EFTA Surveillance Authority

POTENTIAL ROAD SAFETY IMPACTS OF CERTAIN EXEMPTIONS FROM REGULATION EC 561/2006:

A Qualified Assessment of Medical Aspects of Fatigue and Long-Haul Driving

Final Report

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EXECUTIVE SUMMARY

This report reviews research literature of crash risk and medical aspects of fatigue and long-haul driving in the context of Iceland and Regulation EC 561/2006 (the Act), describes relevant Icelandic conditions, and discusses the potential road safety impacts of Iceland's requests for exemptions from the Act.

Icelandic conditions are in important ways different from conditions in mainland Europe or in North America where most research into long-haul driving takes place. Icelandic long-haul drivers generally finish the trip in one day and reach either home, or a home-like base, at the end of each day's drive. It can therefore be expected that the quality of sleep of drivers in Iceland is as good as possible.

Icelandic road conditions are different from continental Europe, with narrower highways, usually one lane in each direction, and some sections are gravel, compared to the European continental freeway system. We find that Icelandic roads may be less monotonous and that drivers in Iceland may be less affected by drift of attention due to monotony than which can occur in freeway driving.

Icelandic weather conditions, especially in winter, are characterized by frequent wind and rain storms, blizzards, snow, drift snow, ice, and fog. These conditions lead drivers to drive at much slower speeds, primarily in mountain passes. We find that placing a strict time pressure on drivers during such conditions can place undue stress on drivers and can detract from safety. Slower speeds under such conditions lead to reduced severity of any crash that might occur.

The first Icelandic exemption asks for one additional hour of driving time compared with the Act. We do not find it likely that exemption 1, discussed in section 3.1, will lead to a reduction in safety compared to the Act. We note that the exemption makes it more likely that drivers reach home or a home-like base and do not suffer from a reduction in quality of sleep, which might otherwise negatively impact safety. We also note that in winter conditions, the time pressure of the Act may detract from safety and the additional time allowed by exemption 1 mitigates this effect. In winter conditions, we find it likely that the overall effect of exemption 1 will be to improve safety compared to the Act.

Research finds that the long-haul drive crash risk is significantly linked with pre-trip fatigue. Exemption 1 might therefore be qualified to ensure added driver rest by stating that the driver should not take the extended driving time of 11 hours, in two consecutive 24 hour periods.

The research literature finds that when driving without a break, the risk of injury crashes turns sharply towards an increase in the 9th hour of driving. The literature finds that taking a rest break before the 6th hour is associated with a reduction in crash risk, indicating that rest breaks taken before fatigue sets in will improve safety.

Iceland's second exemption, discussed in section 3.2, asks to delay the rest break until after 5 hours of driving on the route Reykjavik - Freysnes. Research investigating the crash rates of long-haul drivers as a function of time before taking a break indicates no statistically significant difference in risk between 4.5 hours of driving time and 5 hours of driving time. Extending the time before a rest break allows drivers additional 30 minutes to reach the rest stop at Freysnes, thereby reducing the chance of drivers having to park on the side of the road with a resulting negative safety impact due to limited shoulder width. We therefore find that the Act with exemption 2 will on the whole likely contribute to improved road safety.

Iceland's third exemption, discussed in section 3.3, allows delaying the rest break to 6 hours in certain overnight passenger transport. The statistical evidence does not suggest crash rates will be statistically significantly different after driving for 6 hours compared to 4.5 hours. A decision needs to be tempered with that passenger transport involves more occupants and any serious crash can result in greater number of casualties. However, the Act itself allows night time driving and irregular shifts, which are the primary risk factors, which exemption 3 does not change. We do not find it likely that the exemption will reduce safety compared with the Act. It can be recommended that exemption 3 be qualified by a request that a driver using exemption 3 should be coming from a rest period no less than the full daily rest of 11 hours, in an effort to minimize the effect of pre-trip fatigue.

Finally, Iceland's fourth exemption, discussed in section 3.4, allows passenger coach drivers to delay the weekly rest period until after 12 days. We do not find direct evidence that suggests exemption 4 leads to changes in crash risk, but it is not impossible that such effect exists and that crash risk would then increase. But without

evidence suggesting an increased crash risk, and with other reasoning as detailed in the report, we arrive at the conclusion that it is not likely that exemption 4 will lead to a change in road traffic safety compared to the Act.

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GLOSSARY

Act, the	Regulation (EC) No 561/2006 of the European Parliament and of the Council of 15 March 2006 on the harmonisation of certain social legislation relating to road transport and amending Council Regulations (EEC) No 3821/85 and (EC) No 2135/98 and repealing Council Regulation (EEC) No 3820/85
ADT	Annual Average Daily Traffic
Application, the	Iceland's application for exemptions to Article 6, Article 7 and Article 8 of the Act, in a letter dated 11 April 2008 received by the Authority on 15 April 2008 (event no. 474396)
Authority, the	EFTA Surveillance Authority
Distraction	Lack of attention to the driving task
Drowsiness	The tendency to fall asleep, synonymous with sleepiness
EU	European Union
FMCSA	U.S. Federal Motor Carrier Safety Administration
IMC	Icelandic Ministry of Communications
Tiredness	Physical tiredness, e.g. due to exertion
ToR	Terms of Reference for this report, event no #476316.

1 INTRODUCTION

1.1 ICELAND'S REQUESTS FOR EXEMPTIONS FROM REGULATION EC 561/2006

1.1.1 Iceland's Proposed Measures for Exemptions to Article 6, Article 7, and Article 8 of the Act

As described in the Terms of Reference (hereinafter 'ToR') for this report (ESA Event No: #476316), Regulation (EC) No 561/2006 of the European Parliament and of the Council of 15 March 2006 on the harmonisation of certain social legislation relating to road transport and amending Council Regulations (EEC) No 3821/85 and (EC) No 2135/98 and repealing Council Regulation (EEC) No 3820/85 (hereinafter 'the Act') shall be incorporated in Iceland.

On the basis of Article 14, paragraph 1 of the Act, Iceland has applied for exemptions to Article 6, Article 7 and Article 8 of the Act, in a letter dated 11 April 2008 (hereinafter 'the Application'), received by the EFTA Surveillance Authority (hereinafter 'the Authority') on 15 April 2008 (event no. 474396). The envisaged measures are as follows:

1. Measures constituting an exemption from Article 6, paragraph 1 of the Act, allowing an extension of the driving time on long-distance routes exceeding 400 km up to 10 hours. Furthermore, that this time may be extended to 11 hours not more than twice a week. The total accumulated driving time during any two consecutive weeks shall not exceed 90 hours.
2. Measures constituting an exemption from Article 7 of the Act, allowing that the maximum driving period permitted before a break is taken to be five hours on the route between Reykjavik and Freysnes.
3. Measures constituting an exemption from Article 7 of the Act, in the case of carriage of passengers by coach between points outside the metropolitan area and the international airport at Keflavik during the night so that the maximum driving time permitted before taking a break in such cases should be six hours instead of four and a half hours as laid down in the Act.
4. Measures constituting an exemption from Article 8, paragraph 6 of the Act, allowing drivers of vehicles used for the carriage of passengers, other than those used on regular passenger transport services, to postpone the weekly rest period until after the completion of twelve 24 hours periods.

1.1.2 Provisions of the Act which may Permit Exemptions

The proposed measures must fulfill the requirements laid down in Article 1 and Article 14, paragraph 1 of the Act. These provisions lay down the following criteria:

- Article 1 of the Act establishes the objectives of the Regulation as laying down the rules on driving times, breaks and rest periods for drivers engaged in the carriage of goods and passengers by road in order to harmonise the conditions of competition between modes of inland transport, especially with regard to the road sector, and to improve working conditions and road safety. Furthermore, to promote improved monitoring and enforcement practices by Member States and improved working practices in the road transport industry.
- Provided that the objectives set out in Article 1 are not prejudiced, Article 14 allows Member States, after authorisation by the Commission, to grant exceptions from the application of Articles 6 to 9 to transport operations carried out in exceptional circumstances.

1.2 OBJECTIVES

As specified in the ToR, the objective of this report is to perform a qualified assessment of whether the Application from Iceland, received by the Authority, intending to represent exemptions from the provisions of the Act, are justified on the grounds for which that Act provides, exceptional circumstances, provided that the objectives laid down in Article 1 are not prejudiced. In particular, the report shall advise whether the measures proposed by Iceland comply with the requirement of improved road safety, as laid down in Article 1 of the Act. Furthermore, the Report shall make a qualitative assessment of medical aspects of fatigue and long-haul driving in the perspective of the Act and the specific conditions in Iceland. The assessment shall lead to specific and well-founded conclusions.

The objectives of the report as specified by the ToR are to

- find for each of the four exemption requests whether they comply with the requirement of **improved road safety**;
- make a qualitative assessment of **medical aspects of fatigue and long-haul driving** in the perspective of:
    - the Act, and
    - the specific conditions in Iceland.

The study methodology, state of the art and scientific background are described in Chapter 2. Based on that background, in Chapter 3 it is considered how each of the requested exemptions may affect road safety in light of the effects of fatigue on long-haul driving. Finally in Chapter 4, conclusions regarding the potential effect of each of the requested exemptions on road safety are summarized.

2 STATE OF THE ART AND SCIENTIFIC BACKGROUND

Long-haul driving and traffic safety are in part linked to three fatigue related phenomena affecting drivers:

- Drowsiness – the tendency to fall asleep, sleepiness
- Tiredness – physical tiredness, e.g. due to exertion
- Distraction – lack of attention to the driving task

Each of these medical aspects can occur independently or in combination, and each can affect traffic safety. The methodology applied in this report to investigate the potential road safety impacts of fatigue in long-haul driving under each of the requested exemptions is to review current knowledge, which has been gathered through research of long-haul driving in the published, peer-reviewed, scientific literature.

To locate literature, the ISI Web of Knowledge v.4.3, Web of Science (Thomson Reuters, 2008) and Scopus (Elsevier, 2008) web-search databases are used. The databases are searched for published, peer-reviewed, scientific journal articles containing the following keywords, grouped into phrases to increase the relevance of found articles: “commercial driver fatigue”, “long haul driving safety”, “truck driver fatigue”, “sleepiness truck”. Note, the engines do not search for these phrases, but simultaneously search for the included keywords in the title, abstract, keywords, or contents of the articles.

This results in hundreds of articles. To increase relevance, the search is limited to articles from 1990 or newer. Titles of articles are reviewed and all articles selected that in fact appeared to contain a road safety study of long-haul driving and fatigue. The abstracts of those articles were reviewed and articles removed that presented only general or vague conclusions, e.g. simply state that fatigue increases risk without giving ways to assess the risk. Articles that contain conclusions and recommendations that allow the assessment of risk effects are kept. Articles based on limited data or data subject to opinion are avoided; the focus is on observational studies of long-haul

driving, fatigue, and crashes. For the articles that are found most relevant, the full paper is retrieved for a detailed review. Also used, is "The Handbook of Road Safety Measures" by Elvik and Vaa (2004), and the cited research papers relevant for Elvik and Vaa's conclusions on long-haul driving, fatigue, and road safety are retrieved. Relevant Icelandic research reports are also searched and retrieved.

This results in 61 journal articles, reports, and book chapters that are reviewed in detail, 54 journal article Abstracts reviewed, and numerous web-documents. Not all of these resulted in new material (since some studies resulted in similar findings) or material relevant for the analysis in this report. The authors remained neutral towards the articles and use and cite articles that sometimes do not agree. The material used in the analysis is cited in the report and given in a list of references.

The Authority requested information from the Icelandic Government regarding the safety record of trips that would have fallen under the Act in 2007 and regarding the volume of traffic that would have fallen under the Act and the various exemptions. The Authority received relevant traffic crash information on common long-haul routes in Iceland from the Road Traffic Directorate (2008b) in time for this report. However, data on the volume of traffic falling under the Act and requiring the exemptions had not yet been received. The report is therefore written assuming nothing about the volume of traffic that would require the exemptions.

Upon this review of the state of the art and scientific background, the driving conditions in Iceland are described based on available material (which is cited) and the authors' first hand observations and experience.

2.1 MEDICAL ASPECTS OF FATIGUE AND LONG-HAUL DRIVING

Long-haul driving can contribute in several ways to fatigue, which exhibits symptoms in driver drowsiness (i.e. sleepiness), tiredness, and distraction. Most notably the following items:

- the timing of the trip occurs when the driver would normally be asleep;
- lack of sleep and/or extended period of wakefulness before coming on duty for a long-haul drive;
- the large number of hours spent driving on a long-haul trip;

- a multi-day driving schedule reduces the driver's opportunity to achieve the necessary sleep in a 24 hour period;
- the driving schedule and/or conditions while away from home, or a home-like base, significantly reduce the quality of the driver's sleep;
- physical exertion in loading and offloading contributes to tiredness but is more an issue for short haul driving;
- long-haul driving is physically demanding, long hours behind the wheel can lead to physical tiredness; and
- long-haul driving may lead to driver distraction which means lesser attention to the driving task.

In the review of the scientific literature the aim is primarily to summarize the known effects of:

- driving schedule on fatigue in long-haul drivers and long-haul crash rates,
- road and environmental conditions on fatigue in long-haul drivers, and
- fatigue on crash risk and crash severity.

To give context to the discussion, studies of the required amount of sleep by the average person are consulted. A study by Van Dongen et al. (2003) demonstrated that cognitive performance declines with fewer than 8 hours of sleep. However, Kripke et al. (2002) in a study of more than one million adults found that people who live the longest self-report sleeping 7 hours each night. The National Sleep Foundation (2007) in the United States (US) recommends 7 to 9 hours of sleep for adult humans. The evidence suggests sleep deprivation if a person receives less than 7 hours of sleep (e.g. National Sleep Foundation, 2007). Compare this to truck driver perceptions. In a survey of 4,833 truck drivers in the US and Canada it was found that 25% of the respondents believe that 5 to 6 hours of sleep per night is enough to maintain alertness (Van Hemel and Rogers, 1998).

Research into crash occurrence for all drivers as a function of sleep has found that for every hour short of 7 hours of sleep there is a significant increase in the odds of a sleep related crash compared to a non-sleep related crash. People with on average 5 hours of sleep are found to be five-fold more likely to have a crash be sleep related than non-sleep related, if they experience a crash (Stutts et al., 2003).

Hakkanen and Summala (2000) found that 13% of the long-haul drivers studied were violating then current EEC regulation. They noted that about 40% of the drivers reported alertness problems on at least 20% of their trips. Over 20% of the drivers reported dozing off at least twice while driving, and near crash misses due to this had occurred with 17% of these drivers. Taken together, this means a share of drivers who were obeying then current EEC regulation were suffering from fatigue while driving.

Hakkanen and Summala's (2000) conclusions suggest that sleepiness problems are shared by many drivers, not just a small minority. Compare this with an older study from the US. Braver et al. (1992) found that about two-thirds of the drivers studied, violated hours of work rules. The primary reasons for violating the rules were reported as economic, mainly tight delivery schedule and low payment rates. Braver et al. (1992) cite the necessity for electronic monitoring of driving hours and an increasing number of rest areas to enable drivers to take their breaks.

2.1.1 Effects of driving schedule on fatigue in long-haul drivers and long-haul crash rates

An important and widely referenced study of day and night driving schedules, both regular and shifting each day, was performed in the US and Canada by Mitler et al. (1997). The results indicated that the 80 long-haul drivers in the study received less sleep than thought necessary to maintain alertness. The drivers with steady 10 hour day schedules received the most sleep, on average 5.38 hours, while the drivers with steady 13 hour night schedules received the least sleep, on average 3.83 hours. No crashes occurred during the study but the study revealed that 56% of the drivers had at least one six-minute episode of drowsiness while driving, of those drivers, only 8 drivers had half of the recorded drowsy episodes, and two drivers had one episode of stage 1 sleep while driving.

Irregular sleep schedules between work periods have been found to generate long episodes of staying awake. This can have an important effect on driver performance. Large shifts in sleep schedule, with associated long episodes of staying awake, are found at the onset of a new workweek (Philip et al., 2002). Lack of sleep due to only 5 hours of sleep and a long episode of wakefulness during the day followed by night driving (17 hours in total of wakefulness) has been studied in a simulator setting by Ranney et al. (1999). The study revealed significant driving impairment, with crash frequencies increasing over the night. Taking an afternoon nap improved performance.

A multi-national research project of companies operating across 17 countries has found that fatigue in commercial drivers is linked to time of day, rotation of shifts, and the system of break taking and route scheduling (Adams-Guppy and Guppy, 2003). A study from New Zealand found that about 24% of the sample of 606 drivers failed a psychomotor performance test, indicating fatigue, and that amount of rest and sleep, the length of shifts, and the number of driving days per week were important factors (Charlton and Baas, 2001).

A comprehensive study by Barr et al. (2005) using video data of drivers at work revealed that in 900 hours of driving data 2,745 drowsy events were observed. The data revealed that about 30% of the observed drowsy events occurred within the first hour of the work shift. In a study of sleep related crashes in general (all drivers for all purposes), it has been found that the greatest risk of a sleep-related crash occurs during the second hour of the drive although it should be noted that in this data for the general public, trip lengths are rarely longer than 5 hours (Stutts et al., 2003) thereby missing the effect of long-haul drives that extend for 9 hours or more. However, other research, discussed below focuses on longer drives.

Time of day has been linked to drowsiness, especially the early morning hours (Barr et al., 2005). This fits previous studies, notably Mitler et al. (1997) who showed that the greatest vulnerability to sleep is in the late night and early morning. Also, Lin et al. (1993) found that driving at night leads to a greater crash risk compared to driving during the day.

Another study developed a model to predict whether the driver falls asleep at the wheel. The results found that the factors that made it significantly more likely that drivers fell asleep at the wheel were increasing time spent driving, and violations of driving time and rest period regulation (Monaco et al., 2005).

Lin et al. (1993) found that increasing hours of driving lead to increasing crash risk. In their study, based on US data, the crash risk starts to increase after the 4^{th} hour of driving without a break. Elvik and Vaa (2004) review several studies (including Lin et al., 1993) and develop a picture of crash risk as a function of driving time without a break. Elvik and Vaa (2004) show that the risk of injury crashes fluctuates randomly for the first 8 hours but then turns sharply towards increasing risk in the 9^{th} and 10^{th} hours of driving without a break. The analysis does not look beyond 10 hours.

This result can be placed in a general context. A large number of research studies on long work periods were reviewed by Knauth (2007) and a majority of those studies show that in general, the number of mistakes and incidents goes up when a work shift is extended beyond 8 hours, e.g. to 9–12 hours, although some evidence goes to the contrary. The advice from Knauth (2007) is to err on the side of caution when considering extended work shifts where the work affects public safety.

Lin et al. (1994) explored rest breaks, crash risk, and long-haul driving. They found that in long-haul driving, rest breaks that were taken before the 6th or 7th hour of driving were linked with significantly lowering crash risk. This fits Elvik and Vaa's (2004) analysis which indicates that the primary jump in crash risk occurs when driving into the 10th hour without a break.

Pokorny et al. (1987) explored the length of rest breaks for bus drivers and Elvik and Vaa (2004) use their research to develop measures of crash risk as a function of rest break length. The conclusions indicate that the length of the rest break has a small, and not significant, effect on crash rate but longer breaks tend to reduce the crash rate if only a little.

In January 2004, new US hours of service rules went into effect and they require 10 hours off-duty each day, compared to 8 hours previously, in an effort intended to increase the sleep time of long-haul drivers. Hanowski et al. (2007) measured the hours of sleep for drivers after this rule took effect and found that the sample of drivers was receiving 6.28 hours of sleep. This showed that the US regulation of requiring 10 hours off-duty, 2 more hours than previously required, lead to a significant increase in drivers' verifiable sleep (compared with the 5.38 hours of sleep in the study by Mitler et al., 1997).

The US regulation allows drivers 11 hours of driving during a 14 hour on-duty period, after a 10 hour off-duty period. Hanowski et al. (2007) report the results of comparing the number of incidents during the 10th hour and the 11th hour to find if there are differences. They report no statistically significant differences in the number of incidents in these two hours. Their primary conclusions are that the observed incidents were statistically linked with lack of sleep before the driver went on duty.

The study by Hanowski et al. (2007) collected data for 16 weeks and is in that regard comprehensive. During this time they recorded critical incident information and linked with sleep information. Hanowski et al. (2007) revealed the drivers that experienced a critical incident had on average less sleep the night before, showing a statistical link between incidents and sleep, and indicating the importance of receiving enough sleep before coming on duty. Other research supports this. Williamson et al. (1996) found that the pattern of fatigue experienced by drivers during trips appeared to be related to pre-trip fatigue levels. A study of the general public, e.g. not only trucks or long-haul drivers, also found that the risk of a sleep crash vs. a non-sleep related crash rises dramatically as the hours of wakefulness go past 15 hours, and especially 20 hours (Stutts et al., 2003).

2.1.2 Quality of sleep during rest periods and sleep disorders

It is not just the quantity of sleep but also the quality of sleep that is important. Medical aspects and driver behavior play a role. Some research indicates that drivers potentially bring much of the fatigue with them when they arrive on the job. From this it can be concluded that drivers' use of their off-duty time affects their fatigue, i.e. do the drivers use their off time to receive the necessary rest (Hanowski et al., 2003). Other research supports this and shows that it is not by itself enough to ensure drivers receive time to sleep, but they need to use that time for rest and sleep (Oron-Gilad and Shinar, 2000).

People that experienced a sleep related crash (in general, not only truck crashes) were more likely to report that their sleep quality was fair or poor, than people in non-sleep related crashes (Stutts et al., 2003). Sleep quality itself is therefore a confounding factor when considering fatigue and driving. It might be hypothesized that the quality of sleep on the road is perhaps worse than sleep at home or at a home-like base.

Medical aspects are important since sleep disorders can reduce the quality of sleep for some drivers despite them having appropriate time to rest. Bus drivers are not long-haul drivers but they do drive for long hours. An analysis of 1,016 commercial bus drivers in Hong Kong revealed that 24% indicated having fallen asleep during driving at some point. A selection of those drivers took part in a detailed medical analysis of the quality of their sleep. The final conclusions indicated that about 8.4% of the drivers suffered from sleep-disordered breathing and 5.4% were diagnosed with sleep apnea (Hui et al., 2006). Sleep apnea was indicated in 4% of the drivers studied by Hakkanen and Summala (2000). This indicates significant prevalence of sleep disorders among commercial drivers.

Research finds that commercial long-haul truck drivers tend to have irregular sleep/wake schedules which may contribute to aggravate sleep disorders (Stoohs et al., 1995). The study found that sleep disordered breathing prevalence was high in the study group. It is suggested that this can impact truck drivers' daytime alertness (Stoohs et al., 1995).

2.1.3 Effects of road and environmental conditions on fatigue in long-haul drivers

International research on road and environmental conditions and how they relate to fatigue in long-haul drivers do not always translate directly to Icelandic conditions, due to the different driving environment in Iceland. However, some generalizations are appropriate in the Icelandic context. In a simulator study, drivers have been found to use straight roads to increase speeds and/or reduce strict lane position (Oron-Gilad and Ronen, 2007). Drivers have been found more likely to keep a stricter lane position on winding roads but still, they had a tendency to increase their speed over time (Oron-Gilad and Ronen, 2007). The Icelandic roadway system is by design rarely straight for long but rather slightly curved to enhance distance perception for oncoming vehicles and objects. In many rural locations, Icelandic roads are curvy and follow nature more closely than e.g. US or European freeways.

Monotony of the driving environment can also have an effect. Lisper et al. (1971) noted the importance of monotony of driving as an important factor in combination with sleepiness. More recent research, using driving simulators, indicates the importance of monotony as a risk factor. In a monotonous driving environment, drivers exhibited greater fatigue and less vigilance (Thiffault and Bergeron, 2003). Although a matter of opinion, it can be clamed that the Icelandic roadway system is less monotonous than the continental freeway systems, due to frequent horizontal and vertical curves, intersections, and oncoming traffic, since the rural Icelandic highway system is by and large not divided (i.e. directions are usually not separated by a median) and has mostly one lane in each direction.

2.1.4 Effects of fatigue on crash risk and crash severity

In a study by Arnold et al. (1997) of New Zealand truck drivers, they found that about 12% of the drivers reported less than 4 hours of sleep on one or more working days in the week preceding the study interview. Given what is known about required sleep,

these drivers are likely to have been significantly sleep deprived wile driving. Furthermore, the study revealed that about 20% of the drivers reported less than 6 hours of sleep before starting their current journey. When studying incidents, the results showed that nearly 40% of dangerous events on the trip were reported by the drivers with less than 6 hours of sleep.

Dingus et al. (2006) performed a study where instrumented vehicles recorded incidents and driver alertness during 400,000 km of driving by both driving teams and single drivers. They found fewer incidents with the driving teams than the single drivers. The team drivers received significantly more sleep than the single drivers, and had significantly fewer incidents.

The results of Dingus et al. (2006) indicated that a small minority of drivers had most of the observed incidents. Similar results were also found by Hanowski et al. (2003). This indicates that driver training and driver selection can be of significant importance in affecting commercial driver safety.

Research has found that in fatal two-vehicle crashes that involved a commercial truck, the truck driver was more likely to be found at fault when driving at night (Hakkanen and Summala, 2001). Hertz, (1988), noted that tractor-trailer driver fatality was found to be significantly associated with sleeper-berth use in two shifts, suggesting that splitting the sleeping period into two periods resulted in a reduction in safety. This lends support to a single daily rest period, long enough for the driver to receive the required hours of sleep.

As discussed, fatigue (sleepiness, distraction) is important when considering crash risk. It should not be omitted that fatigue is also important for crash severity. When a crash occurs, it has been found that sleepiness and distraction significantly increase the probability of the driver suffering a fatal injury, e.g. Bunn et al., (2005), who explored commercial vehicle crashes in Kentucky.

2.1.5 Managing fatigue in long-haul driving

Some research has investigated how drivers manage fatigue in long-haul driving. The most notable results for the purposes of this report are studies by Feyer and Williamson (1993, 1995) and Williamson et al. (1992) who found important systematic differences between how truck drivers and passenger coach drivers managed fatigue. The results

indicated that the factors that contribute to fatigue and the occurrence of fatigue are similar between the passenger and goods transport sectors. However, truck drivers frequently (more than 75%) reported using sleep and rest as methods to manage fatigue, while more than 75% of the bus drivers in the study used temporary measures such as music and drinking caffeinated drinks. Only about a third of the studied bus drivers used sleep or rest. However, we identified no relevant research on fatigue management and crash risk.

2.2 DRIVING CONDITIONS IN ICELAND

2.2.1 Conditions of competition between modes of inland transport in Iceland

The Act specifies that in part it is meant to harmonise conditions of competition between modes of inland transport. It is therefore important to note, that in the Icelandic context road transport is the only inland mode of transport. There are no railway lines or barge waterways. There is ocean transport but such transport appears excluded by the Act. Competition between inland modes of transport is therefore not an aspect of the Icelandic context for the Act.

2.2.2 The Safety Record of Heavy Transport Vehicles in Iceland

Limited studies have been performed on the safety record of heavy transport vehicles in Iceland. One research report found that in the 5 years 1999–2003 the average number of heavy transport vehicles (in the report defined as having an allowed total weight exceeding 12,000 kg, the Act covers vehicles down to 3,5 tonnes or 9 or more occupants) in a crash per year was 104 per a thousand heavy vehicles in traffic. This represented a total of 2,013 heavy vehicles in all police reported crashes, noting that by far, most of these crashes were minor, non-injury crashes (Thordarson and Ulfarsson, 2005). Data for the 10 year period, 1994–2003 show that 7 heavy vehicle drivers were fatally injured in single- or multi-vehicle crashes. The data also show that 10 passenger car drivers (data for passengers is not available but a majority of cars have only a single occupant) were fatally injured in crashes with a heavy vehicle (Thordarson and Ulfarsson, 2005). There are therefore about 2 fatalities per year that are associated with heavy vehicle crashes in Iceland, and about 6 major injuries per year.

Thordarson and Ulfarsson (2005) tabulate the most common types of police reported crashes that occur for heavy vehicles. By far the most common crash type is when the vehicle crashes into a fixed object or object that has fallen onto the road (e.g. cargo), a total of 735 crashes in 10 years. These crashes led to only 6 injuries and are therefore

minor. The second most common crash, the most linked to fatalities, is a two-vehicle head-on crash, 170 crashes in 10 years, where 8 crashes lead to fatalities. The crash types that are linked to the most injuries are driving off the road, 20 injuries in 10 years, and vehicle rollovers, 19 injuries or fatalities in 10 years. The most common crash involving passenger coaches, and the crash type with the most fatalities, is a two-vehicle head-on crash, 47 in 10 years, with 4 fatalities. The passenger coach crash type with the most injured people is driving off road, 116 injured parties in 16 crashes in 10 years.

In studying the causes (as determined by police) of heavy vehicle crashes in Iceland during 1994–2003, Thordarson and Ulfarsson (2006) tabulate causes for the three most common crash types, and find the most frequently listed causes. For object (fixed or fallen onto road) crashes, the truck driver is determined to be at fault, fatigue is not marked, in 87 (12%) of the crashes. It is possible that fatigue is underreported, since other causes may be more immediately noted in the police investigation. The number of times that the driver is simply named as the cause is therefore noted as well. Although that is an imperfect measure of fatigue related crashes, due to a variety of other human factors, this should give an indication or upper limit. Inattention is noted in 16 (2.2%) of the crashes. Fatigue by itself is not noted as one of the top causes (8 causes are reported), which represent 83% of object crashes. For two-vehicle head-on crashes, the truck driver is said to be at fault in 14 (8.2%) of the crashes, fatigue does not appear as one of the top causes (5 causes are reported). For vehicle rollovers, the majority of the crashes are caused by the vehicle's load, e.g. not secured properly etc. The driver is determined to be at fault in 8 (5.3%) of the crashes, fatigue is not noted as one of the top causes (7 causes are reported).

Thordarson and Ulfarsson (2006) specifically examine single-vehicle crashes where a heavy truck is driven off the road. In these crashes the driver is named as the cause in 36 (17%) of the crashes, and driver fell asleep is mentioned in 3 (1.4%) of the crashes. It should be noted that the condition of driver fell asleep is as determined by an investigating police officer.

This research shows that other factors, not fatigue, falling asleep, nor inattention, are the primary causes for heavy vehicle crashes in Iceland 1994–2003 as determined by police. In about 5%–17% of crashes by crash type, the driver is named as the cause but fatigue, sleeping, or inattention are rarely mentioned specifically (Thordarson and Ulfarsson, 2006).

The Authority requested and received data on truck and passenger coach crashes in 2007, prepared by the Road Traffic Directorate (2008b) in Iceland. The data tabulate crashes on the most common long-haul routes in Iceland. In 2007, there were 1,485 crashes involving heavy goods or passenger coach vehicles that are subject to the Act on these routes. Of those crashes, there were 294 that involved any type of injury (Road Traffic Directorate, 2008b). Only 1 of the crashes was attributed to driver drowsiness. A similar reservation must be made here, as was done in discussing the results of the reports by Thordarson and Ulfarsson (2005, 2006), that it is unclear how consistently the police investigation seeks out whether drowsiness was a contributing factor or a cause for the crash.

The conclusion is that drowsiness (sleepiness or fatigue) are rarely noted in police records as a cause or a contributing factor to a heavy vehicle crash in Iceland. This could indicate that the driving time regulations in effect in Iceland at the time were functioning.

2.2.3 Road conditions

Contrary to Europe and the US, where long-haul driving can take place on multi-lane, directionally divided freeways with high design speed, in Iceland long-haul driving takes primarily place on two-lane highways (one lane in each direction) with total roadway width (including shoulders) of only 7.5 m (class C1 road, see Table 2 for definitions of highway classifications), and for about 9 months (especially in the 7 months of October–April) out of the year, weather conditions can frequently be treacherous.

The Icelandic road system on some of the longest long-haul routes, and specifically important in relation to the requested exemptions, are trips between the City of Reykjavik and the Town of Egilsstadir (696 km) and Reykjavik and the Town of Neskaupstadur (715 km), (Icelandic Road Administration, 2008). These routes lie together for the most part and the roads are classified mostly as C1 (see Table 1),

In the eastern portion of the route, especially at about 100 km away from Egilsstadir, there are still long sections of gravel roads (52 km), about 7.5% of the total route length. On the route to Neskaupsstadur, about 3% (15 km) of the total route length is a gravel road in the eastern fjords. Most of these gravel sections fall under the C2 classification, 39 km, and about 28 km fall under C1. Significantly lower speeds are necessary in these

areas due to the gravel surface. Furthermore, some of the eastern road segments are based on old roadway geometry and do not support the design speeds, criteria, and volume of modern roadways.

In a survey of long-haul operators in Iceland, the operators stated that the primary reasons for crashes at their firms were narrow roads, narrow shoulders, weak shoulders that can collapse, weather, inconsiderate drivers, and lastly fatigue (Thordarson and Ulfarsson, 2006). It is the perception or opinion of long-haul operators that the road system itself is the greatest detractor to traffic safety for long-haul driving in Iceland.

Table 1: Classification of Iceland's Ringroad, road number 1, from Reykjavik, Vesturlandsvegur to Egilsstadir

A1	0	0,0%
A2	0	0,0%
A3	7,09	1,0%
B1	43,32	6,3%
B2	13,69	2,0%
B3	59,15	8,6%
C1	526,05	76,5%
C2	38,68	5,6%
Total	687,98	100,0%

Data Source: Icelandic Road Administration (2008a)

Table 2: Highway classifications in Iceland.

A1	Divided highway with at least 2 lanes in each direction, with shoulders and or curb. Width >= 34 m w/o curb. ADT > 25.000 (rural)
A2	Divided highway with at least 2 lanes in each direction, with shoulders and or curb. Width = 27 m w/o curb. ADT > 5.000 (rural).
A3	Divided highway with at least 2 lanes in each direction, with shoulders and or curb. Width = 22 m w/o curb. ADT > 6.000 (rural).
B1	Two lane (one in each direction) highway, with shoulders and or curb. Width = 13,5 m w/o curb. ADT > 4.000 (rural).
B2	Two lane (one in each direction) highway, with shoulders and or curb. Width = 10 m w/o curb. ADT > 1.500 (rural).
B3	Two lane (one in each direction) highway, with shoulders and or curb. Width = 8,5 m w/o curb. ADT > 600 (rural).
C1	Two lane (one in each direction) highway. Width = 7,5 m w/o curb. ADT > 100 (rural).
C2	Two lane (one in each direction) highway. Width = 6,5 m with shoulders.

Data Source: Icelandic Road Administration (2008b)

Some sections of the route from Reykjavik to the eastern fjords are at higher elevation above sea level, 100 m or more, which in Iceland leads to a significant increase in inclement weather and related degradation in road condition due to snow, drifting snow, ice, and fog. These sections are about 30 km or 4% of the total length, but in bad weather can consume a significant amount of the total driving time.

2.2.4 Environmental conditions

Winter driving presents special considerations. Snow on the ground and a cloudy or foggy sky can appear to merge into one visible area of white. This lack of contrast between sky and ground is negated at night, when the sky is dark and the ground remains white in the vehicle headlights. Night driving, during such whiteout conditions, can therefore be preferable due to visibility concerns. This tempers research results indicating greater crash risk in general when driving at night due to increased levels of fatigue at night.

In general it is preferable to drive on asphalt roads compared to gravel roads. However, in certain conditions in winter driving, the loose gravel can be a benefit to traction. Gravel can then reduce the skidding effect of snow or thin ice, since gravel rocks jab through and provide traction.

Long-haul driving takes place all year round in Iceland. Long-haul drivers in Iceland must regularly drive in snow, during blizzards, whiteout due to drift snow in windy conditions, and on icy roads. Such weather conditions force a much lower speed, e.g. 20–40 km/h. Driving in bad conditions has been found to increase stress levels and the heart rate of drivers (Moe, 2003). The placement of time pressure on drivers that get caught in a blizzard or other winter weather and road conditions can be detrimental to safety. Thordarson and Ulfarsson (2005) found that heavy vehicles (used for long-haul driving) have the lowest crash rate in winter conditions of all trucks and coaches, indicating that long-haul drivers are responding to conditions by driving slower and more carefully, which means increased driving time in winter.

Driving in icy conditions extends the driving time due to lower speeds. In certain icy road conditions it is important that drivers install chains on the vehicle tires before ascending a mountain pass. The chains must be removed once the drivers have descended from the pass. Since installing/removing chains counts as driving time, this can lengthen the driving time for about 30 minutes on each side of the pass. Such a delay can contribute to time pressure on the driver in order to complete the trip within the allowed total driving time. Such a time pressure may lead drivers to take a chance and skip the sometimes crucial step of installing chains. There is no doubt about the increasing crash risk associated with driving in icy conditions without appropriate chains.

Since the route between Reykjavik and the eastern towns, via Freysnes, is of particular importance for the requested exemptions, since exemptions 1 and 2 relate to this route. On this route meteorological data suggest that it is mainly in winter when inclement weather affects traffic (Sveinbjornsson, 2008). The main weather conditions are limited visibility due to snowfall, high wind and high wind gusts, along with snow accumulation on the road. There are mainly six locations that are significant trouble spots. Four of these are on the route between Reykjavik and Freysnes, which has a rest stop, and two are within 30 minutes east of Freysnes (Sveinbjornsson, 2008).

Fully loaded trucks (about 40 metric tons) can withstand wind speeds approaching 40 m/s (hurricane level wind) if road conditions are excellent. Wind gusts south of Vatnajökull glacier on the route are often measured above that wind speed, with a maximum measured wind speed of 53 m/s. The frequency of this windy weather is not high, about 1.5–2%, equivalent to about six to seven 24-hour periods over the winter months (Sveinbjornsson, 2008).

2.2.5 Trip characteristics

Current Icelandic long-haul terminal stations are for the most part within 715 km of each other. Under good weather, road, and traffic conditions, a 9 hour driving time can be enough to traverse that distance in one day of driving. However, this assumes an average speed of 80 km/h, which is not realistic for long-haul trucks in Iceland. This is because 80 km/h is the maximum speed allowed by Icelandic law (no. 50/1987) for heavy vehicles. Also, mountain sections can significantly reduce the speed of heavy vehicles due to long up-/downgrades. With slippery road conditions, downgrades must be travelled especially slowly. Reaching an 80 km/h average speed is therefore impossible without at some point driving faster than allowed. This speed can therefore not be assumed. The Act allows a 10th hour of driving, twice per week, which would yield a margin for the driver to still reach the terminal station in one day of driving, if maintaining just over 71 km/hour average speed. However, inclement weather can reduce average driving speeds, even below these levels.

When considering a common long-haul route, between Reykjavik and Egilsstadir, via Freysnes, it is about 700 km (note the route could be longer depending on exact starting/ending point of the trip within Reykjavik, and if the driver must detour due to a winter closure). Under excellent road and weather conditions the route cannot realistically be completed within the Act's total daily driving time of 9 hours due to the 80 km/h speed limit (see Table 3). As Table 3 shows, given a realistic reduction in average speed down to 70 km/h, the driver cannot reach the rest stop at Freysnes when driving from Reykjavik within the Act's time of 4h 30m when a rest break must be taken. An average speed of 67 km/h is the lowest speed necessary to traverse the distance between Reykjavik and Freysnes given a 5 hour driving time before taking a rest break at Freysnes. However, at the average speed of 67 km/h, the total driving time exceeds the maximum allowed, at 10h 27m. The minimum average speed necessary to traverse the route under 11 hours is 64 km/h.

Table 3: Driving time scenarios given different average speed

		Driving time given average speed			
	Distance (km)	80 km/h	70 km/h	67 km/h	64 km/h
Reykjavik – Freysnes	332	4h 9m	4h 44m	4h 58m	5h 11m
Freysnes – Egilsstadir	368	4h 36m	5h 16m	5h 24m	5h 45m
Total	700	8h 45m	10h 0m	10h 27m	10h 56m

Note: These figures represent driving time, which does not include time on rest breaks or rest periods. The actual trip time, which includes rest breaks and rest periods, would be longer.

In general, long-haul trips begin at around 17:00 when leaving the capital area, but begin at around 15:00–17:00 when leaving rural areas on a trip to the capital, based on schedules from the two largest transport companies (Flytjandi, 2008; Landflutningar, 2008). This indicates that long-haul driving in Iceland is generally on regular shifts, thereby avoiding increases in crash risk associated with irregular shifts.

2.2.6 Day trips vs. multi-day trips

It is an important special concern that Icelandic long-haul trips are on the border of being completed in one day given the Act, with drivers driving between home and a terminal station at which the driver has a home-like base in which to sleep. In continental Europe, the US, or Canada, a long-haul drive can carry on for several days for one trip, with the driver having to sleep in the truck or find lodging along the way. Research into long-haul driving often occurs in these areas and under the conditions of a multi-day trip.

This is mentioned due to its potential effect on road safety. If an Icelandic driver fails to reach the destination due to reaching the driving time limit and must sleep on the road, possibly in the vehicle, this can lead to a reduction in the quality of the driver's sleep compared with sleeping in their own bed or in familiar surroundings. A reduced quality of sleep can possibly lead to increased fatigue on the following day, and thereby to increased crash risk and reduced safety.

2.3 INTERPRETATION OF RESEARCH BASED ON STATISTICAL ANALYSIS

Motor-vehicle crashes are, to a large degree, random events. Crash occurrence cannot be predicted with perfect accuracy. Data on crashes and driver behavior are generally samples from a population, not the entire population. This requires the use of statistical analysis, whereby the population importance of observed factors on crash occurrence is estimated based on the observed sample. Any such estimates include a standard error, which means each estimate is not truly a single value but is better represented by a confidence interval.

An important question for such estimates is whether the estimated result is statistically significantly different from a given value or not. For example, take 0 as the given value,

with 0 meaning the estimated result has no impact on crash probability. To investigate this question using statistics an assumption must be made of the statistical distribution to be used, generally the normal distribution which leads to a statistical *t*-test or an *F*-test. Given this, researchers can say if the estimated result is statistically significantly different from 0 at a particular confidence level.

The typical confidence level used in research is the 0.05 level. In this report, the phrase, 'not statistically significantly different', indicates that statistical evidence was not available to reject the hypothesis that two values are the same at the 0.05 confidence level. This does not mean the values are in fact the same, but merely that the statistical analysis cannot tell the two values apart. This means one value could be lower than the other value but the statistical analysis cannot firmly answer which is lower and which is higher.

In this report, the phrase, 'not statistically significantly lower', indicates that statistical evidence was not available to reject the hypothesis that the two values are the same at the 0.05 confidence level. This does not mean the values are in fact the same but merely that the statistical analysis cannot tell the two values apart.

These two phrases, 'not statistically significantly different' and 'not statistically significantly lower' both mean that statistical evidence could not tell the two values apart, i.e. their difference was not measurable based on the data. The use of the word 'lower' indicates that it is the opinion of the authors that one value will likely fall lower than the other, even though there is presently no statistical evidence to tell the two apart. The latter phrase is used with other words than 'lower', e.g. 'higher', 'increase', 'decrease', which can be interpreted in a similar fashion.

In Icelandic, the number of fatal crashes is about 20 in a year, and serious crashes are about 160 in a year, in the entire volume of all road traffic (Road Traffic Directorate, 2008). These are small numbers in statistical analysis. Small numbers lead to a large variance, which means a large confidence interval on estimates. In the Icelandic context, it is especially difficult to use statistics to measure differences between two conditions, such as the environment with the Act alone, and the environment with the Act and certain exemptions.

A further complication is that the discussed prior research is based on statistical analysis of data collected in primarily mainland European nations, the US, Canada, Australia, and New Zealand. As explained above, road conditions in Iceland are different. The available research can not be assumed to be absolutely transferable to Icelandic conditions, leading to a need for expert judgment.

3 ANALYSIS OF THE REQUESTED EXEMPTIONS

3.1 EXEMPTION 1: INCREASED DRIVING TIME ON LONG ROUTES

Extension of the driving time on long-distance routes exceeding 400 km up to 10 hours. Furthermore, that this time may be extended to 11 hours not more than twice a week. The total accumulated driving time during any two consecutive weeks shall not exceed 90 hours.

An important concern in Iceland is the effect of inclement weather and related bad road conditions which can lead to driving difficulty and can extend the normal driving time considerably. This can lead to drivers having to sleep over, in the truck. Sleeping in rough conditions or unfamiliar environment can lead to a reduction in the quality of the driver's sleep compared with sleeping in their own bed or in familiar surroundings at a home-like base. A reduced quality of sleep can possibly lead to increased fatigue on the following day, and thereby to increased crash risk and reduced safety. In this regard, the Act may contribute to reduced safety which the exemption mitigates by allowing added driving time flexibility for drivers in Iceland. Such flexibility helps ensure that drivers can complete regular routes in good and most poor environmental conditions.

Article 12 of the Act allows drivers to extend the driving time to reach a suitable stopping place, which means that drivers should not have to stop in a remote location without services or at a unsuitable location due to dangerous weather or road conditions, but could drive to the nearest suitable stopping location. The nearest suitable stopping location however, is not a home base. Article 12 would therefore not be helpful in many cases, on the grounds of sleep quality at home or a home-like base.

The previous regulation on driving time in Iceland (No 136/1995), valid until 2006 when Europe passed the Act, allowed a 10 hour driving time per day, which could be extended to 12 hours twice a week, with 100 total driving hours in two consecutive weeks. A comparison with the old regulation is relevant because under that previous

regulation, crashes of heavy vehicles were rarely contributed to driver drowsiness (sleepiness or fatigue) as discussed in section 2.2.2. Since the Act with the exemption mandates shorter driving time and longer breaks and rest periods than before, it is likely that crash rates due to fatigue will either not change or that they will decrease and safety will be improved.

When considering the effect of driving past 9 hours, Elvik and Vaa's (2004) analysis may be considered. It indicates a 3 times increase in injury crash rate in the 10^{th} hour of driving without a break. The analysis does not extend beyond 10 hours and therefore does not give information about risk in the 11^{th} hour of driving without a break. However, it is a serious limitation that the research presented by Elvik and Vaa (2004) considers driving without a break but the Act and this exemption require rest breaks. Because of this limitation, it is questionable if the Elvik and Vaa (2004) analysis can truly be representative of driving 9 to 11 hours with the Act required rest breaks. It is expected that the rest breaks will lead to a decrease in crash risk compared with the results described by Elvik and Vaa (2004).

Research exploring the specific difference between incident risk after driving 10 hours and after driving 11 hours, under driving time rules in the US did not find a statistically significant difference between those conditions (Hanowski et al., 2007), which means the difference could not be measured in that study. The Hanowski et al. (2007) study is relevant because it explores long-haul driving under hours of service rules and represents extensive data. It is not unlikely that rest breaks taken during the drive result in a lack of difference between the 10^{th} and 11^{th} hours of driving. There is therefore no research evidence basis to claim it is safer or less safe to drive 10 hours or 11 hours. The Act with the exemption requires a 45 minute rest break no later than after 4.5 hours (or 5 hours given a simultaneous use of Exemption 2), and another rest break after another 4.5 hours of driving. These rest breaks should work to reduce the elevated crash risk indicated by Elvik and Vaa (2004) at the tail end of a long drive.

Based on this analysis, we do not find it likely that the exemption will lead to reduced safety compared to the Act. As discussed, the shorter driving times mandated by the Act increase the chance that drivers may have to sleep while on the road, which can negatively affect the quality of sleep. A reduced quality of sleep can possibly lead to increased fatigue, and thereby to increased crash risk and reduced safety, which the exemption mitigates.

It is also noted that in winter conditions, the time pressure of the Act may detract from safety, since time pressure may lead drivers to attempt to maintain higher speed than is safe for winter conditions, and/or may lead drivers to forego installing chains. The additional time allowed by the exemption mitigates this effect. Slower speeds under such conditions lead to reduced severity of any crash that might occur. In winter conditions, we find it likely that the overall effect of this exemption will be to improve safety compared to the Act.

As discussed, research finds that the long-haul drive crash risk is significantly linked with pre-trip fatigue. The maximum driving time under the exemption is 11 hours twice a week and this leaves time for the required daily rest period of 11 hours. The exemption might therefore be qualified to ensure added driver rest by stating that the driver should not take the extended driving time of 11 hours, in two consecutive 24 hour periods.

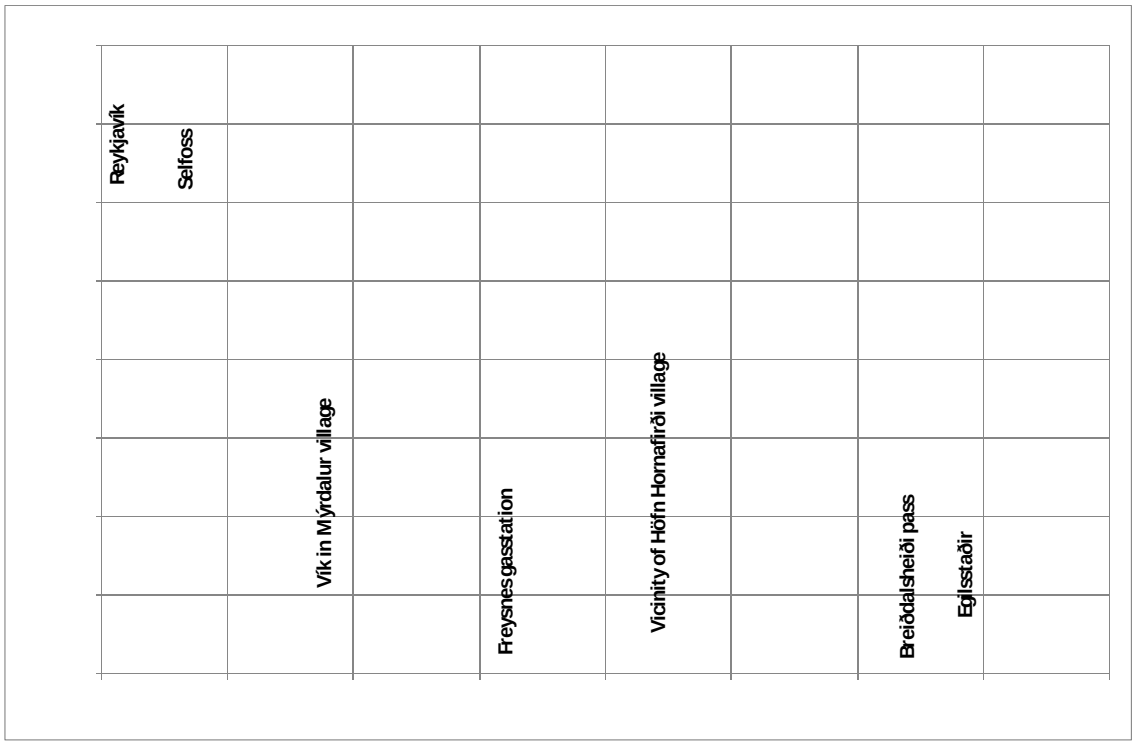
3.2 EXEMPTION 2: INCREASED TIME BEFORE A REST BREAK ON A PARTICULAR ROUTE

Maximum driving period permitted before a break is taken to be five hours on the route between Reykjavik and Freysnes.

The route between Reykjavik and Freysnes is special, primarily since there is a long gap without a rest stop or facilities on either side of Freysnes. The exemption clearly requests only the route between Reykjavik and Freysnes, but it is unclear if that is erroneous, some personal communication to the Authority and a written discussion from the Icelandic government seems to discuss the eastern side of Freysnes. However, since the formal exemption request specifically mentions the route Reykjavik and Freysnes this discussion pertains only to that section, and not the section east of Freysnes. For that, the exemption request would have to be changed.

The analysis first explores direct driving time. Based on driving speed and time (see Table 3) it is unlikely that drivers can reach the rest stop in Freysnes when traveling from Reykjavik in 4.5 hours, but quite likely given 5 hours. It is noted that drivers stopping on the side of a two-lane road without parking or rest facilities can pose a crash risk for other drivers. It is doubtful that drivers could validly apply Article 12 of the Act to reach Freysnes on the grounds of such crash risk. Enabling drivers to reach the rest facilities in Freysnes will avoid that risk.

Despite better roads near Reykjavik, the traffic volumes are significantly higher (see Figure 1) and the traffic density as well. Congestion can also occur in urban areas within about an hour's drive of Reykjavik. The average urban speed is about 50 km/h. The time taken to traverse the 130 km closest to Reykjavik is possibly extended due to traffic congestion. The other 75% of the route has road segments with between 100 and 600 ADT, which is considered low traffic volume. The traffic volume peak, visible on the chart to the left of 200 km in Figure 1, indicates the position of the nearest rest stop west of Freysnes. Freysnes is a rest area close to the middle of the route and it is the logical place to take the rest break, aside from there not being rest facilities for a long distance on either side of Freysnes.

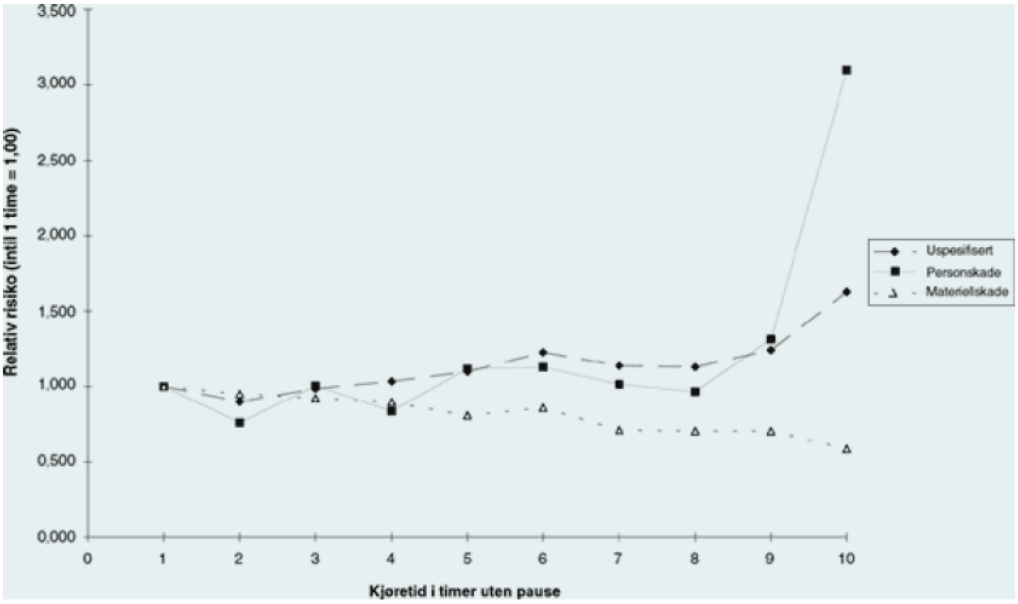


Data source: Icelandic Road Administration (2006).

Figure 1: Annual average daily traffic on road segments on the route from Reykjavik to Egilsstadir, through Freysnes.

Research investigating the crash rates of long-haul drivers as a function of time before taking a break indicates no statistically significant difference in risk between 4.5 hours of driving time and 5 hours of driving time. The relative risk of crashes as a function of time while driving without a break is mapped in Elvik and Vaa (2004), see Figure 2 (their Figure 6.11.1). For injury crashes, the risk fluctuates randomly around the value

of 1 (for the base risk, set after 1 hour of driving) in the first 8 hours of driving. It is not until the 9th hour of driving without a break that the injury crash risk takes a clear turn towards increase, when it increases dramatically (Elvik and Vaa, 2004). Lin et al. (1994) found that taking a rest break before the 6th and 7th hours of driving leads to a reduction in crash risk, indicating that breaks taken later than the 6th and 7th hours of driving may be taken too late and that fatigue has already set in.



Figur 6.11.1: Ulykkesrisiko pr kjørt time ved ulikt antall kjørte timer uten pause for lastebilførere. Kilde: TØI.

Data source: Transportøkonomisk Institutt (2008)

Figure 2: Relative crash risk for truck drivers as a function of driving time without a break.

Taken together, we find that the Act with exemption 2 will on the whole likely contribute to improved road safety.

3.3 EXEMPTION 3: INCREASED TIME BEFORE A REST BREAK ON CERTAIN AIRPORT COACH ROUTES

Carriage of passengers by coach between points outside the metropolitan area and the international airport at Keflavik during the night so that the maximum driving time permitted before taking a break in such cases should be six hours.

During the night, food, drink, and indoor rest service facilities on these routes in Iceland are currently closed and only limited toilet access is available for the driver and passengers, (not counting built-in toilet facilities in specially equipped coaches). Although the requested exemption asks for a delay in taking a rest break until after 6 hours, in practice, drivers must take one or two breaks, on request by passengers to access toilet facilities. These breaks are expected to be around 10–15 minutes. However these are shorter than the rest break required by the Act.

This exemption concerns three factors, extension of driving time before a break, night time driving, and the likelihood of irregular work hours. The first point concerns extending the driving time before a 45 minute rest break has to be taken from 4.5 hours to 6 hours. The discussion of Figure 2 in section 3.2 is directly relevant here and the same result holds. Taking a break after driving for 6 hours occurs before fatigue appears to set in and before injury crash risk starts rising.

One important difference exists, which is that this exemption regards only night time driving. The research on driving time and rest breaks considers general driving, night and daytime driving. It is not known if the crash risk curve of specifically night time driving is different, e.g., the effects of fatigue on crash risk might appear earlier during night time driving than for the population of all long-haul driving.

It is also a question whether the Act mandated rest break will have beneficial effects on crash risk if the driver is unable to separate himself from the passengers, as in this case. Research on fatigue management (Feyer and Williamson 1993, 1995; Williamson et al., 1992) indicates that drivers in passenger transport are less likely to manage fatigue by taking a nap than truck drivers. This is logical, since the passenger coach driver has no berth, and would find it difficult to nap in the driver’s seat in front of a coach full of waiting passengers. It is therefore a question what impact a rest break during a time where there are no facilities for the driver to rest, have coffee, etc., will have on crash risk. Is the rest break possibly leading to the driver having been awake for even longer when the last hours of the trip are completed? This is an open question.

In general, research finds a statistically significantly increased crash risk for drivers driving during a time when they would normally be at sleep. This can be linked to the primary season for these trips. It is the primary air travel season in Iceland, which takes place during the summer months. During the Icelandic summer, driving at night means driving in daylight, due to the northern latitude of Iceland. Research into driving at night

is without exception (based on the literature reviewed) also driving in darkness. Driving in daylight, although during the night hours, is potentially different. It can be hypothesized that the presence of light and even sun can possibly lead to increased alertness when driving at night. However, the fact remains that driving during times when the driver would normally be asleep will lead to a lower alertness than driving during other times, whenever that time occurs, and the presence of light has not been shown to compensate for lack of sleep.

This type of trip could possibly occur on an irregular shift, i.e. the driver is sometimes driving at night and sometimes driving during the day. Research has shown that driving irregular shifts can lead to an increased crash rate of about factor two compared to driving regular shifts (Elvik and Vaa, 2004). Driving at night can lead to a long period of wakefulness if the driver awoke the previous morning. Research consistently shows that pre-trip fatigue and long hours of wakefulness are associated with higher crash risk (e.g. Williamson et al., 1996; Stutts et al., 2003).

To deliver passengers to the airport in time for their flights, the coaches must generally reach the airport before 5:45 AM. The coaches would therefore be traversing the outskirts of the Icelandic Capital area at around 5:00 AM at which time there is low volume of traffic on the roads. This may appear unusual given the size of the Capital area of just over 200,000 people. However, the volume of traffic around the Capital area in Iceland is much lower than in similarly sized cities in mainland European nations because the Icelandic Capital area stands alone, whereas the mainland European cities of similar size are linked to a network of other cities and towns, with hundreds of thousands, if not millions, of people within a few hours driving distance. The traffic in the Icelandic Capital area is therefore not comparable in volume to the traffic in similarly dense areas in mainland Europe.

Taken together, the statistical evidence does not suggest crash rates will be statistically significantly different after driving for 6 hours compared to 4.5 hours without a break. In fact, the results show that the risk of injury crashes turns towards a sharp increase first in the 9th hour of driving without a break. In practice, this driving will also likely not occur completely without breaks, due to necessary toilet breaks for passengers. The traffic volume at night is minimal, with few serious crashes occurring across all traffic (Road Traffic Directorate, 2008). A decision needs to be tempered with that passenger transport involves more occupants and any serious crash can result in greater number of casualties. However, the Act itself allows night time driving and irregular shifts, which are the primary risk factors, which this exemption does not change.

Given this information and reasoning, we do not find it likely that the exemption will reduce safety compared with the Act. It can be recommended that the exemption be qualified by a request that a driver using this exemption should be coming from a rest period no less than the full daily rest of 11 hours, in an effort to minimize the effect of pre-trip fatigue.

3.4 EXEMPTION 4: DELAYING WEEKLY REST PERIOD ON CERTAIN PASSENGER COACH TRIPS

Allowing drivers of vehicles used for the carriage of passengers, other than those used on regular passenger transport services, to postpone the weekly rest period until after the completion of twelve 24 hours periods.

The exemption requests a permission similar to what is granted in current and was granted in previous Icelandic regulation (No. 662/2006; No. 136/1995), and previous EC regulation (EEC No 3820/85), which is to allow drivers to postpone their weekly rest until after twelve 24 hour periods, at which time two weekly rest periods are combined. The drivers' total rest period and driving time over two weeks are within the limits of the Act.

The exemption does not call for changes in rest breaks or daily rest periods. The authors were unable to find research that investigates whether there are differences in safety for drivers that drive for 12 days with or without a weekly rest period. Charlton and Baas (2001) find that number of days of driving is associated with greater fatigue but show no connection with crashes. This means that the safety impact of delaying the weekly rest period is unknown.

An important long term factor that is associated with higher crash risk and daily driving is an irregular structure of the driving shifts, e.g. sometimes the driver works mornings and days, sometimes evenings and nights, etc., as previously discussed. This exemption is regarding trips for the carriage of passengers other than regular passenger service. These are sight-seeing trips with groups of tourists that must book the trip. In this sense these trips are irregular; they are not coach trips that travel between fixed locations at pre-determined times. However, since the purpose is sight-seeing for tourists, these trips involve a consistent time schedule, that takes place during normal waking hours. The

important risk factor of irregular schedule, as in sometimes driving at night and sometimes driving during day, is thus eliminated.

Tourist sight-seeing on extended trips in Iceland primarily takes place in the Icelandic interior and highlands during summer. Roads in those areas are gravel mountain roads, and speeds are generally below 80 km/h, and in quite many cases can be below 50 km/h. This contributes to reducing the risk of a severe crash.

We do not find direct evidence that suggests this exemption leads to changes in crash risk. Given the research suggesting increased fatigue level with increasing number of days of driving, it is not impossible that such effect exists. Without evidence suggesting an increased crash risk, given that no research were identified indicating negative impacts of such 12 day trips on traffic safety, given that the trips are day-time trips for sight-seeing that involve travel on lower speed roads, we arrive at the conclusion that it is not likely that this exemption will lead to a change in road traffic safety compared to the Act. This conclusion is based on the assumption that the driver obeys the articles of the Act about driving rest breaks and daily rest periods during the trip, and provided that the total driving time remains within 90 hours in two consecutive weeks.

4 CONCLUSIONS

This Chapter summarizes the specific conclusions for each of the four exemptions as previously discussed. Based on the analysis, we do not find it likely that exemption 1, discussed in section 3.1, will lead to a reduction in safety compared to the Act. It is noted that the shorter driving times mandated by the Act increase the chance that drivers may have to sleep while on the road, which can negatively affect the quality of sleep. A reduced quality of sleep can possibly lead to increased fatigue, and thereby to increased crash risk and reduced safety. In this regard, the Act may contribute to reduced safety which the exemption mitigates by allowing added driving time flexibility for drivers in Iceland.

It is also noted that in winter conditions, the time pressure of the Act may detract from safety, since time pressure may lead drivers to attempt to maintain higher speed than is safe for winter conditions, and/or may lead drivers to forego installing chains. The additional time allowed by exemption 1 mitigates this effect. Slower speeds under such conditions lead to reduced severity of any crash that might occur. In winter conditions,

we find it likely that the overall effect of exemption 1 will be to improve safety compared to the Act.

As discussed, research finds that the long-haul drive crash risk is statistically significantly linked with pre-trip fatigue. Exemption 1 might therefore be qualified to ensure added driver rest by stating that the driver should not take the extended driving time of 11 hours, in two consecutive 24 hour periods.

For exemption 2, discussed in section 3.2, it is found that research investigating the crash rates of long-haul drivers as a function of time before taking a break indicates no statistically significant difference in risk between 4.5 hours of driving time and 5 hours of driving time. It is not until the 9th hour of driving without a break that the injury crash risk takes a clear turn towards increase, when it increases dramatically (Elvik and Vaa, 2004). Lin et al. (1994) found that taking a rest break before the 6th and 7th hours of driving leads to a reduction in crash risk, showing that a rest break taken before fatigue sets in will improve safety. Extending the time before a rest break allows drivers additional 30 minutes to reach the rest stop at Freysnes, thereby reducing the chance of drivers having to park on the side of the road with a resulting negative safety impact due to limited shoulder width. We therefore find that the Act with exemption 2 will on the whole likely contribute to improved road safety.

When considering exemption 3, discussed in section 3.3, the statistical evidence does not suggest crash rates will be statistically significantly different after driving for 6 hours compared to 4.5 hours. The results show that the risk of injury crashes turns towards a sharp increase in the 9th hour of driving without a break. The traffic volume at night is minimal with few serious crashes occurring across all traffic. A decision needs to be tempered with that passenger transport involves more occupants and any serious crash can result in greater number of casualties. However, the Act itself allows night time driving and irregular shifts, which are the primary risk factors, which exemption 3 does not change. We do not find it likely that the exemption will reduce safety compared with the Act.

It can be recommended that exemption 3 be qualified by a request that a driver using exemption 3 should be coming from a rest period no less than the full daily rest of 11 hours, in an effort to minimize the effect of pre-trip fatigue.

In conclusion for exemption 4, discussed in section 3.4, we do not find direct evidence that suggests exemption 4 leads to changes in crash risk. Given the research suggesting increased fatigue level with increasing number of days of driving, it is not impossible that such effect exists. Without evidence suggesting an increased crash risk, given that no research were identified indicating negative impacts of such 12 day trips on traffic safety, given that the trips are day-time trips for sight-seeing that involve travel on lower speed roads, we arrive at the conclusion that it is not likely that exemption 4 will lead to a change in road traffic safety compared to the Act. This conclusion is based on the assumption that the driver obeys the articles of the Act about driving rest breaks and daily rest periods during the trip, and provided that the total driving time remains within 90 hours in two consecutive weeks.

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