of Minister's recently adopted common position amends the clause by providing that the Commission following an impact assessment of that exclusion, *"may propose conditions under which self-employed drivers would be subject to the Directive".* These provisions would require new negociations in the Council.

- provide flexibility to individual requirements

When it is not possible to fulfil a particular principle, then compensatory measures need to be made to allow the human system to readjust to its normal patterns.

In addition to these general principles, it is also suggested that good management in an industry where safety is at a premium should adopt the following additional measures:

- monitoring of the health and well-being of those subject to irregular working hours individually and collectively;
- provide an appropriate career structure and career management to prevent long term problems of adaptation to the roster system;
- provide advice and training in personal sleep and fatigue management;
- undertake systematic monitoring of incidents and accidents; and
- provide a mechanism, including consultation, for the continuous improvement of the roster system to fulfil and reconcile, technical, operational and individual needs.

These or some equivalent set of principles should be expanded and promulgated by the regulator as an advisory Code of Good Practice.

Flexibility

From the transport operator's point of view, there is always the call for flexibility. It is arguable that flexibility could be built into the system if it can be shown that some operations are technically or socially necessary while at the same time making it impossible to meet the regulatory standard of limits. In these cases the starting point should be that such an operation falls short of the recommended standard for safe practice. In such a case two conditions would need to be satisfied.

- The operator should have to demonstrate against criteria set by the regulator that such operations are technically or socially necessary and that no practicable alternative exists. In order to minimise the risk associated with operating outside the prescribed standard, a set of stringent procedures would become mandatory.
- This would be based on the code of practice, formulated in a manner which permits effective oversight. The principle should be that if safety margins are reduced there must be clear and effective compensatory measures to control and monitor risk. For example, it may be safe to exceed the daily working limit on one occasion; however, extra time for rest and recuperation is needed to prevent the accumulation of fatigue.

Considerable caution should be exercised in simply arguing from general principles as to what would be an acceptable deviation from the core set of regulatory limits. Williamson et al. (2000b; 2000c) have explored the fatigue effects of various alternative work rest regimes. They demonstrated that, while working normally within the regulations, few fatigue effects were evident, for those working to the upper limits of the regulations, the risk of fatigue is increased significantly. They also showed that, while, on a once-off basis, it is possible to prolong working hours without significant fatigue effects, repeating this led to significant deterioration in performance. Thus, any proposal for a more flexible regime of regulation needs to demonstrate empirically that it does not undermine the safety objectives of the regulation.

Enforcement

A basic principle of enforcement is that the risk of punitive consequences for violation of regulations should weigh more heavily than the gain accrued through the violation. Both the risk of detection and the size of the penalty are important.

Accountability for the management of safety requires that the system be subject to audit, and that the outputs of the system be subject to inspection. Such audits and inspections would appropriately be at three levels: the contractual relationships between firms, the management system within the enterprise, and the actual work and driving assignments of each driver. More effective regulations for automatic recording devices are an important contribution to this. The main advantage of the tachograph as an aid in enforcement in the regulations is that, insofar as it is fraud resistant, it provides an objective mechanism for producing evidence of non-compliance. One major disadvantage is that the variable most directly measured – time spent at the wheel – may not be the most relevant variable in the build up of fatigue.

The European Commission‘s efforts to harmonise enforcement practices, data collection and treatment, as well as the levels of penalties among EU Member States, should be amplified in order to combat distortions and allow accurate comparisons between Member States. Collaboration and exchange of information between the various authorities in charge of enforcement in the respective Member States should be reinforced and the practice of cross-border concerted checks should be extended. However, most importantly, the volume of enforcement activity has to substantially increase in order to ensure that the probability of detection of infringements is increased, and penalties applied to ensure that there is an effective deterrent effect.

The recent proposal to extend the Working Time Directive to road transport is severely deficient in that it does not address enforcement beyond stipulating requirements to display information and keep records, and requiring Member States to determine a range of penalties and to take steps to enforce the regulations. The Commission should consider in much greater detail how this proposed Directive might be enforced; otherwise, its provisions (even if enacted) are likely to remain an aspiration.

Selection and professional training

Occupational selection is important at two levels – management and driver. Effective safety management requires competent managers. A demonstration of competence in relation to the management of fatigue and working time could appropriately be built into systems for regulating entry requirements for road transport operator. The development of logistics has the potential to radically alter the organisation of driving work. It is important that such new logistical systems pay attention to human constraints and limitations. This implies that those who are responsible for devising such logistical systems as well as those who manage them need to have the competence to accomplish this.

For the driver, the impact of the stresses of work, particularly those associated with working time, have long been known to have an impact on the career of the driver (Hollowell, 1969; Hamelin, 1989). The management of fatigue and safety over the

length of a career in road transport demands a high degree of occupational mobility. Licensing and initial professional training of drivers should address the importance and mechanisms of fatigue and alertness management. Both public and private training agencies should give attention to career planning and occupational mobility in order to provide the flexibility to ensure that drivers do not become trapped in an occupational niche, where they are unable to cope adequately with the demands.

6. RECOMMENDATIONS

There are three main areas of policy which need to be addressed if there is to be a chance of overcoming the limitations of current policy and successfully reducing the influence of fatigue on safety. These are the overall framework of regulation and enforcement, the specific provisions for hours of work and rest, and the co-ordination of research that would support and develop this policy. These recommendations are completely congruent with the consensus statement of an international group of scientists who study human performance, safety and the prevention of accidents associated with work schedules, night activity and inadequate sleep (Åkerstedt, 2000).

The framework of regulation and enforcement

The framework for the regulation of working and driving time needs to be broadened to include a range of complementary measures which are specifically designed to improve the safety of road transport operations.

- Safety management. It is the responsibility of the transport operator to manage the operation safely, and of the driver to drive safely and only when in a fit condition to do so. These responsibilities should be the starting point for a framework regulation for the safe management of working time for all operators irrespective of size.
- Code of practice. A code of good practice for effective fatigue management in road transport should be promulgated and promoted by the relevant authorities on the basis of input from impartial expertise.
- Contracts. The contractual relationship between shippers/freight forwarders/prime contractors and sub-contractors should be regulated through the adoption of obligatory contracts allowing verification of compliance with labour laws and operator and traffic regulations.
- Auditing, monitoring and inspection. The implementation of all the above should be subject to systematic auditing and monitoring at the level at which responsibility rests for compliance with the requirements. This should be complemented by an improved, standardised system of roadside inspection that ensures a high probability of detection of non-compliance. A new generation of digital tachographs is essential to effective monitoring.
- Enforcement. There needs to be a consistent level of enforcement across the Community, with penalties designed to strongly influence behaviour towards compliance. Consideration should be given to measures which would support and encourage small operators with few management resources to develop more effective management of their operation.

- Training. Managing fatigue and alertness should be an essential component of a curriculum for the professional training of drivers and should be incorporated in the new European Directive on driver training.
- Management and operator qualifications. Managing working time in order to ameliorate fatigue should be an essential part of mandatory qualification standards for transport operators.

Hours of work and rest

The framework of hours limitations should explicitly take account of the scientific evidence concerning fatigue and the risk of accident. In particular:

- Daily and weekly rest. Sufficient time for daily rest and recuperation needs to be guaranteed. Where this cannot be taken at physiologically appropriate times of the day or in adequate facilities, adequate time for full recuperation on a weekly (or shorter) basis must be ensured.
- Night-work. Permissible working hours during the hours of circadian low activation should be substantially fewer than those permitted during the day.
- Working and driving time. There should be a co-ordinated approach to regulating driving and working time to ensure that permissible driving times do not inevitably lead to unacceptably high working times.
- Rest-breaks. Adequate time and facilities should be ensured for rest, meal-breaks and naps.

Intensification of research

A co-ordinated programme of research is needed to address some of the gaps in the evidence. In particular it should seek to:

- Quantify more precisely and routinely (e.g. in official road accident statistics) the role of fatigue in road safety.
- Extend our knowledge of the parameters that govern the influence of fatigue, especially those factors which span over several days or longer.
- Identify the social and commercial costs associated with fatigue related accidents.
- Evaluate the effectiveness of regulatory interventions and other counter-measures in reducing fatigue-related accidents.

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