2012-01-01

Condition Monitoring of Truck-Drivers in the EU and the USA

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Dedication

To my wonderful family, my amazing friends, especially Ivke, Zuzke, Alenke, and Nele!

CONDITION MONITORING OF TRUCK-DRIVERS IN THE EU AND THE USA

by

STEFANIA SEMANOVA

THESIS

Presented to the Faculty of the Graduate School of

The University of Texas at El Paso

in Partial Fulfillment

of the Requirements

for the Degree of

MASTER OF SCIENCE

Department of Civil Engineering

THE UNIVERSITY OF TEXAS AT EL PASO

May 2012

Acknowledgements

I would like to thank everyone in the Atlantis Dual Master Degree Program (between the EU and the U.S.) for the opportunity to study abroad and for provided financial support. Also, I would specially like to thank my American supervisors: Ing. Thompson Sarkodie-Gyan, Ph.D. (for keeping a positive attitude), and Salvador Hernandez, Ph.D., for the guidance during the writing process of thesis. My sincere gratitude is for my Slovak supervisor doc. Ing. Miloš Poliak, Ph.D., who knew how to encourage me and guide me in the writing process of thesis also despite to far distance only via emails. This thesis was possible thanks to his expert knowledge and passion in the area of interest. I also want to thank Dr. Kelvin Cheu for his perseverance and patience as the Atlantis program coordinator. For help with obtaining the crash data, I am grateful to Mouyid Islam and doc. Ing. Miloš Poliak, Ph.D.

I would also like to thank my family for their unconditional support, whether moral or financial, during my educational career. Their love and faith in me always helps me in meeting my goals and progress. I have special gratitude to my best friend Ivka. She always stands by me and supports me in difficult situations. The fact that I was able to complete the study in college is also due to her help. I thank my “colleagues” Nela and Petr, in the BIG lab, who were helping me with every little daily thing during the writing process of thesis. It has been a pleasure for me to meet them.

Declaration

This thesis is an output of the Transatlantic Dual Masters Degree Program in Transportation Science and Logistics Systems, a joint project between Czech Technical University, Czech Republic, The University of Texas at El Paso, USA and University of Zilina, Slovak Republic.

This thesis is jointly supervised by the following faculty members:

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The contents of this research were developed under an EU-U.S. Atlantis grant (P116J100057) from the International and Foreign Language Education Programs (IFLE), U.S. Department of Education. However, those contents do not necessarily represent the policy of the Department of Education, and you should not assume endorsement by the Federal Government.

This research is co-funded by the European Commission's Directorate General for Education and Culture (DG EAC) under Agreement 2010-2843/001–001–CPT EU-US TD.

Abstract

Road accidents involving trucks cause far-reaching consequences for property as well as human lives in comparison with other accidents. Therefore, it is necessary to create an environment in which truck drivers can safely perform their work and find a way of keeping tired truck drivers off the roads.

The goal of this research is to review the required policies and legislation for truck drivers in the EU and the U.S. Based on this review, a comparison analysis of both policies will be performed. A further step will involve the analysis of crash data from the EU and the U.S. A principal focus is labeled at the behavior of drivers and driving conditions. Statistical analyses will be performed on the crash data and inferences will be drawn. This work will also draft recommendations and propose changes in legislation in terms of road safety based on the advantages extracted from both the EU and the U.S.

Key words: Truck drivers, Condition monitoring, Policy of the EU and the U.S., Comparison of policies, Crash data analysis.

Abstrakt

S narastajúcim podielom cestnej nákladnej dopravy na trhu nákladnej dopravy je potrebné venovať stále väčšiu pozornosť bezpečnosti cestnej premávky. Vo všeobecnosti majú dopravné nehody zahŕňajúce jazdné súpravy ďaleko rozsiahlejšie následky na majetku ako aj na ľudských životoch ako to je v porovnaní s ostatnými nehodami. Preto je potrebné vytvárať prostredie, v ktorom môžu vodiči jazdných súprav bezpečne vykonávať svoju prácu a tak držať unavených a prepracovaných vodičov mimo ciest.

Cieľom tejto práce je zosumarizovať požiadavky pre prácu osádok v EU ako aj v U.S. a na tomto základe vykonať porovnanie oboch politík. Ďalším krokom je analýza dát o dopravných nehodách v EU a U.S. Dôraz bude tiež kladený na správanie vodičov a jazdné podmienky. Táto práca tiež navrhne odporúčania na zmenu v legislatíve pri zohľadnení pozitív jednotlivých politík.

Kľúčové slová: Vodiči jazdných súprav, Monitoring pracovných podmienok, Porovnávacia analýza, Analýza dát o nehodách

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

1.1 Background

The importance of the transportation may be expressed through the relationship between the production and consumption that involves the realization of imports and exports, and the provision of supplies to the population. It unites the areas and states into one technical and economic unit. Efficiency in freight transportation plays an important role in the existence of the successful and competitive economy, the satisfaction of consumer requirements, and the creation of a significant number of jobs.

In the modern world, there arises the tendency for continuous growth of world trade and associated increase(s) in the intensity of the freight transport. A substantial proportion on the freight market has the road transportation. For example, Figure 1 illustrates the proportion of modes of the transportation on the freight market of European Union. This is because the road transportation is flexible and allows fast and efficient transport from “door to door”. The road network is also relatively dense.

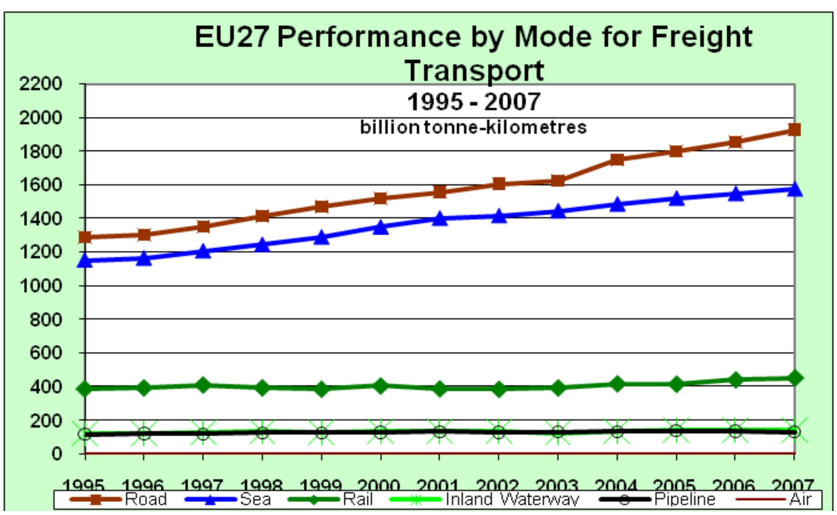

Figure 1.1: Proportion road transport on the freight market EU (European Commission, 2009)

Figure 1.2 depicts the performance of road freight transportation in the United States. Although, the proportion of rail transport remains greater than in the case road transport, there is still substantial amount of goods transported by road transportation in growing tendency.

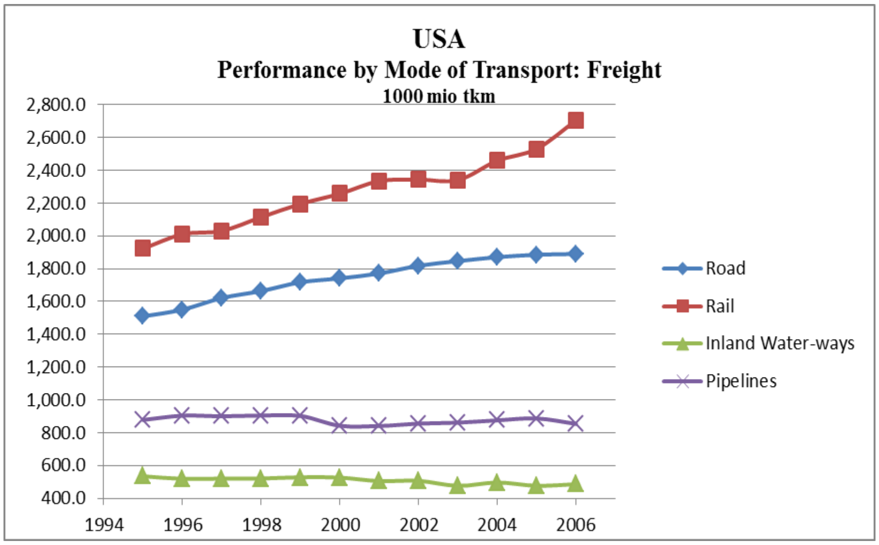

Figure 1.2: Proportion road transport on the freight market USA (European Commission, 2009)

However, the increase in the volume of road transportation leads to more accidents, including fatal ones, on the road. The accruing damage consists of both material but also human lives. These accidents cause injuries to the vehicle occupants as well as to pedestrians or non-road participants. Every year, there are thousands of trucks involved in road accidents. Table 1 illustrates the numerous deaths in these accidents by road.

Table 1: Fatalities in accidents involving heavy goods vehicles by road user type, EU-23, 2008 (Annual Statistical Report 2010)

Accidents involving	HGVs	
	Fatalities	%
HGV occupant	676	13
Bus or Coach occupant	16	0
Car occupant	2,604	49
Light GV occupant	271	5
Moped rider	119	2
Motorcycle rider	322	6
Pedal cyclist	325	6
Pedestrian	865	16
Other/unknown	90	2
All	5,288	100

Trucks are mainly dangerous when the drivers become exhausted and fatigued. Such drivers are required to be kept off the road. Therefore, it is necessary to create an environment where the drivers can safely perform their work.

Why are trucks so dangerous?

- The truck weight is often several times greater than passenger cars (it can weigh as much as 80,000 pounds and can be over 65 feet long)
- When braking, the loaded truck can take 190 – 200 feet to stop
- Because of the truck weight, big rigs take longer to reach cruising speed what means that it is more difficult for them to climb hills as much as drive downhill or rapidly move from the lane to the lane
- Truck drivers have large blind spots in the rear, on both sides and even in front of the cab
- Regarding maneuverability, truck drivers prefer the middle lane and often move left to make a right turn
- Large trucks are more likely to be involved in a fatal multi-vehicle crash than are passenger vehicles

Therefore, in terms of road safety there is the needed to pay attention to the use of qualified drivers, and the availability of vehicle maintenance to the creating schedules, and etc…

1.2 Objective

The objective of this research is to analyze the requirements of social legislation for work of the truck drivers in the EU and the U.S. The ultimate aim is to examine under what conditions the drivers should work in terms of driving time, and also the rest period in both communities.

Based on the comparison of both policies, there may arise certain differences in the work of the truck drivers, with respect to advantages and disadvantages of driving within the EU and in the USA, respectively.

The objective of the research is also to analyze crash data both from the EU and the U.S. The focus of the analysis is based also on the behavior of drivers and driving conditions. Statistical analyses will be performed on the crash data and inferences will be drawn. The work then will draft recommendations and propose changes in the legislation in terms of road safety by drawing from the positives of both the EU and U.S.

1.3 Thesis Organization

Chapter 1 addresses the need to pay attention to the legislation pertaining to truck drivers since there exists a significant number of accidents of trucks on the roads. The properly adjusted legislation helps keep tired drivers out the roads. Chapter 2 addresses the literature review. This chapter reviews studies conducted on driving conditions of truck drivers. It also summaries and explains the legislative requirements and conditions necessary for truck driving in the EU and the U.S. Chapter 3 performs the comparison of both policies. The rules of Chapter 2 were applied for the simulation of transportation in

search for evidence for the confirmation of the hypothesis relating to differences in truck driving between the EU and the U.S. Chapter 4 analyzes the crashes data from both the U.S. and the EU. The hypothesis that driving conditions as well as driver's behavior are the same, or at least similar, is examined. In Chapter 5, recommendations for improvements in legislations of both communities are drawn.

Chapter 2: Literature Review

The task confronting a truck driver is not easy since driving remains an extremely monotonous and repetitive activity. Since drivers perform driving tasks on frequently basic over long distances still devote sustained attention, the driving task then becomes tedious and fatiguing. Therefore there are, in the EU and in the U.S., many studies that deal with the causes of road accidents, the factors associated with falling asleep at the wheel like drowsiness and sleepiness, and the effects of age or time of day, and etc… The most studies have been performed on face-to-face bases using surveys at rest areas and routine road inspections, and others by using simulators so road safety was not compromised.

The study by McCartt et al (1999) was aimed at falling asleep as a factor. The six underlying independent factors were chosen: greater daytime sleepiness, more busy schedules, older drivers, poorer sleep on road, the tendency for nighttime driving and symptoms of sleep disorder. The need of shoulder rumble strips on roads was also another factor. The reported result indicated that the irregular schedule and the total driving times affect the crash risk for more than the time of day or driving experience. Around 25 % of drivers reported that they had fallen asleep at the wheel on at least one occasion.

In another study by Otmami et al (2005), the age of the drivers and time of day were examined over simulated driving conditions. The drivers were divided into two groups: young and middle-age. There were simulated conditions, low and heavy traffic conditions, those were observed in two sessions: i.e. the first session was the afternoon between 2:00 – 4:00 p.m., whereas the second one was fixed between 11:00 p.m. – 1:00 a.m., respectively. It was observed that young drivers exhibited the tendency of decreased alertness during low traffic conditions as opposed to middle-age drivers. They also demonstrated the tendency for sleeping during the evening sessions.

A study performed by O'Neill et al. (1999) dealt with effects of cargo loading and unloading on truck driver alertness. The physical activities as loading and unloading tended to have a short-term tendency to improve alertness and response latency. However, as the day progressed the decline in overall performance was identified after 12 to 14 hours of duty. Another benefit was the finding of mild

deterioration of lane-keeping immediately after the loading and unloading tasks. The reason could be as a result of the upper-body muscle fatigue. However, this study examined a sample of only ten drivers.

In this study the legislative requirements of working conditions of truck drivers will be reviewed and compared between the EU and the U.S. in order to make recommendations for improvements in these legislations with respect to road safety. Focus is also on how drivers are remunerated since this may influence their working environment. Furthermore, a research question of the existence of differences in policies between the EU and the US will be also examined. This will be done through reviewing in the following parts of this chapter and examination will continue with applying the rules for driving to simulation of transportation in Chapter 3. Based on this comparison, there will be evidence to reject or adopt the research question.

2.1 Analysis of the Policy of the Truck Drivers in the European Union

The work of the truck drivers is governed by legislation such as Regulation (EC) No 561/2006 of the European Parliament and of the Council Regulation, and Council Regulation (EEC) No 3821/85. These regulations apply to all vehicles (gross vehicle weight rating is over 3.5 tons) registered in EU states and all transport, where the origins and the destinations lie within European Union or Switzerland, Norway, Liechtenstein and Iceland. In practice, there may be a case of the transportation between the above-mentioned countries and "third countries" (which is name for non-European Union states), but which are part of the AETR Agreement (Economic and Social Council, 2004). Then it is necessary to comply with the rules of this Agreement. However, since there is a continuous effort to harmonize the AETR Agreement with the European regulations, this thesis will deal only with European Union law. The particular states can use the same or stricter law for the intrastate commerce transportation.

Under this law there are four driver activities: driving time, break, rest periods, and other work.

Driving time includes time when the driver is operating a vehicle and also any time when the vehicle is temporarily stationary due to reasons related to driving, e.g. traffic jams.

Break is short period during which the driver may not drive or perform any other work; this time is designed exclusively for recovery of the drivers. Time does not devoted to driving but spent in a vehicle next to the second driver who drives a vehicle can be also considered like a break.

Rest period is a longer period when the driver can freely dispose of their time. There are mandatory daily and weekly rest periods.

Other work is meant any work except driving, primarily activities associated with loading and unloading, cleaning and technical maintenance, dealing with the customs, police and immigration authorities, and etc…For other work is also considered time the drivers spend traveling to pick their truck up, which is not in motor carrier's location.

2.1.1 Driving Time and Breaks

The drivers are required to observe a break after 4.5 driving hours. This break must be a continuous one and must have a minimum duration of 45 minutes.

This break can be subdivided into two parts: the first of which must be at least 15 minutes and the second, at least 30 minutes. In any case, it is still necessary to meet the above requirement to observe a break of 45 minutes within 4.5 driving hours.

However, it is important to note that should the first part of the break exceed 15 minutes, for example 25, the next break-component must constitute a minimum duration of about 30 minutes (any break less than 30 or 15 minutes does not constitute to the break time). The common practical question reflects on the beginning of the 4.5 hours counting of the drive-time. This time may be effectively calculated right from the daily or weekly rest period, or from the last break of at least 45 minutes duration.

Figures 2.1, 2.2, and 2.3 illustrate examples of correct and incorrect drawing breaks.

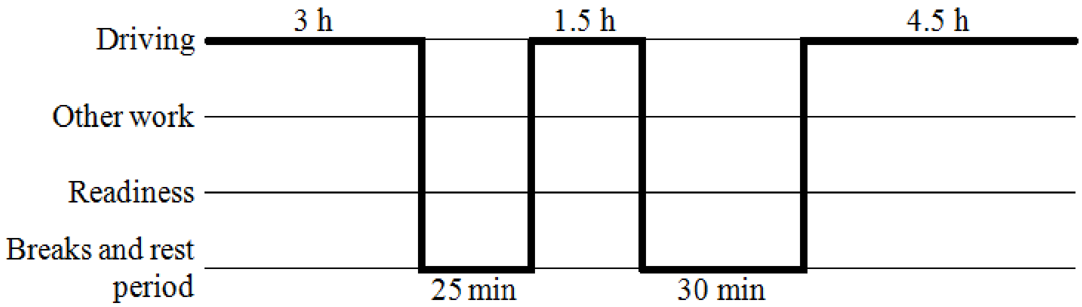

Figure 2.1: Example of the proper using of the driving and break time

In this case as in Figure 2.1, the driver complies with all requirements of driving and taking a break. Even though the first part of the break was longer than 15 minutes, second part respected the minimum 30 minutes for 4.5 hours of driving.

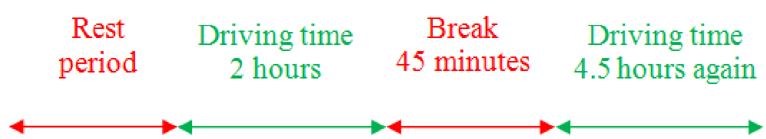

Figure 2.2: Example of the proper using of the driving and break time

In the case as depicted in Figure 2.2, the driver has already observed the 45 minutes break after a driving time of just 2 hours; hence he could start "new driving time" for duration of 4.5 hours again.

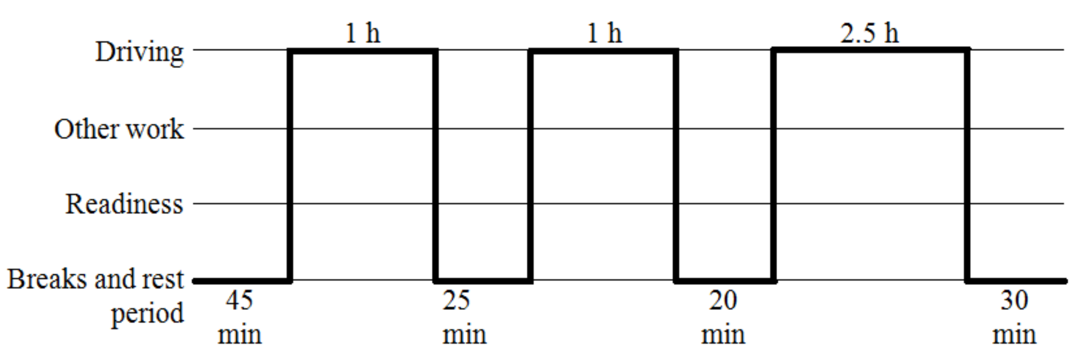

Figure 2.3: Example of the violation of the driving and break time

The Figure 2.3 illustrates the violation of the legislation relating to the time of break, because the second part of the break should have been at a minimum of 30 minutes.

2.1.2 Daily Driving Time

The daily driving time is accumulated as the time between the end of a daily or weekly rest period and the start of the next daily or weekly rest period. This illustrates the fact that the daily driving time is not in a relation to the calendar day. It may start in one calendar day and end in the next one.

The daily driving time should not exceed nine hours. However, the daily driving time may be extended to a maximum of ten hours twice during a calendar week (calendar week means time from Monday 0:00 to Sunday 24:00). These ten hours limit can be applied also in two consecutive days.

2.1.3 Weekly and Fortnightly Driving Time

The accumulated driving time during the calendar week must not exceed fifty-six hours. However, the total accumulated driving time during any two weeks must not exceed ninety hours.

The Figure 2.4 shows the example of the proper and wrong using of the weekly and fortnightly driving time.

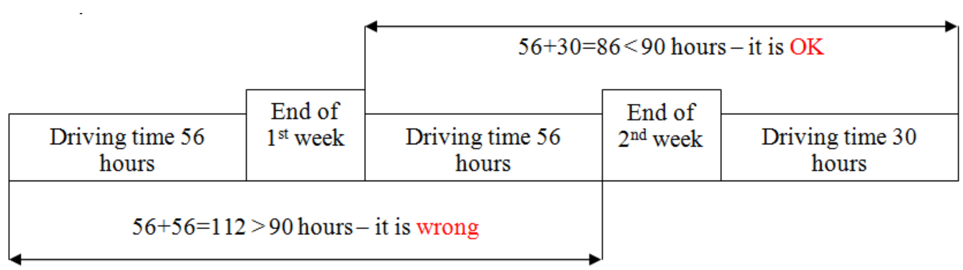

Figure 2.4: Example of the using weekly and fortnightly driving time

2.1.4 The Daily Rest Period

During every 24 hours from the end of the previous daily rest period or the weekly rest period the drivers must take a new daily rest. The daily rest period depicts any uninterrupted period of at least 11 hours. During this time, the drivers may freely dispose of their time. It is important to note that the daily rest is not related to the calendar day.

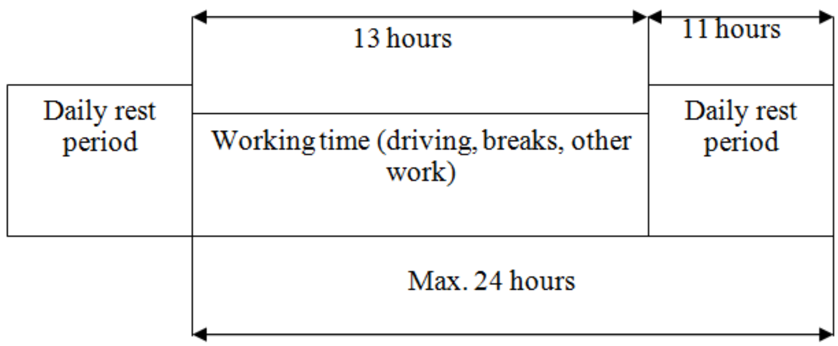

Figure 2.5: The daily rest period

Figure 2.5 illustrates the working time of 13 hours duration. Through the use of the ten driving hours exception, this time could become 15 hours.

In the case that daily rest period ends sooner within 24 hours limit, a new 24 hour limit immediately begins to complete the daily rest period.

The daily rest period may be replaced by a reduced daily rest period of at least 9 hours. But there can be at most three reduced daily rest period between two weekly rest periods. These reduced periods may follow one another. Alternatively, a regular daily rest period may be replaced by two periods, the first of which must be a rest period of at least 3 hours and the second a rest period of at least 9 hours; however, both periods have to be accomplished within 24 hours.

Note: A reduced rest may also be considered to be any rest for less than 11 hours, for example 10 hours and 30 minutes. After this reduced rest period, the drivers can reduce the rest period only two times per week for at least 9 hours.

The Figure 2.6 shows the split daily rest period.

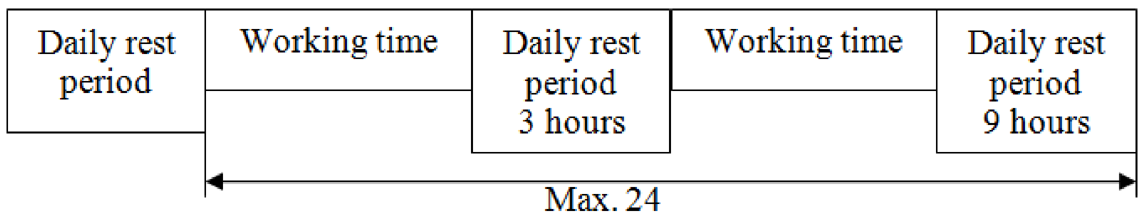

Figure 2.6: The split daily rest period

Note: The drivers must have access to the berth throughout the rest period for any split-rest period during both parts. In the case that the truck is not equipped by berth, the drivers must have plausible confirmation of the accommodation.

When the transportation is performed by two or more drivers, they have 30 hours after the end of a daily or weekly rest period to observe the new daily rest period a minimum of 9 uninterrupted hours.

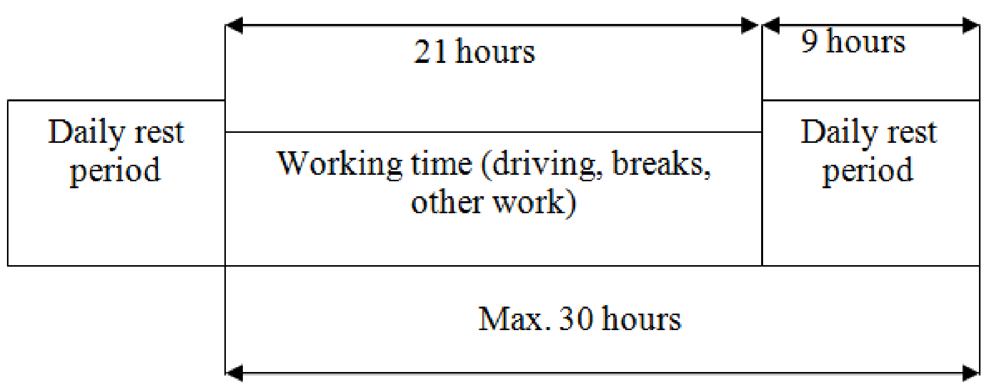

Figure 2.7: Daily rest period in the case of two or more drivers

During the performance of the transportation task, the participation of all drivers is required for the entire trip except for the first hour. Furthermore, the driver, who may not be performing the driving task, may spend his/her break in the moving vehicle. However, a driver may not take the daily rest periods in the moving vehicle and both drivers must have access to berth during the rest period.

2.1.5 Weekly Rest Period

A weekly rest period of at least 45 hours shall start no later than 144 hours after the end of the previous weekly rest period. There is also an alternative to take the reduced weekly period of at least 24 hours. However, before the end of the third calendar week after reduced weekly rest period has been taken, the reduction shall be compensated by an equivalent period of rest attached to another rest period of least nine hours. A minimum of one weekly rest period must be 45 hours or more in any two consecutive calendar weeks. Figure 2.8 and Figure 2.9 illustrate the above mentioned cases.

Figure 2.8: The weekly rest period

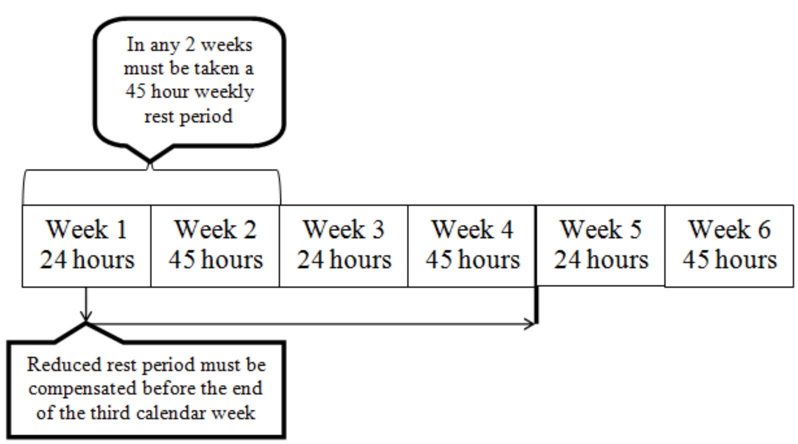

Figure 2.9: The reduced weekly rest period

2.1.6 Transport by Ferry or Train

During a transportation task by ferry or train, the regular daily rest period (in duration at least eleven hours) can be interrupted at most twice for boarding and/or landing activities. This interruption cannot exceed one hour. But there should still be eleven hours available for rest (eleven hours plus one hour of interruption). Reduced daily rest period or reduced or regular weekly period is not possible to interrupt.

2.1.7 Exceptions of the Regulations

These provisions do not apply to vehicles listed in Article 3 of Regulation (EC) No 561/2006. In the case of the threat to road safety or cargo or in the case of the unforeseen circumstances, there may be deviation from the regulation. The cause of the deviation must be recorded and it is assessed by inspection from case to case.

2.1.8. The System of Driver's Wages

The system of driver's wages is governed by Regulation (EC) No 561/2006 of the European Parliament and of the Council Regulation. This regulation stipulates that the calculation of driver's wage cannot be based on the number of kilometers traveled or amount of transported goods. This requirement also applies to bonus of the wage.

2.2 Analysis of the Policy of the Truck Drivers in the U.S.

The work of the truck drivers is governed by Federal Motor Carrier Safety Administration (FMCSA) of the U.S. Department of Transportation. FMCSA stipulates the restrictive limits for the driver's performance. It is called the Hours-of-Service regulations (HOS). This regulations must be

followed when the commercial motor vehicle (CMV, the definition is found in § 395.1 of FMCSA) is used in the interstate commerce, as well as in the intrastate commerce during transportation of hazardous materials in quantity requiring the placard. For the intrastate commerce the particular states may have identical or similar regulations.

There are four duty limits set by HOS, which must to be followed at all time: the 14-hour duty limit, 11-hour duty limit and 60/70 duty limit.

It may now be appropriate to explain the meaning of the on-duty and off-duty times. On-duty is considered as the time the drivers are required to be ready for work or may have just started work by virtue of the responsibility for the performing. This time includes activities like driving, fueling, loading and unloading, handling the paperwork, maintenance, and etc…, plus the other paid work, for example, the part-time job. On the other hand, off-duty is considered as the time the drivers are exempt from performing and from responsibility towards work, and they can freely dispose of their time.

2.2.1 The 14-Hour Duty Limit

The 14-hour duty limit is that limit considered as the "daily limit" even though it may not be related to the 24-hour period. The limit is intended for on-duty status during which it is possible to perform the driving task. By reaching this limit prohibits the drive task until it has been off-duty for another ten consecutive hours. It is possible to perform a different task from driving at this stage. The additional on duty time will be counted toward the 60/70 duty limit (will be explained later). Off-duty time such as nap or lunch break during fourteen consecutive hours is counted to this limit and there should be no driving after the limit. But this off-duty time is not calculated to 60/70 duty limit.

2.2.2 The 11-Hour Duty Limit

The 11-hour duty limit is related to the maximum driving time included within the fourteen consecutive hours limit, as already explained. However, there exists no limit on how many hours are allowed to drive at one time. It can be for as a few minutes or as much as 11 hours in a row. If this limit is reached, it is necessary for the next driving to take off-duty for at least ten consecutive hours. Figure 2.10 shows an example of the proper use of the 14 and 11 hours duty limit.

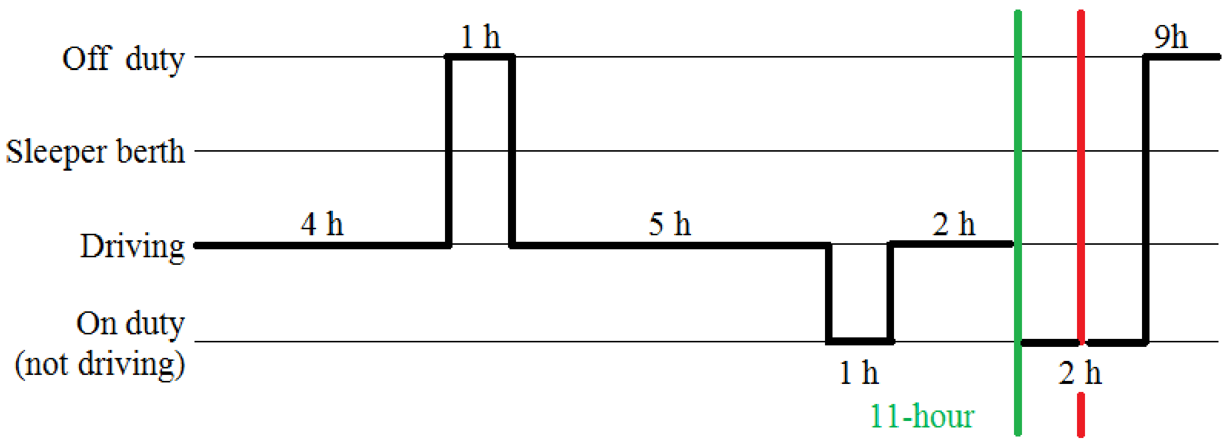

Figure 2.10: The 11-hour and 14-hour duty limit

Figure 2.10 assumes that the driver started to drive for four hours after taking ten consecutive hours off-duty. Before the start of the next five hours driving, the driver was for one hour off-duty for lunch. It is a matter between driver and motor carrier as to the logged time for lunch: as off-duty or on-duty. But the driver's help during unloading for one hour is logged as on-duty. After nine hours of driving he could continue only two hours because of the total eleven hours. Note: The driver continued on-duty status after the fourteenth hour after coming to duty, but there was no driving after that time so there is no violation.

2.2.3 The 60/70-Hour Duty Limit

These limits are "weekly limits" based on seven or eight consecutive days. There may be chosen as 60 hours on-duty during a seven day schedule or 70 hours on-duty for an eight day schedule. The beginning of this period (day and time) is set by the motor carrier; for instance, in the case of 60/7-hour duty limit it can be estimated from the midnight of a Monday to the midnight of the next Monday. After reaching the set limit, other work is allowed, but not more driving. Further driving is possible after sufficient off-duty days in order to arrive at the set limit. In fact, it is necessary to add the total limit to the hours performed on behalf of a person other than the major motor carrier.

34-Hour Restart

By taking 34 consecutive hours off-duty, it is possible to "restart" the above explained 60/70-hour duty limit and then the full 60 or 70 hours are available to accumulate again.

Table 2.1 shows the example of the 60/7 hour duty limit schedule. It is also assumed that the motor carrier set the 24 hours period from the one midnight to the next one.

Table 2.1: Example of the 60/7-hour duty limit schedule

Day	Hours
1. Tuesday	6
2. Wednesday	12.5
3. Thursday	10
4. Friday	9
5. Saturday	10.5
6. Sunday	0
7. Monday	10
Total	**58**

For the determination of how many on-duty hours are available for the next day (Tuesday), the first day in Table 2.1 will drop out from the calculation. Now there are already 52 hours on duty (12.5 + 10 + 9 + 10.5 + 0 + 10 = 52) so eight on-duty hours are still available for the next Tuesday (60 – 52 = 8). The Tuesday's log may then look as illustrated in Figure 2.11.

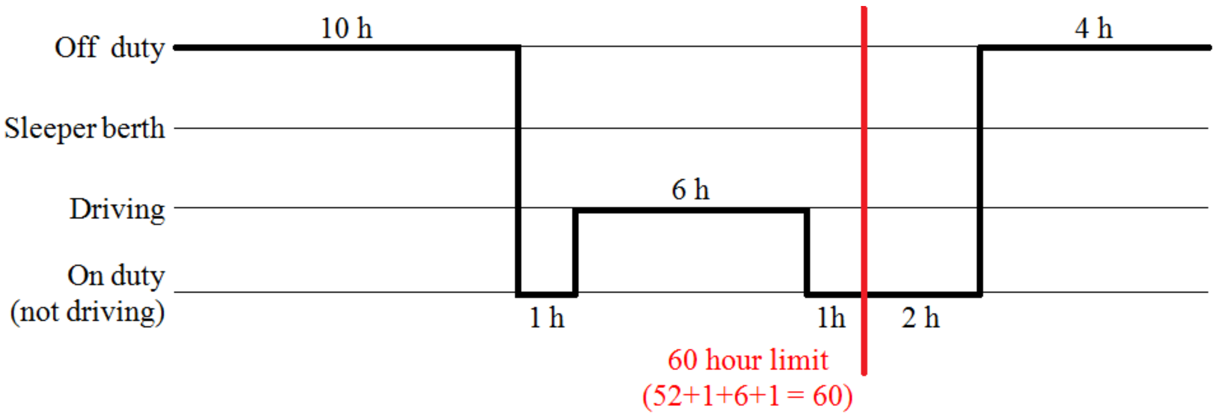

Figure 2.11: Example of the 60/7-hour duty limit

As seen in Figure 2.11, the drivers may perform the other work after they hit the 60 hour limit, however, without any driving task. At the end of the Tuesday, the total hours should sum up to 63 hours, and there will be 9.5 on-duty hours available for further driving during, unless the 34 hour restart time is not observed.

2.2.4 The Sleeper Berth Provision

The vehicle must be equipped with a berth that meets §395.2 and §393.76 of HOS. There are three possible way to use sleeper berth. In the first instance, it may be obtaining ten consecutive hours off-duty, similar to the combination of sleeper and/or off-duty times. The new fourteen hours limit for eleven hours of the driving is available. Another way is to use the sleeper berth for the expansion of the fourteen hour limit, because any time at least eight consecutive hours spent in sleeper berth will not be

counted as part of fourteen hours limit. In third way, it is possible to use the equivalent of ten consecutive hours off-duty divided into two rest periods. One of them is necessary to spend in sleeper berth and it has to last at least eight consecutive hours (but less than ten consecutive hours and is not counted to 14-hour duty limit). Other one is at least two consecutive hours (but less than ten consecutive hours and it is count to 14-hour duty limit). This time can be spent in sleeper berth or as off-duty or as the combination of both. It does not matter which rest period will be taken first. But after the second rest period has been completed the new "calculation point" for 14-hour duty limit will be calculated. This point will be set at the end of the first rest period. Figure 2.12 illustrate an example of sleeper berth provision and how to estimate the calculation point (CP).

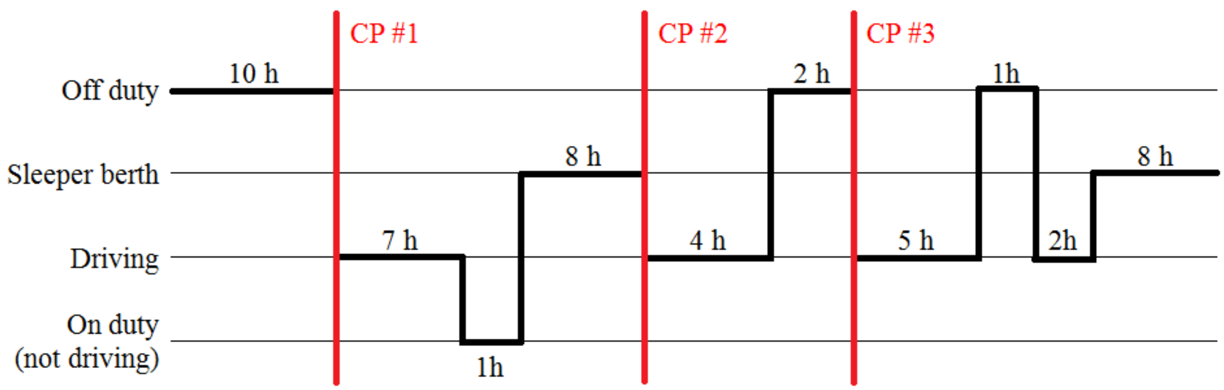

Figure 2.12: Example of the sleeper berth provision

The first calculation point (CP#1) is set at the end of the ten hours period off-duty. From this moment the fourteen hours limit for eleven hours of the driving is available. After having eight hours on duty the driver observes the sleeper berth. Since this period lasts eight hours, it will be excluded from the 14-hour duty limit; therefore, the driver has still six hours available for on-duty (and four hours available for the driving task). When the 11-hour duty limit is reached, the driver takes two hour off-duty (and it will be counted to the 14 hour duty limit). These two hours represent the second rest period of the sleeper berth provision, so it is necessary to estimate the new calculation point after this period is done (CP#2 – which is set at the end of the first rest period). There is a new 14-hour duty limit again

from which the driver was already on duty for six hours. After eleven hours of driving (4+5+2) and fourteen hours on duty (4+2+5+1+2) the driver observes the sleeper berth for eight hours. At the end of this period it is necessary to set calculation point again (CP#3). It will be at the end of first period (two hours off-duty).

2.2.5 Adverse Driving Conditions Exception

These conditions involve snow, fog or shut down of traffic due to a crash, and etc…They included those situations where the drivers are unable to predict, yet still retard their progress. In this case it is possible to drive up to two extra hours, thirteen hours for driving time during 14-hour duty limit.

2.2.6 Exceptions of the Regulations

Non-CDL Short-Haul Exception (Section 395.1(e)(2) of HOS)

This exception consists of two conditions:

- to steer a truck which does not require a commercial driver's license (drive short distances)
- to work within a 150 air-mile radius where there is the return to normal work by reporting to the location each day

Then it is possible to extend the 14 hour duty limit up to a 16 hour duty limit two days of any seven consecutive days or after any 34-hour restart. This exception cannot be combined with another exceptions or split sleeper berth.

The 16 Hour Short-Haul Exception - Section 395.1(o) of HOS

Necessary conditions for this exception are:

- to return to work reporting location that day, as well as for the last five "workday" (time between two off-duty of at least 10 consecutive hours)
- the drivers must be released from duty within 16 hours after assuming duty

This allows the extension of the 14 hour duty limit up to 16 hours once every 7 consecutive days or after any 34-hour restart. Exception is not applicable when the drivers are subjected to "Non-CDL Short Haul Exception".

There are also another exceptions related to mile radius or for special purpose vehicles, which is possible to find in section 395 of HOS.

2.2.7. The System of Driver's Wages

The U.S. legislation allows several ways to remunerate the truck drivers. One of them is to pay in terms of percentage of gross revenue of the truck. It can involve around 25% +/- of this revenue. Another way is to apply an hourly pay. However, these two mentioned ways are not used so much in practice, and only a handful of companies deal with them. Currently, the standard pay for truck drivers is through the mileage. It means that when the drivers do not drive because of traffic jams, waiting for loading or unloading, or broken truck, they are not paid. Moreover, there is often a tendency towards "short miles", meaning that for longer distances there are decreased rates per mile. For example, for a distance of 200 miles or less it constitutes 0.39 cents per mile, but in the case of distance between 201 and 400 it is only 0.37 cents per mile. These facts can lead the drivers to violate hours-of-service and also increase risk of accidents.

2.2.8 The New Changes in the Hours-of-Service Regulations

Based on the conducted studies and research in the area of driver's working conditions and level of fatigue, the Federal Motor Carrier Safety Administration has revised the HOS in the selected areas. There are also two mandatory dates for compliance with them.

February 27, 2012 was the effective date for the changes in the definition of on-duty that was introduced into force. According to this, the any time spent by resting in a parked CMV is excluded from on-duty. Also, any time up to two hours spent in the passenger seat of a moving CMV, which is taking before or after eight consecutive hours in the sleeper berth, is not considered to be on-duty time. This time is logged as off-duty and it is recommended that the drivers note in the "Remarks" section of the log that these two hours were spent in the passenger seat of a moving CMV.

The July 1, 2013 is the compliance date for the following provisions. The first one is related to 34-hour restart provision. This provision is applicable only once every 168 hours and it has to contain two periods of time from 1:00 am to 5:00 am. The second one requires the break during on-duty status. This break must be taken no later than eight hours of on-duty. The drivers can take this break anytime within eight hours. The essence is to prevent the driver's on-duty for longer than eight hours in a row without taking the break. A break is qualified meal break or any other off duty time of at least 30 minutes; for example, it can also be the shorter sleeper-berth period of at least two hours.

Chapter 3: Comparison of Policies of the EU and the U.S.

Because each community has different parameters set for the work of truck drivers, the comparison of both policies is not always easy and somewhat ambiguous. In this study, there are several areas in which the comparison will be done.

The first is the comparison of the *continuous driving time*. In European law, this time is represented by the 4.5-hour period, as opposed to the U.S. law. The U.S. law allows up to eleven driving hours in a row. In the case of adverse conditions, it is even possible to extend the eleven hours up to thirteen hours.

With respect to the *break*, there is a 45-minute break after a four and a half hours continuous driving time in the EU, or the possibility to split the break during the driving time. A necessary condition for split break is two periods, first of which must be at least 15 minutes and the second at least 30 minutes. The requirement of break is not specified in the U.S. law. This can be considered as a matter of truck drivers and motor carriers.

A further concern involves the total driving time that can be performed during one day. Any 24-hour period is considered be a day in the EU. The maximum *daily driving time* is nine hours (4.5 + 4.5); however twice per week (a week is period defined from midnight on Monday to midnight on Sunday), it is possible to extend nine hours up to ten hours (4.5 + 4.5 +1). This exemption can also be applied in two consecutive days. According to the U.S. legislation, the requirement of maximum driving time is set for eleven hours of possible driving during fourteen hours from assuming on-duty. It can also be considered with two extra hours for driving (in total thirteen hours) because of adverse conditions as already mentioned in the paragraph above. There are several exceptions regarding the extension of the fourteen hour limit:

- The use of the sleeper berth provision because any eight hours period spent in sleeper berth will be not counted to that limit.

- The use of the 16-hour short-haul exception and once every seven consecutive days to extend the fourteen hour limit up to sixteen hours
- The use of the NON-CDL short-haul exception and in two days in any seven consecutive days period to extend the fourteen hour limit up to sixteen hours

The important part of the driver's performance is rest period. In this paragraph the ***daily rest period*** is compared. In the EU, in the case of single driver transport, the mandatory rest period lasts eleven consecutive hours and has to be completed within 24 hours from the end of the previous daily rest period. This time is can be drawn as two periods, first of which must be at least three hours and second at least nine hours. There is also possibility of reduced daily rest period at least nine consecutive hours in three times per week. It can also be applied in three consecutive days. On the other side, when transportation is performed by two drivers, there is the requirement of nine consecutive hours that need to be completed within 30 hours from the end of the previous daily rest period. With regard to the U.S. policy, after the allowable number of hours was completed, for next driving it is necessary to take ten consecutive hours off-duty or alternative that time as combination of sleeper berth and off-duty or use the sleeper berth provision (at least 8 + 2 hours).

The next step of comparison analysis is related to ***daily working time***. It is essential in terms of time which is available for daily performance as driving, loading and unloading, handling paperwork, maintenance, and etc…In European legislation there are following possibilities:

- the case of one driver:
    - 24 h – 11 h (daily rest period) = 13 hours available for working time
    - 24 h – 9 h (reduced daily rest period) = 15 hours available for working time
- the case of two driver:

  30 h – 9 h (daily rest period) = 21 hours available for working time

The U.S. policy stipulates restrictive fourteen hour limit for the eleven hours driving time, but there is still the possibility to be on-duty. Only not driving is allowed. The restriction of working time

during any 24 hour period is not clearly specified. The exemption is only the using of the 16-hour short-haul exception, where the condition is to be released within 16 hours after coming on duty.

The comparative analysis continues with *weekly driving time*. According to European rules, the only 56 hours driving time can be realized. The substantial notion stipulates the availability of 90 hours for any two consecutive weeks. On the other hand, the U.S. policy has 60/70-hour duty limit, which is thought of as a "weekly" limit. This limit represents a choice of two variants of on-duty schedules, as:

- 60 hours on-duty during seven days schedule, or
- 70 hours on-duty during eight days schedule

Once one of those limits is reached no more driving is allowed, but the other work can still be performed. Further driving is possible after it has being off-duty enough days to get below the limit.

Finally, the *weekly rest period* is compared. The law of the EU specifies a requirement of the weekly rest period of at least 45 hours shall start no later than 144 hours after the end of the previous weekly rest period. The alternative of that time can be the reduced weekly rest period of at least 24 hours. For the case of use the reduced period it is necessary resulting reduction to compensate by an equivalent period of rest attached to another rest period of at least nine hours. The U.S. regulation defines only 34-hour restart in this field. This provision serves to restart 60/70-hour duty limit, so then there is the new set of 60 or 70 hour limit available again.

Seven parameters were chosen for the comparative analysis of the work of truck drivers in the EU and the USA: continuous driving time, breaks, daily driving time, and daily rest period, daily working time, weekly driving time, and weekly rest period, respectively. The Table 3.1 and 3.2 briefly summarize and compare the basic working conditions of both policies and they also help to gain insight into the comparative analysis.

Table 3.1: Comparison of the driving and working time

Parameter	European Union		United States of America	
Continuous driving time	4.5 h		11 h (during 14 h)	
Daily driving time	4.5+4.5=9		11 h (during 14 h)	
	2x/week	4.5+4.5+1=10	13 h (adverse conditions)	
Daily working time	1 driver	24-11=13h	not exactly specified - posssibility of on-duty after 14th h	
		24-9=15 h (3/week)		
	2 drivers	30-9=21 h	16 h - (16 Hour Short-Haul Exception)	
Weekly driving time	1 week	56 h	60/70 hour duty limit	60h/7days
	any 2 weeks	90 h		70h/8days

Table 3.2: Comparison of the breaks and rest periods

Parameter	European Union			United States of America
Breaks	45 min			not specified
	15 + 30 min			
Daily rest period	1 driver		11 h (during 24 h)	10 h off duty
			3+9=11 h (during 24 h)	combination 10 h off duty/Sleeper Berth
		3x/week	9 h (during 24 h)	8 h Sleeper Bert + 2 h off duty/Sleeper Berth
	2 drivers		9 h (during 30 h)	
The weekly rest period	45 h (after 144 h)			34 h restart
	24 h (!compesation!)			

As a result from previous Table 3.1 and Table 3.2, it can be seen that there are more restrictions in the European Union legislation for the performance of the truck drivers than there are under the U.S. law. Also in the EU, the rules differ according to the number of drivers performing the task.

The stricter regulations may contribute to more safety in transportation, but on the other hand, the drivers can have problem in the orientation of complex regulations and the result can be a violation of the rules, even unintentional violation, and stressful working conditions.

3.1 The Comparison by Using Concrete Example of Transportation

The next step of this analysis is the comparison through the application of the rules of both systems on the same concrete example of transportation; to show how rules affect the overall driving time and rest periods during a single trip. The transportation is simulated at a distance of 4,000 miles with an average vehicle speed of 50 miles per hour. It is supposed that the trip starts on Monday at 5:00 am, and before this, the three days of rest were taken. The estimated time of loading and unloading is one hour each. During the trip it is necessary to include two hours for road inspections and eight hours for other work such as fueling, maintenance, dealing with authorities, and etc…

As a result of the application of minimum rest periods, as permitted by law, the realization of the transportation, by using European Union rules, lasts 197 hours that is eight days and five hours. On the other hand, by using the U.S. rules, the realization takes 191 hours, that is seven days and 23 hours. The driving time and rest periods for a particular day, as well as, overall duration of these activities for whole trip is indicated in following Table 3.3 and Table 3.4. The daily driver's logs according to the EU and the U.S. legislation can be seen in Appendix A and Appendix B, respectively.

Table 3.3: Summary of the trip duration according to the European Union rules

	Day	***Driving***	***Other work***	***Rest periods***	***Total***
1	**Monday**	10	2	12	24
2	**Tuesday**	10	2	12	24
3	**Wednesday**	11.25	1	11.75	24
4	**Thursday**	11.25	1	11.75	24
5	**Friday**	9.5	2	12.5	24
6	**Saturday**	4	0	20	24
7	**Sunday**	9	1	14	24
8	**Monday**	11.75	0	12.25	24
9	**Tuesday**	3.25	1	0.75	5
	Total	80	10	107	197
	Total [%]	40.61	5.08	54.31	100

Table 3.4: Summary of the trip duration according to the U.S. rules

	Day	***Driving***	***On-duty (no driving)***	***Rest periods***	***Total***
1	**Monday**	11	1	12	24
2	**Tuesday**	10	2	12	24
3	**Wednesday**	12	1	11	24
4	**Thursday**	12	2	10	24
5	**Friday**	12	2	10	24
6	**Saturday**	4	0	20	24
7	**Sunday**	7	1	16	24
8	**Monday**	12	1	10	23
Total		80	10	101	191
Total [%]		41.88	5.24	52.88	100

In the next step, the period of eight days is considered for the following comparison, which means that in the case of the trip duration according to the European Union rules, the ninth day from Table 3.3 is drop out from this comparison. And thus, the comparison is conducted between eight-day trip for the EU rules and eight-day trip for the U.S. rules.

The average daily driving and rest time in the case of the EU is 9.59 and 13.28 hours, respectively. In terms of standard deviation for these periods, it is 2.45 and 2.81, respectively. On the other side, for the trip according to the U.S. legislation there is the tendency of higher daily driving period; it is 10 and 12.63 for driving and rest time, respectively. The similar tendency of higher values is also indicated for the case of standard deviations (2.98 and 3.58 hours for driving and rest, respectively), which means that the greater differences exist between the daily averages of mentioned periods. These differences can contribute to the fluctuations in the driver's habits and also affect the overall level of the fatigue.

Based on Table 3.3 and Table 3.4, the differences within the driving and rest time are graphically illustrated in the following figures (Figure 3.1 and Figure 3.2).

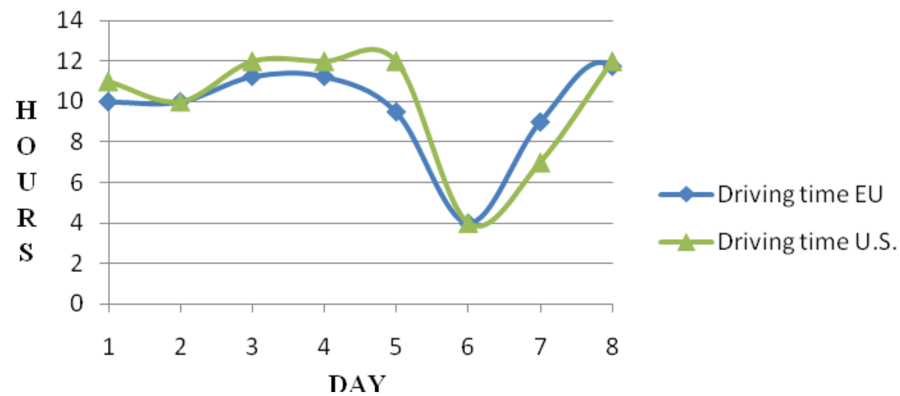

Figure 3.1: The proportion of the driving time in the EU and the USA in particular example

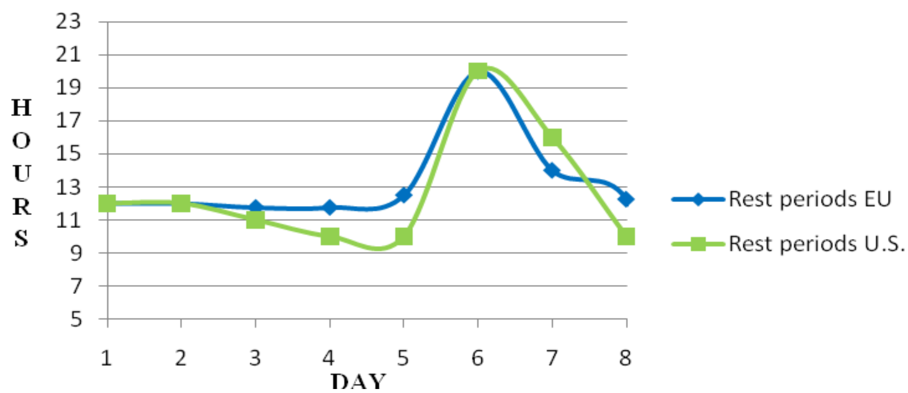

Figure 3.2: The proportion of the rest time in the EU and the USA in particular example

The study by McCartt et al (1999) identified that one of the factors associated with the sleepiness-related driving is the time of the day. Also Mackie and Miller (1978), and Harris et al. (1972) found an association between time of day and level of fatigue. Based on this knowledge, the comparison of the driving and rest time within morning and afternoon hours is conducted. In closing, there is the tendency of more driving hours in the morning and on the sixth day there is no afternoon driving in the case of both policies. Moreover, in the case of the U.S. this scenario continues even on the seventh day in the morning. In terms of rest time, the tendency of more hours of rest is indicated in the afternoon.

The resulting differences between the EU and the USA are shown in the Figure 3.3, and Figure 3.4, and summary of the average driving and rest time within morning and afternoon hours in Table 3.5.

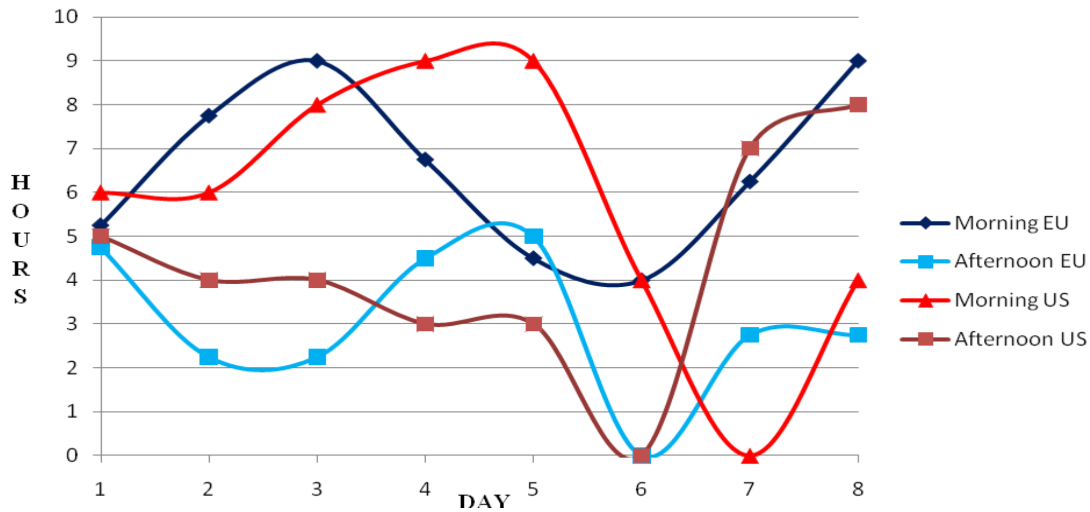

Figure 3.3: The proportion of driving time in the morning and in the afternoon

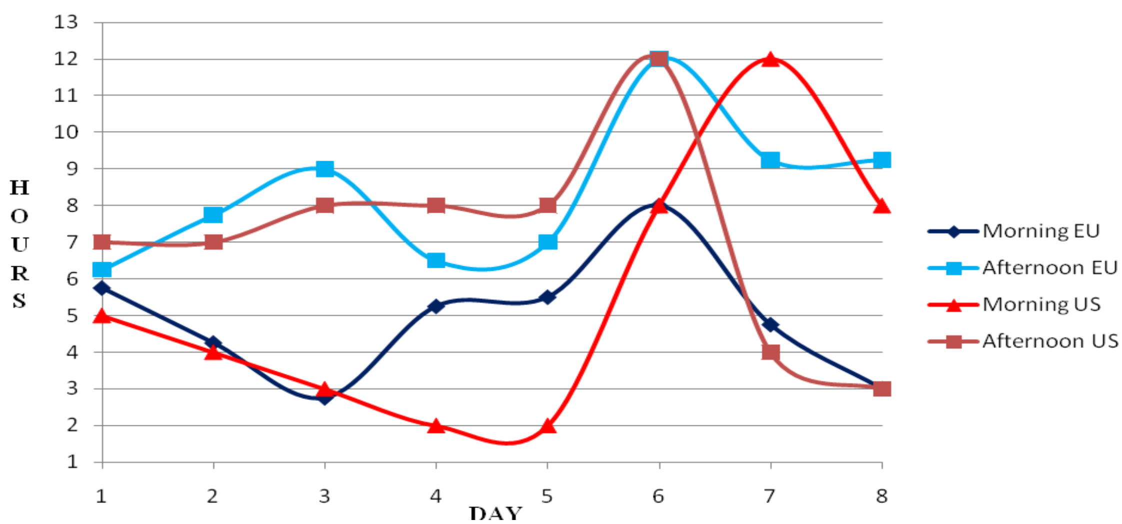

Figure 3.4: The proportion of rest periods in the morning and in the afternoon

Table 3.5: Summary of the driving and rest time within morning and afternoon hours

	European Union				United States of America			
	Driving time		Rest time		Driving time		Rest time	
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
Average	6.56	3.3	4.91	8.38	5.75	4.25	5.50	7.13
Std deviation	1.93	1.67	1.67	1.90	3.6	2.49	3.55	2.36

In practice, there are a lot of cases when the driver's schedules can require sleeping during the daytime. The daily sleep may not achieve the restorative quality of night-time sleep (Lavie, 1986). Therefore, in the last step of the comparison, the rest period that includes time from 0:00 to 6:00 a.m. is examined. As a result, in the case of the U.S. there is higher tendency to spend the rest time within above mentioned period than it is in the EU (in average 2.5 and 2.34 hours, respectively). But with the regard of standard deviation the bigger dispersion is found out in the case of the U.S. This is shown in Figure 3.5.

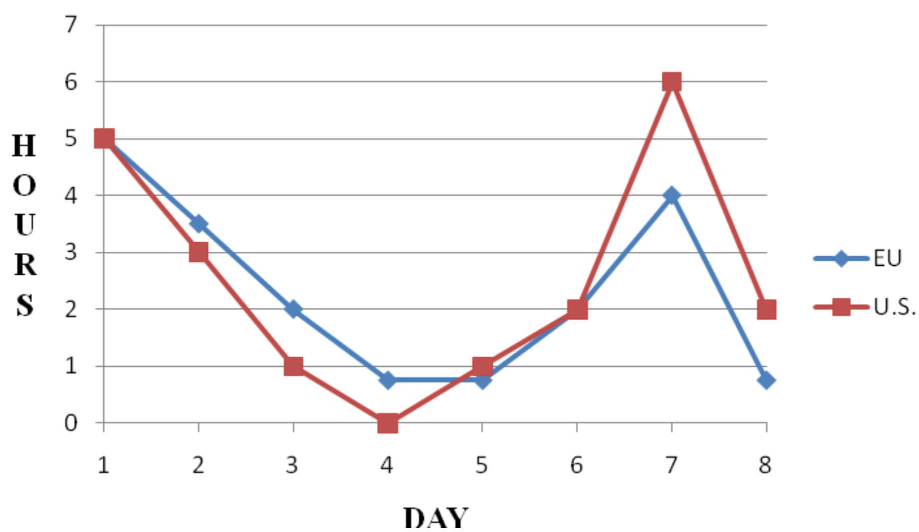

Figure 3.5: The comparison of the rest time between 0:00 and 6:00 am

3.2 The Summary and Conclusion of Comparative Analysis

The first step of the analysis compared the seven parameters such as continuous driving time, break, daily driving time, daily rest period, and etc… between policies of both the EU and the U.S. It could be seen that there are more complex restrictions (for driving as well as rest periods) for work of truck drivers in the EU than in the U.S. Also, the EU law differs in according to number of drivers performing the driving task. In the second step of analysis, the comparison was conducted through concrete simulation of transportation to see how rules affect the overall driving time and rest periods during a single trip. It was found out that there is the tendency of higher daily average of driving time and lower daily average of rest time in the U.S. in compared to EU. The standard deviations in the case of the U.S. are also higher than in the EU, what can have a negative effect on driver's working conditions. However, the positive of U.S. policy is that there is higher tendency of drivers to spend their rest time within 0:00 – 6:00 a.m. in comparison with EU policy.

As a result of the comparative analysis in this chapter, it can be concluded that there is strong evidence to adopt the research question from Chapter 2. Furthermore, in the next chapter of this study, the crash data analysis will be performed and another research question can be examined. There are the crash data from the EU and crash data from five chosen U.S. states.

Chapter 4: The Crash Data Analysis

The goal of this chapter is to analyze the crash data from both the EU and the U.S. The focus is on how many crashes happened in a particular state, and behavior of truck-drivers, and driving conditions. Based on the results, it may be possible to draw inferences and conclusions.

4.1 The Analysis of Crash Data from the U.S.

In this study, the five states were purposely selected from different areas of the U.S., which can be seen in Figure 4.1. All crash data used are drawn from the database of the Fatality Analysis Reporting System (FARS) and include the years 2005 to 2008. Moreover, the crashes are indicated in terms of:

- Fatal injury (FATAL), which means the case of death due to crash
- Incapacitating injury (INCAP), which prevents the injured person from doing normal activities as before injury. For example, it can be severe lacerations, skull injuries, unconsciousness, and etc…
- Non-incapacitating injury (NON-INCAP), which includes, for instance, abrasions, bruises, and etc…
- Possible injury (POSS), where claim of injures is not evident, complaint of pain, hysteria, and etc…
- Property damage only (PDO), where the resulting damage is only on property.

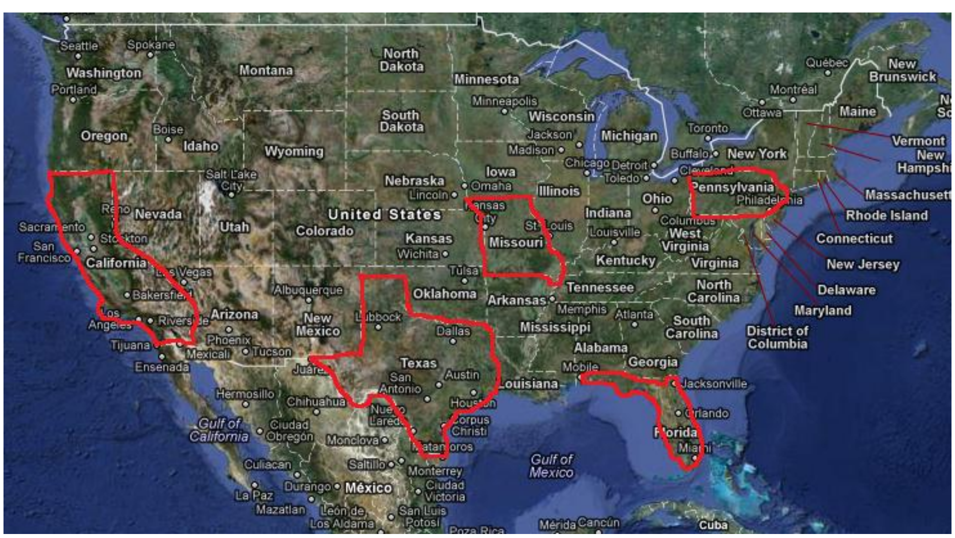

Figure 4.1: The five chosen states from different areas of U.S.

In this analysis it is supposed that behavior of the truck-drivers as well as driving conditions in above mentioned U.S. states are the same, or at least similar. This assumption can be considered as another research question, which is going to be examined. Furthermore, the requirements for qualification of driver's performance are not taken into consideration, and this study will not examine the level of these requirements. It is assumed that when drivers drive trucks, they meet all necessary requirements for the qualification.

Table 4.1 and 4.2 provide underlying information about mentioned states such as area, population, roads length, and etc…In terms of area, Texas is the largest from all the selected states; moreover, it is also the second largest state in the U.S., followed by California. Hence, it is clear that Texas has the most miles of public roads. However, California has the highest population, and hence, there are more trucks registered. In terms of speed limits there is a tendency of higher limits in Texas and Florida; especially in Texas, there are extreme differences in comparison with other states.

Table 4.1: The underlying information about five chosen U.S. states (Federal Highway Administration)

State	Area (sq mi)	Population (July 2008)	Public roads length (2008) in miles			Truck and Truck-tractor registration (2008)
			Rural	Urban	Total	
California	163 695	36 756 666	83 482	89 029	172 511	13 504 551
Florida	65 755	18 328 340	40 366	81 021	121 387	8 230 776
Missouri	69 704	5 911 605	106 765	22 953	129 718	2 234 560
Pennsylvania	46 056	12 448 279	76 484	45 287	121 771	4 240 216
Texas	268 580	24 326 974	212 998	93 406	306 404	9 284 324

Table 4.2: Speed limit five chosen U.S. states (National Motorist Association)

State	Speed limit (trucks) in mph		
	Rural interstate	Urban interstate	Other limited access roads
California	55	55	55
Florida	70	65	70
Missouri	70	60	65
Pennsylvania	65	55	65
Texas	75,80 or 85 on specified segments	75	75

In the following analysis, the number of crashes is computed as 1 million trucks registered (MTR) in each state. Therefore, the comparison is possible not only within one state but also between the states themselves. Firstly, the analysis of crash data between the years 2005 and 2008 is conducted.

4.1.1 Analysis of Crash Data between Years 2005 and 2008

In terms of fatalities, the only decrease is in Missouri. However, it is also the state with the largest proportion of fatal accidents involving trucks amongst all selected states. In the state of Missouri, it may be necessary to question the high rate of accidents. The proper adjustment of legislation of working conditions of truck drivers can prevent the driver's fatigue associated with accidents and can achieve reduction of crashes not only in Missouri, but also in other U.S. states. Other states with large proportion of fatal accidents involving trucks are Pennsylvania, Texas, Florida, and California, respectively. In California, Florida, the most critical year for fatal injuries is 2008, and the biggest difference in proportion of fatalities between this year and the other years is recorded in California. On the other hand, the most positive trend in the number of fatalities can be seen in Missouri and Texas between 2007 – 2008, and 2006 – 2007, respectively. The above mentioned is shown in Figure 4.2. In Figure 4.3 the number of crashes with incapacitating injury is examined. There are years with no crashes in 2005, 2006, and 2007 for Pennsylvania, California, and Florida, respectively. In California this number (except year 2006) is the same across all years with no fluctuations. Overall, Missouri, Florida, and Pennsylvania are the states with higher proportion of incapacitating injuries. In terms of non-incapacitating and possible injury, and property damage only (Figure 4.4, Figure 4.5, and Figure 4.6), overall there can be seen a tendency of improvements in crashes between 2005 and 2006 mainly in California and Florida, and then between 2006 and 2007 mainly in Texas. On the other side, the most deterioration is detected between 2007 and 2008.

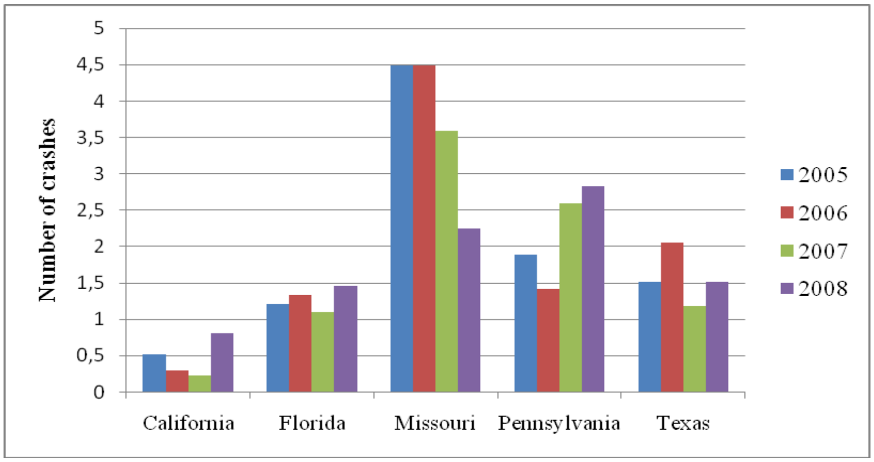

Figure 4.2: The proportion of crashes per MTR with fatal injury between 2005-2008

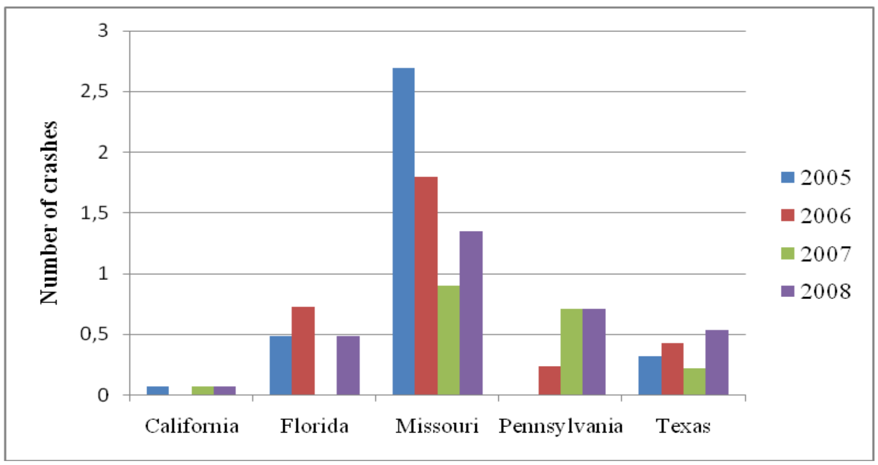

Figure 4.3: The proportion of crashes per MTR with incapacitating injury between 2005-2008

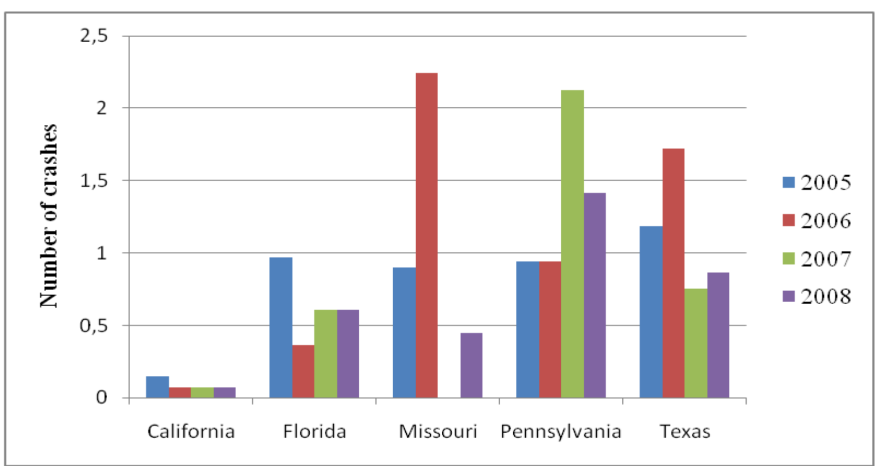

Figure 4.4: The proportion of crashes per MTR with non-incapacitating injury between 2005-2008

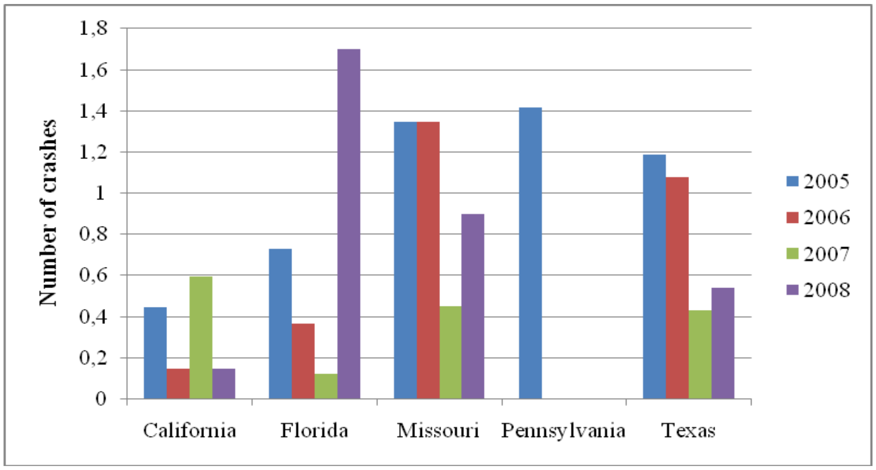

Figure 4.5: The proportion of crashes per MTR with possible injury between 2005-2008

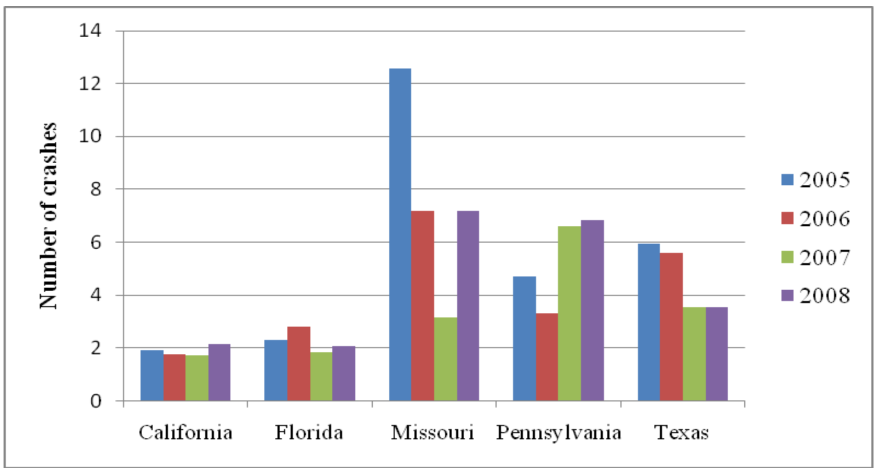

Figure 4.6: The proportion of crashes per MTR with property damage only between 2005-2008

4.1.2 Analysis of Crash Data in terms of Season

For this analysis for particular season is considered to include following months:

- Spring: March, April, and May
- Summer: June, July, and August
- Fall: September, October, and November
- Winter: December, January, and February

In Figure 4.7, the season of Summer and Fall (related to seasonal peak in freight transportation because of Thanksgiving and Christmas) are typical periods for fatalities in all states except Pennsylvania, where a stronger evidence of occurrence of this type of accidents is indicated in the winter. A reason can be that Pennsylvania is northernmost state from all, so harsh weather conditions can be found in the winter. In the case of incapacitating injuries there is a tendency of fall in all states and plus season of winter in California and Florida and spring in Texas (Figure 4.8). In Figure 4.9 and Figure 4.10, for accidents with non-incapacitating and possible injury is likely to occur in winter and fall, except in the state of Texas where spring is the frequent season. The reason may be attributed to the season of rainfall in Texas is in spring. Finally, for property damage only is typical spring for Florida; Fall for California and Missouri, and winter for Texas and Pennsylvania (Figure 4.11).

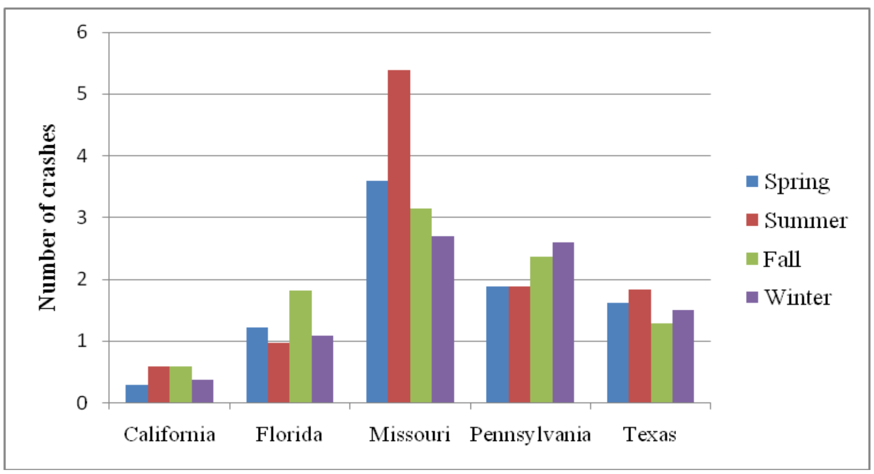

Figure 4.7: The proportion of crashes per MTR with fatal injury in terms of season

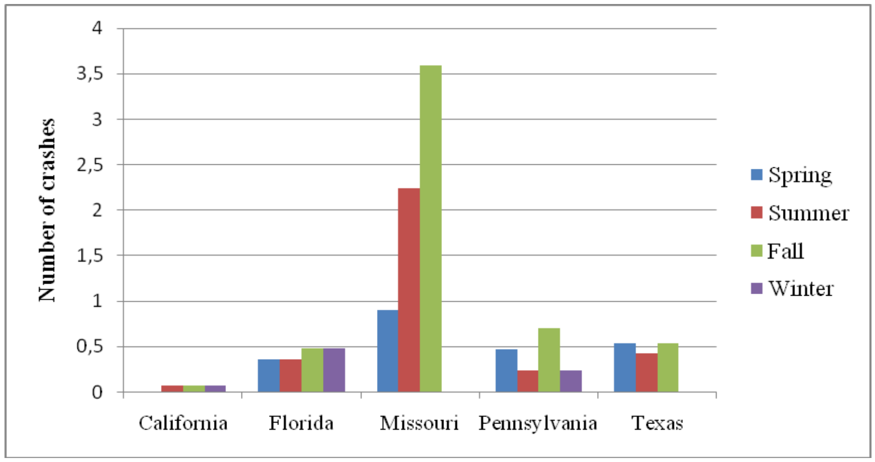

Figure 4.8: The proportion of crashes per MTR with incapacitating injury in terms of season

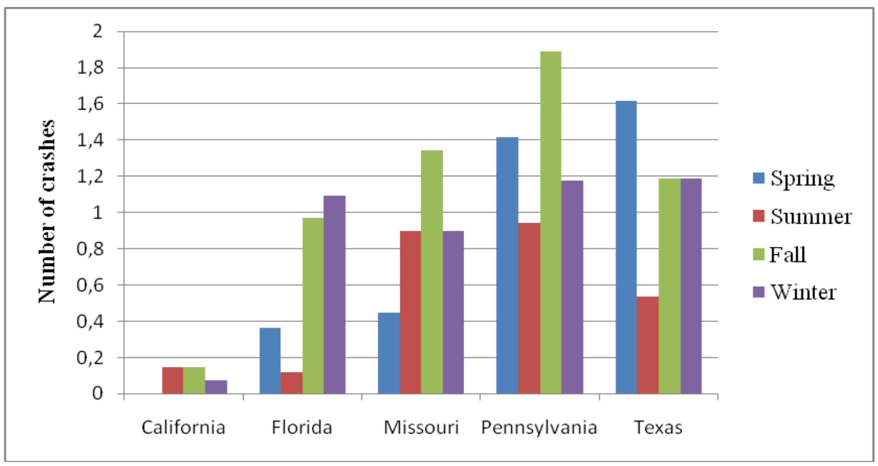

Figure 4.9: The proportion of crashes per MTR with non-incapacitating injury in terms of season

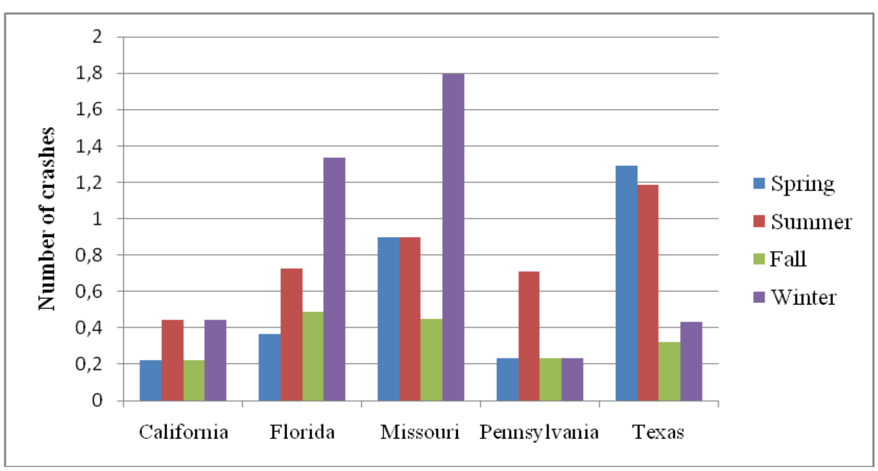

Figure 4.10: The proportion of crashes per MTR with possible injury in terms of season

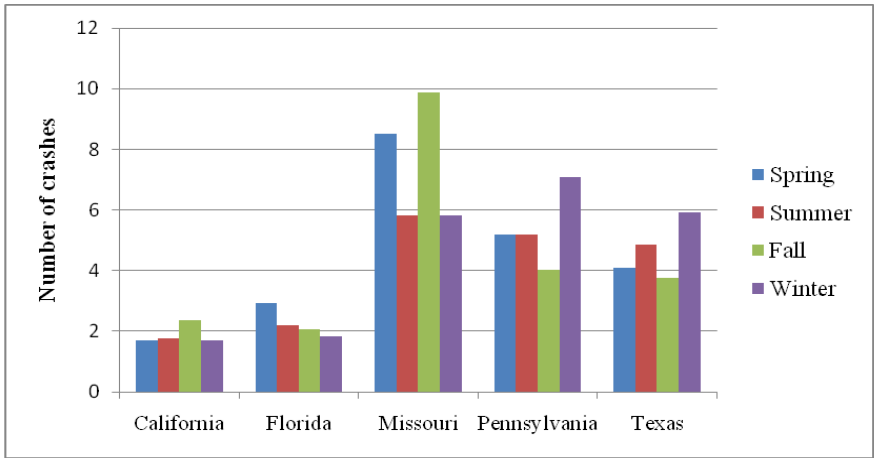

Figure 4.11: The proportion of crashes per MTR with property damage only in terms of season

4.1.3 Analysis of Crash Data in terms of Time of Day

In this analysis, the day (24 hours period) is divided into four periods of six hours each. Figure 4.12 indicates a significant proportion of accidents with fatal injury maily in early morning hours between midnight and 6 am, except the state of Pennsylvania for morning peak hours. The time between midnight and 6 am is also critical for cases of incapacitating injury in California, Florida, and Texas (this time is very significant for Texas through all analysis in terms of time of day). But in Missouri and Pennsylvania, it is evidence for morning and afternoon peak hours, respectively. Non-incapacitating injuries occur mostly during evening hours (Figure 4.14). Accidents with possible injury and property damage are most significant during afternoon peak hours (Figure 4.15 and Figure 4.16).

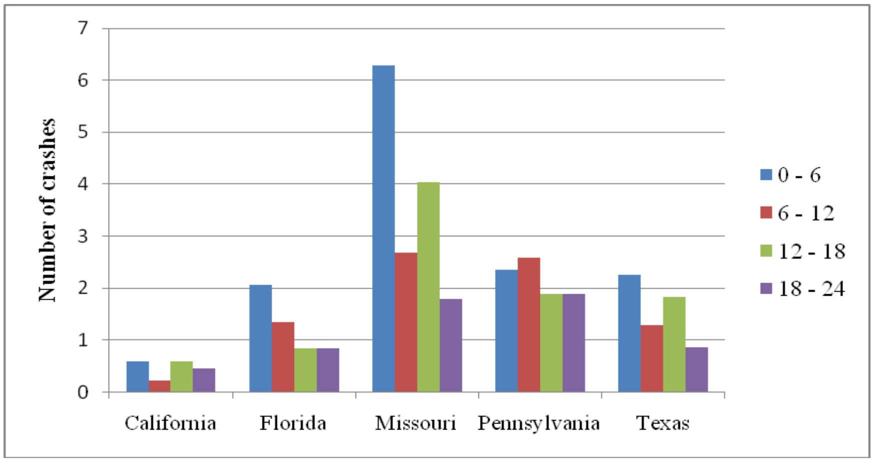

Figure 4.12: The proportion of crashes per MTR with fatal injury in terms of daily time

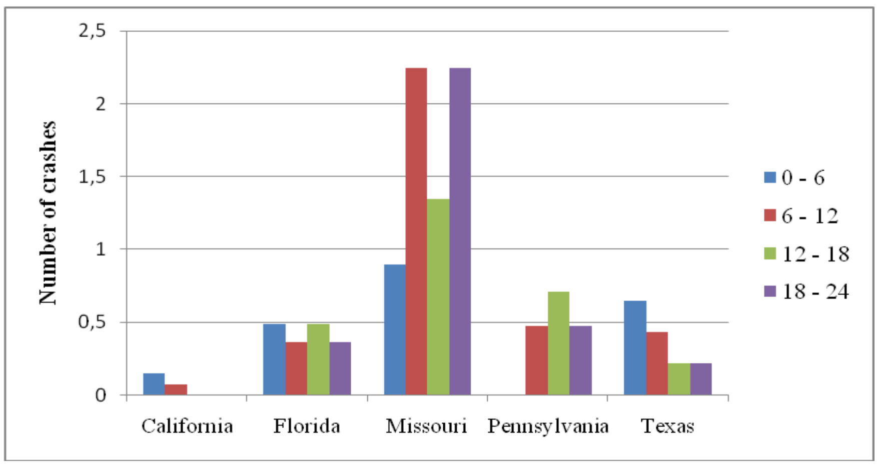

Figure 4.13: The proportion of crashes per MTR with incapacitating injury in terms of daily time

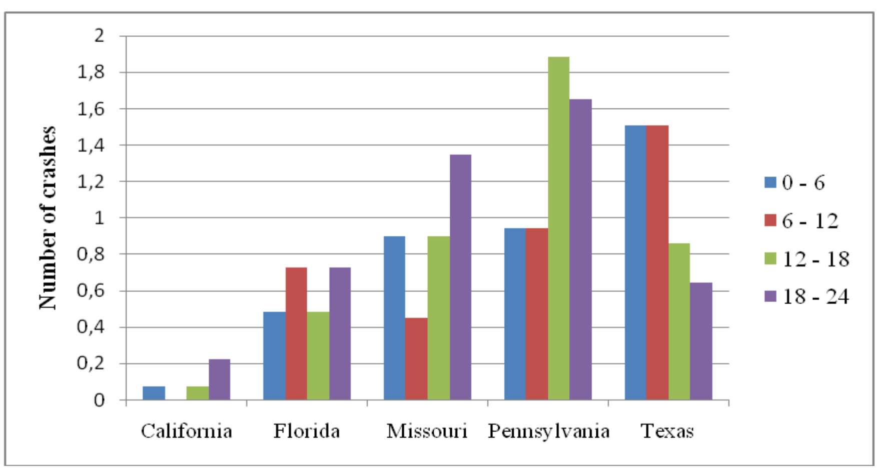

Figure 4.14: The proportion of crashes per MTR with non-incapacitating injury in terms of daily time

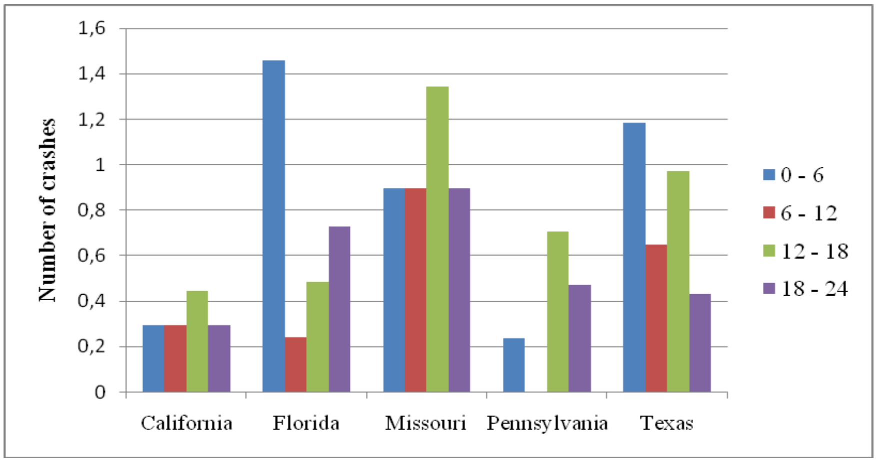

Figure 4.15: The proportion of crashes per MTR with possible injury in terms of daily time

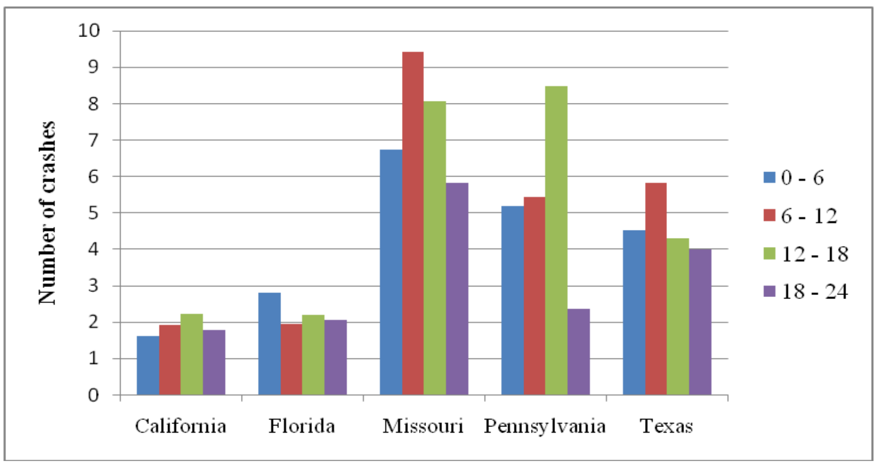

Figure 4.16: The proportion of crashes per MTR with property damage only in terms of daily time

4.1.4 Analysis of Crash Data in terms of Speeding

The number of accidents in which speeding was recorded is examined in this analysis. In Figure 4.17, it is shown that the most drivers violate the speed limit in the state of Texas. There is alarming 93 % proportion of all accidents which happened on roads. Moreover, as it was shown in Table 4.1 Texas has the highest permitted speed limit and also has the most miles of rural roads. The fact that there are many miles of long and straight roads through mostly desert areas explains a higher tendency of drivers

to tend to the violation. Also, it suggests that the State of Texas has a problem with law enforcement. Other states with higher numbers of rural roads are Missouri and California, where the proportion of speeding is not negligible. On the other side, states with the fewest violations are Florida and Pennsylvania, respectively.

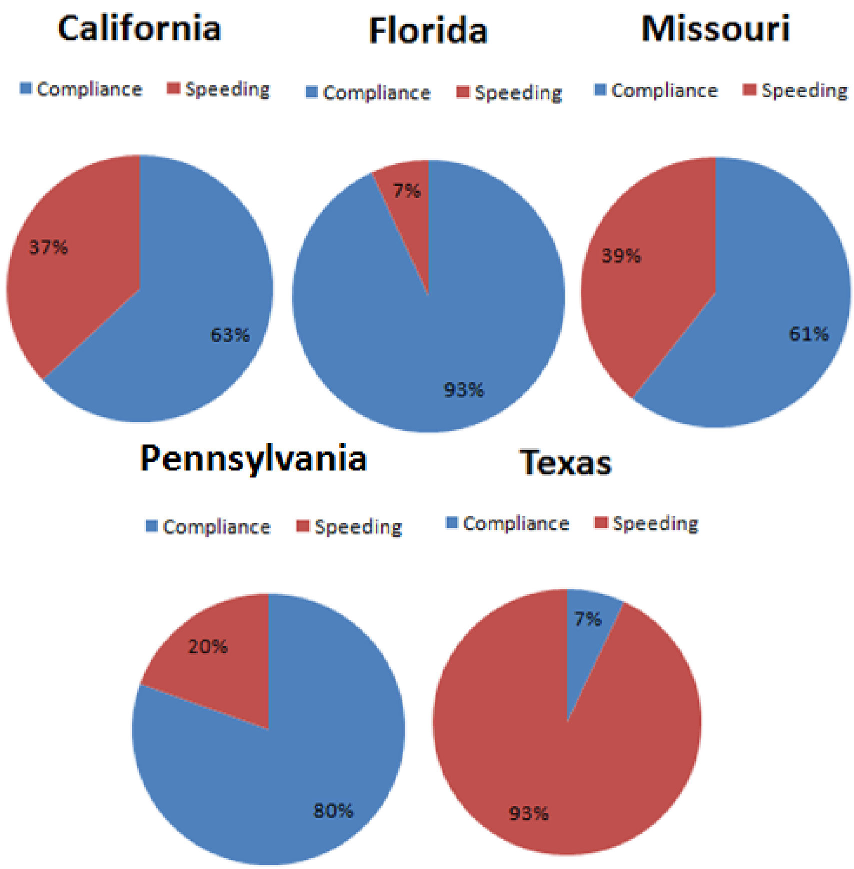

Figure 4.17: The proportion of crashes with speeding

4.1.5 Analysis of Crash Data in terms of Age

In this analysis, four age groups are examined in terms of serious accidents, accidents with minor injuries, and property damage only accidents. Insight into this issue can be provided by the Table 4.3, which shows what proportion of the population in particular age range, is licensed drivers.

Table 4.3: Licensed drivers by age in 2008 (Federal Highway Administration)

	≤19	20 - 39	40 - 59	≥60
California	943 083	8 989 243	9 233 551	4 531 790
Florida	760 179	4 523 767	5 063 046	3 686 582
Missouri	221 973	1 456 002	1 558 006	960 701
Pennsylvania	346 005	2 756 934	3 380 763	2 162 571
Texas	703 989	5 866 263	5 796 839	3 006 972

Based on Table 4.3 the number of crashes for a particular age-range is estimated to be one million licensed drivers (MLD). Figure 4.18 shows that the most serious accidents are caused by drivers between 40 and 59 years old in Missouri, Texas, and Pennsylvania, respectively. Prevalence of drivers of age between 20 – 39 years involved in serious crashes is found in Florida, and in California, respectively. In Figures 4.19 there is a significant proportion of range of 40 – 59 years involved in accidents with minor injury. In terms of property damage only, there is a tendency of drivers within the age-range of 40 – 59 years more involved in crashes in Missouri, Texas, and California, respectively; and the drivers within the range of 20 – 39 years are more involved in crashes in Pennsylvania and Florida, respectively.

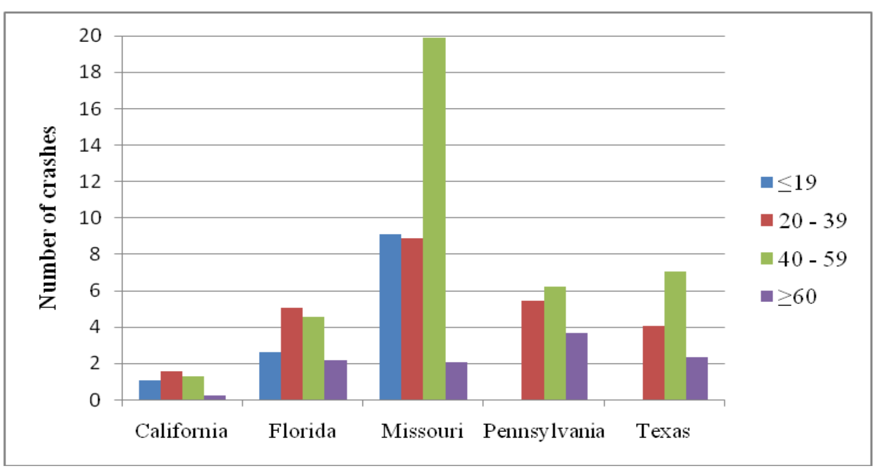

Figure 4.18: The proportion of crashes per MLD with FATAL and INCAP injury in terms of age

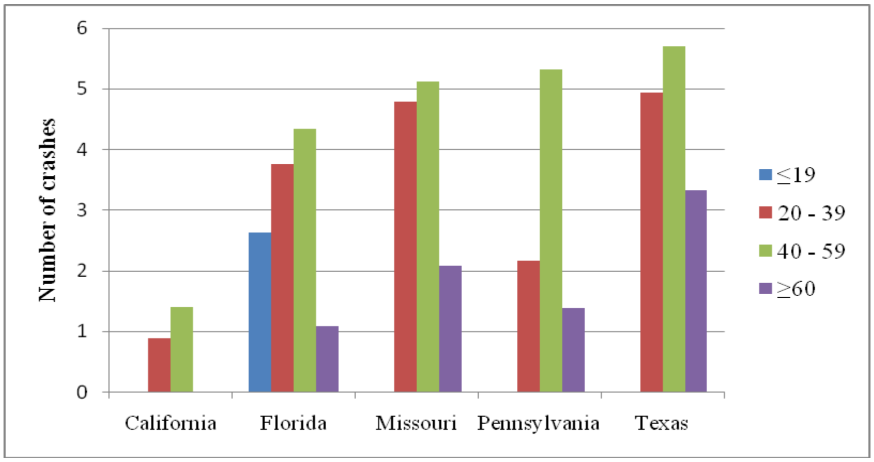

Figure 4.19: The proportion of crashes per MLD with NON-CAP and POSS injury in terms of age

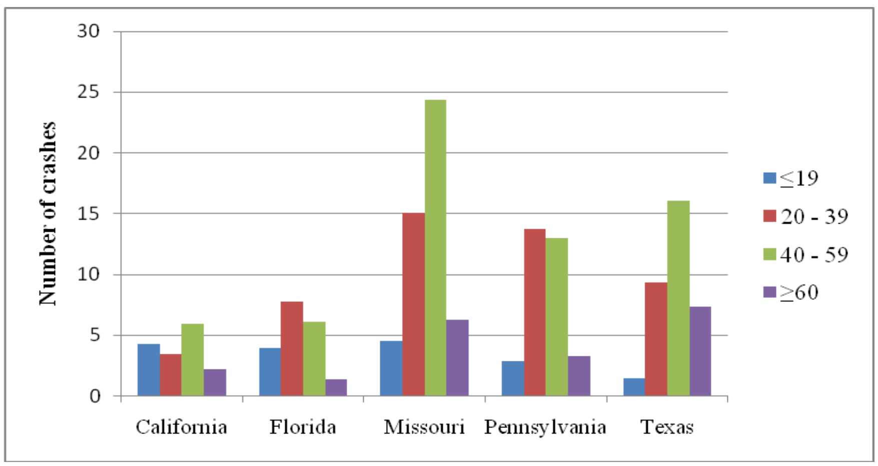

Figure 4.20: The proportion of crashes per MLD with PDO in terms of age

4.1.6 Analysis of Crash Data in terms of Gender

In terms of the gender of truck drivers involved in crashes, in general there is a significant proportion of the male population compared with female in all examined states. This fact can be seen in Figure 4.21. It can be caused because of greater number of male licensed drivers in comparison with female licensed drivers.

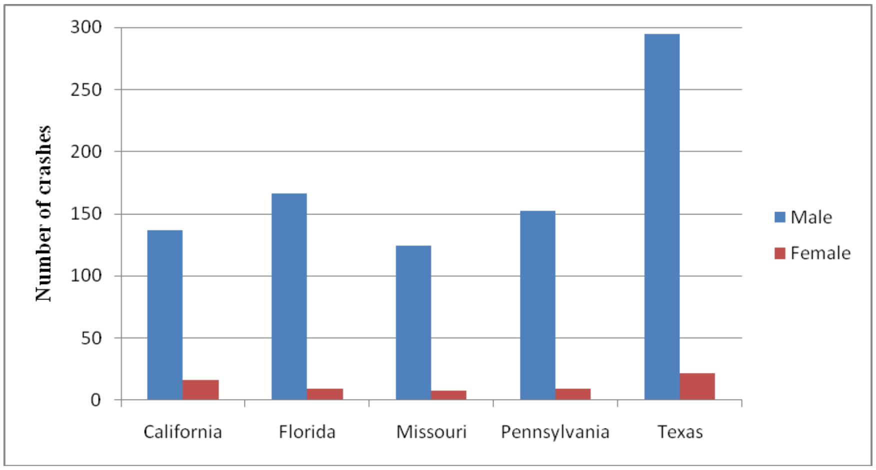

Figure 4.21: The proportion of crashes in terms of gender

4.1.7 Analysis of Crash Data in terms of Rollover and Jackknife

Rollover

In this analysis, rollover is considered any vehicle rotation of 90 degrees or more about any true longitudinal or lateral axis. It is also related to overturn cases. There may be two cases of rollover:

- Rollover, tripped by object/vehicle – it is presented by suddenly slowing or stopping the vehicle by an opposing force, inducing the rollover. As opposing force it can be considered pot-hole, another vehicle, curb, tree, and etc…
- Rollover, untripped - it is related to cases other than tripped by object/vehicle. It can happen due to vehicle instability.

In a paper, "*Rollover of Heavy Commercial Vehicles*" by Chris Winkler (2000), it is shown that relatively low roll stability of trucks more contributes to rollover. Furthermore, the untripped rollover is common for trucks but rare for cars. Figure 4.22 shows that in all examined states there is a greater tendency for case of rollover, untripped. An example for this case can be a situation in which the truck

drivers swerve to avoid a collision at high speed or when they carelessly pass sharp curves of highway ramps at high speed.

Jackknife

Jackknife is related to crashes involved only power unit/trailing unit combinations such as truck tractor or single-unit truck with one or more trailers. Jackknife occurs when the trailer attached to a semi-truck speeds up and it does not follow directly behind the trailer (power unit). In this analysis the occurrence of jackknife is examined from two possibilities:

- First event – when an uncontrolled situation was reported as occurring before or as part of the first injury or damage producing event for this vehicle
- Subsequent event – when an uncontrolled situation occurs after the first injury or damage producing event for the vehicle

This type of accident can take up several lanes due to the position of truck and trailer after accident and it can stop traffic for several hours. Causes of jackknife are, for example, adverse conditions (icy and wet surface, unexpected gust of wind), speeding, entering a curve at too high speed, and braking improperly. In Figure 4.22 it can be seen that the most common case is jackknife as "subsequent event" and also that there is more of tendency to rollover than jackknife in all states.

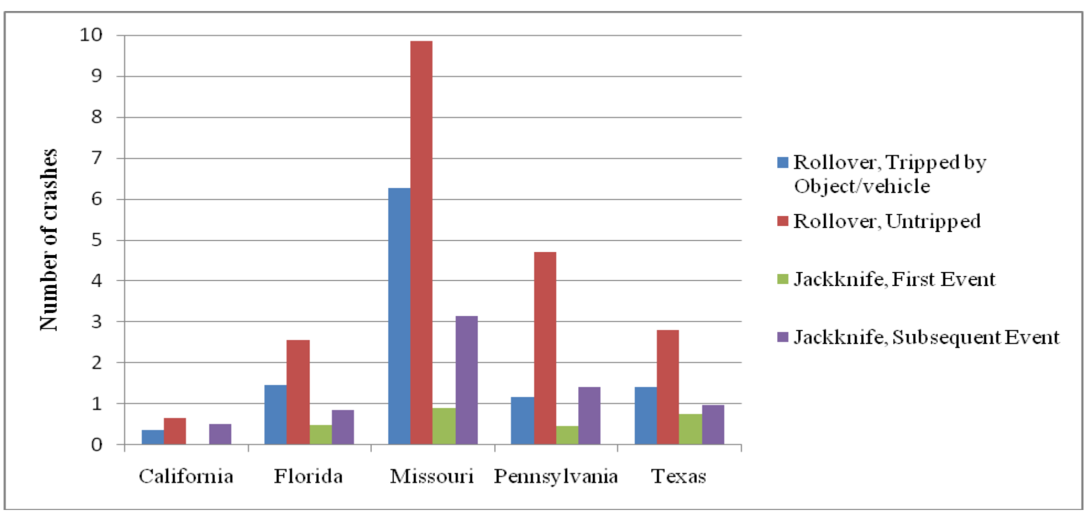

Figure 4.22: The proportion of crashes per MTR in terms of rollover/jackknife

4.1.8 Analysis of Crash Data in terms of Vehicle Maneuver

The vehicle maneuver for this analysis is considered to be the driver's action or intention prior to the beginning of a collision. The most occurring vehicle maneuver prior to crashes, in each of the examined states, is going straight. The number of occurrences of this situation is 103, 140, 89, 84, and 252 for states of California, Florida, Missouri, Pennsylvania, and Texas, respectively. The fact that the drivers do not manage to respond to incoming collision in front of them may indicate drowsy driving, driving while drunk, speeding or distracted driving. For example, it can result in crossing into oncoming traffic followed by fatal accidents. Furthermore, the Table 4.4 lists other common vehicle maneuvers that occurred during the reporting period.

Table 4.4: The list of examined vehicle maneuvers

Marking of Maneuver	Description of Vehicle maneuver
2	Slowing or stopping in traffic lane
3	Stopped in traffic lane
4	Controlled maneuver to avoid an Object
5	Changing lanes or merging
6	Negotiating a curve

Figure 4.23 indicates that the vehicle maneuver of stopped-in-traffic lane (vehicle maneuver 3) is the most common action before collisions in Missouri, Texas, and California. Stopped-in- traffic constitutes a vehicle which is stopped on the traffic way in an area normally used for vehicle travel such as outside a parking lane. In this situation, a rear-end accident is very likely. Also, vehicles trying to avoid the stopped vehicles face the risk of unforeseen circumstances in the opposite direction. In the Pennsylvania there is strong evidence of negotiating a curve (vehicle maneuver 6). This is also one of dangerous vehicle maneuvers, where the speed is number one for fatal accident. Moreover, Pennsylvania

is the northernmost state from all examined states so there is greater presence of weather condition such as snow, sleet, icy, and black ice which contribute to failure of this vehicle maneuver. Another most common vehicle maneuver for Florida is changing lanes or merging (vehicle maneuver 5). This implies that drivers are less careful in passing other vehicles, checking blind spots, and keeping proper speed. All failures of the enumerated vehicle maneuvers can bring fatal consequences. The trigger for this situation can be driver's fatigue. Therefore, there arises a need for attention towards the legislation of working conditions of truck drivers.

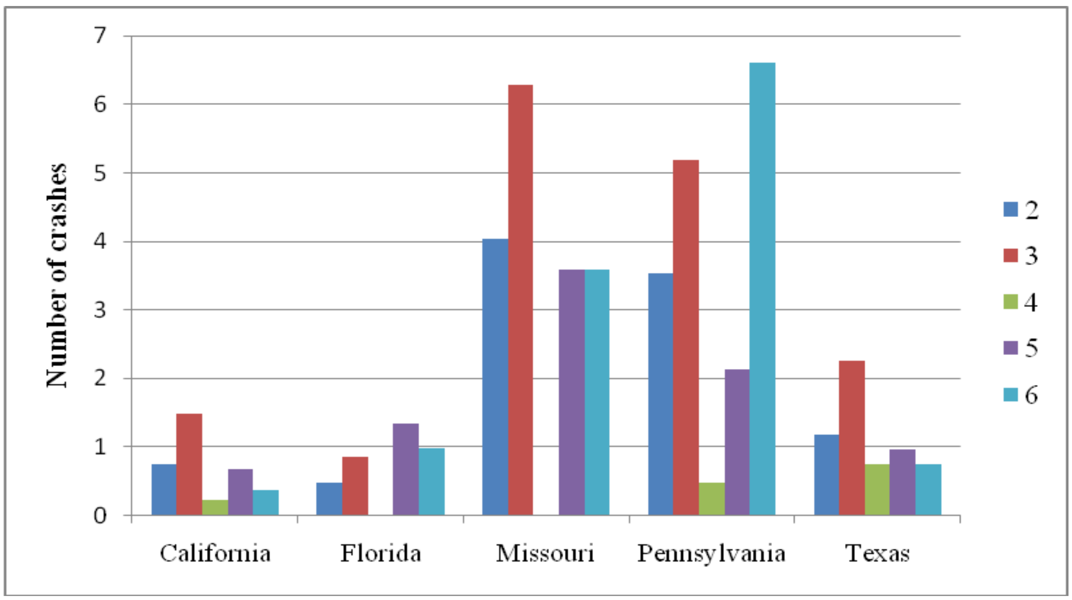

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Figure 4.23: The proportion of crashes per MTR in terms of vehicle maneuver

4.1.9 Analysis of Crash Data in terms of Manner of Collision

In this step of analysis the possibilities of occurrence collision listed in Figure 4.24 are examined.

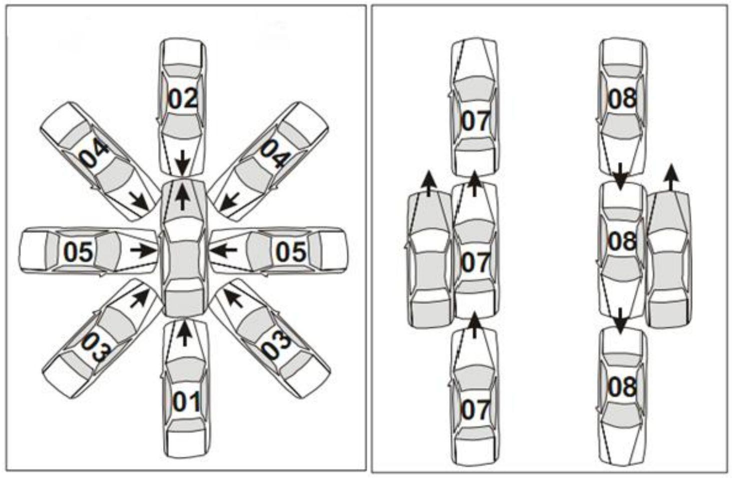

Figure 4.24: The examined manners of collision (FARS, 2009)

In Figure 4.25, the greatest proportion of Front-to-Rear collisions (collision 1), includes all Rear-ends and it is indicated in all states. This fact is also related to the previous step of analysis where the most common vehicle maneuver before the accident is going straight. The reason can be that drivers often tend to speeding and tailgating and they do not have enough time for taking a proper reaction. Another frequent collision is Front-to-Side, right angle (collision 5) what can be found mainly in Florida and Texas. This type of collision often occurs at intersections where reckless drivers fail to yield at a red light or stop sign. This collision is also more likely to be fatal than Front-to-Rear accidents of similar force. On the other side in California and Pennsylvania there is a tendency toward Sideswipe – Same direction (collision 7). This kind of collision occurs when one driver attempts to make a lane change without properly looking or when the driver carelessly drifts into the adjacent lane, distracted by phoning, sleepy or driving while drunk. In Missouri, the second most significant collision after Front-to-Rear is Front-to-Front (collision 2), includes all Head-On. This type of collision occurs when front ends of vehicles hit the objects in front of them, such as trees, walls, or other front ends of other vehicles. It results in more catastrophic consequences than other type of accident. The most common reasons for this collision are unsafe passing, driver distraction or fatigue, driving while drunk, or swerving to avoid an object on the road. There is also inattention of drivers when they fail to enter a freeway via off-ramp instead of an on-ramp. This fact is often associated with influence of alcohol or drugs, or fatigue and

overwork. The next occurred collisions are Front-to-Side, opposite direction (collision 4), what can be found mainly in Missouri and Texas. They are common at intersection and across streets.

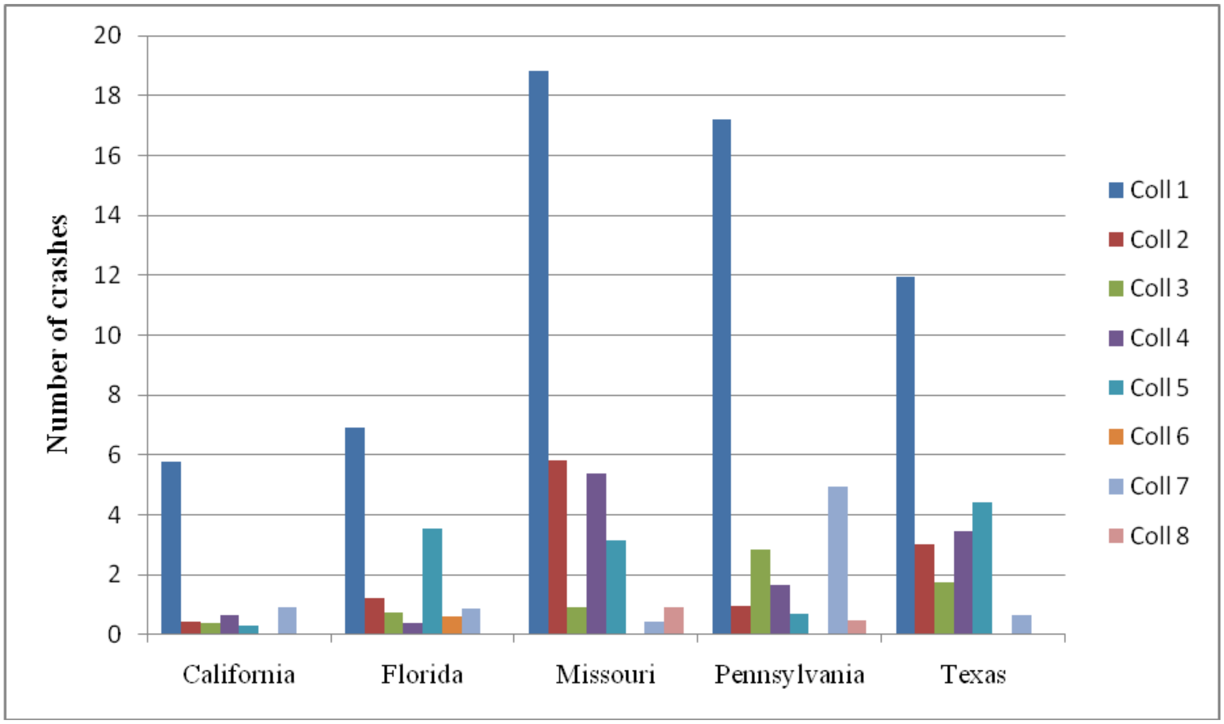

Figure 4.25: The proportion of crashes per MTR in terms of manner of collision

4.1.10 Analysis of Crash Data in terms of Weather Conditions

The last step in this analysis of crash data from the U.S. is a look at the weather conditions under which the accident occurred. As a result, it will be able to see what weather conditions contribute most to accidents in particular state. The weather conditions that the most occurred and which proportion of accidents is examined are listed in Table 4.5.

Table 4.5: The list of examined weather conditions

Marking	Description of weather conditions
1	Rain
2	Fog, smog, smoke
3	Severe crosswinds
4	Blowing sand, soil, dirt
5	Sleet (hail)
6	Snow or blowing snow

Figure 4.28 shows that the most accidents were caused by rain in all states. The rain is a dangerous factor because it makes the road slippery (especially at the beginning of a rain, because when the roads first get wet, oil rises to the surface and a greasy surface is created). Another effect of rain is impairment of visibility. The season of rainfall can be found, for example, in months of May, March, and April in Texas, in months of June through September in Florida, and etc… Only in California there is a slightly greater tendency of blowing sand, soil, dirt than rain. The Coastal and Southern parts, which are the most populated, are known by dry summers. The cause of blowing sand has also a significant proportion in Texas, where similar dry climate can be found especially in west and south area. In Missouri and Florida the frequent weather conditions caused the accidents are fog, smog, and smoke. Especially, Florida has a winter maximum in dense for conditions and there is the highest annual occurrence of fogs per year, on average in comparison with remainder of the Southeastern region of the U.S. In general the fog is dangerous because it reduces visibility, limits contrast and distorts perception, so that drivers have a problem to estimate the speed of other vehicles, or they may misjudge distance. On the other side, the drivers in addition to rain have to face snow and blowing snow in Pennsylvania the most. The cold climate and snowfall in larger quantity can be found mainly in the Northwest part of Pennsylvania. The harsh winter conditions can bring black ice and icy roads. Moreover, the driving on icy road is more risky as driving in the rain.

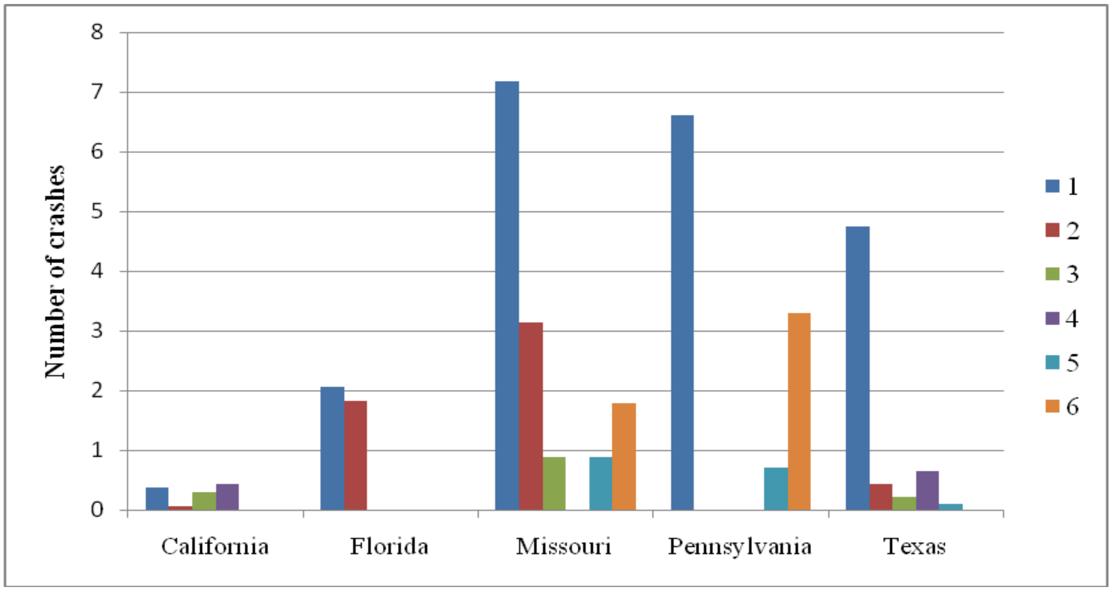

Figure 4.26: The proportion of crashes in terms of weather conditions

4.1.11 The Summary and Conclusion of Analysis of Crash Data from the U.S.

In this analysis, the number of crashes in the states of California, Florida, Missouri, Pennsylvania, and Texas was examined. The mentioned states were purposely selected from different areas of the U.S. The focus was also on driving conditions and the most common driver's behavior in a particular state. The purpose of the performed analysis was testing the null hypothesis which is that behavior of the truck-drivers as well as driving conditions in the mentioned U.S. states are the same, or at least similar. In this regard there were analyzed the following factors: season, time of day, speeding, age and gender, rollover or jackknife, vehicle maneuver, manner of collision, and weather conditions. Overall result of this analysis is established on the following facts.

The seasons of Summer and Fall were constituted as the period during which the most crashes happened in California. Furthermore, it was presented by Fall and Winter in Florida, Fall in Missouri, Winter in Pennsylvania, and Spring and Winter in Texas. In terms of time of day, there was significant time period between midnight and 6:00 a.m. for states of Florida and Texas. But in the case of California and Pennsylvania there was the evidence of time period between 12:00 a.m. and 6:00 p.m. The

proportion of occurrence of accidents in Missouri was divided equally into the three periods: 0 – 6 a.m., 6 – 12 a.m., and 12 – 6 p.m. Another factor was speeding. The most drivers tend to speed in Texas, where speeding was recorded in 93 % cases of all occurred crashes. For states of Missouri, California, Pennsylvania, and Florida was proportion of speeding 39%, 37%, 20%, and 7%, respectively. The prevalence of the age range of drivers involved in crashed between 40 and 59 years was the same for all states. However, the difference between age range 20 – 39 years and 40 – 59 in Florida was really small. The same was also for the greater proportions of male drivers involved in crashes compared with female drivers in all states. In terms of rollover or jackknife, there was a higher tendency of rollovers, untripped and jackknifes, subsequent event in all states. The common vehicle maneuver was going straight. The second most common vehicle maneuver occurred before accidents, was stopped-in-traffic lane in California, Missouri, and Texas. On the other hand, for the states of Florida and Pennsylvania it was the changing lane or merging, and negotiating curve, respectively. There was the same manner of collision which was Front-to-Rear. After this collision there was a tendency of Front-to-side collisions in Florida and Texas, and a strong evidence of Sideswipe, same direction was recorded in California and Pennsylvania. In Missouri there were typical Front-to-Front collisions. Finally, the weather conditions were analyzed. In all states, a significant contributor for crashes was rain. Next, blowing sand, soil, and dirt were detected as causes of accident in California and Texas. The fog, smog, and smoke were typical reasons for collisions in Florida and Missouri and in Pennsylvania it was snowing and blowing snow.

Based on previous mentioned facts, it can be concluded that there are more differences in driving conditions and driver behavior in certain situations within the examined states than common features. The inference can be drawn that there is evidence to reject the research question that behavior of the truck-drivers as well as driving conditions in mentioned U.S. states are the same, or at least similar.

There is an objective outcome to the effect that most cases of accidents may be caused as a result of fatigue. This maybe is a significant attribute or trigger of collisions. However, one way to remove the tired drivers off the roads is to modify legislation of working conditions of truck drivers.

4.2 The Analysis of Crash Data from the EU

Since there is no uniform database about accidents involving heavy good vehicles (HGVs) in the European Union (because there are different definitions and records about accidents from the one EU country to the other), this analysis will provide an overall summary of accidents in the EU, not so detailed as in the previous section of analysis of crash data from the U.S. The goal is to work towards the conclusion that driver's fatigue is also an important factor contributing to serious accidents and also that appropriate legislation for work of truck drivers can reduces or prevents these accidents.

First at all, the data from the CARE database are used. This is Community database that comprises data on accidents resulting in death or injury. Based on these data, Figure 4.27 shows rates of fatalities in accidents involving HGVs between years 1999 and 2008 in a decreasing tendency. Figure 4.28 illustrates that more than half fatalities happen on rural roads.

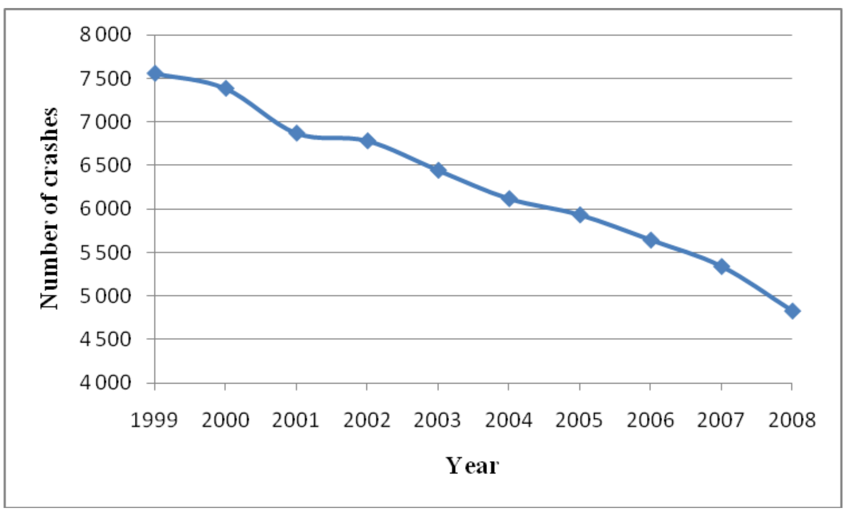

Figure 4.27: Fatalities in accidents involving HGVs between years 1999 and 2008

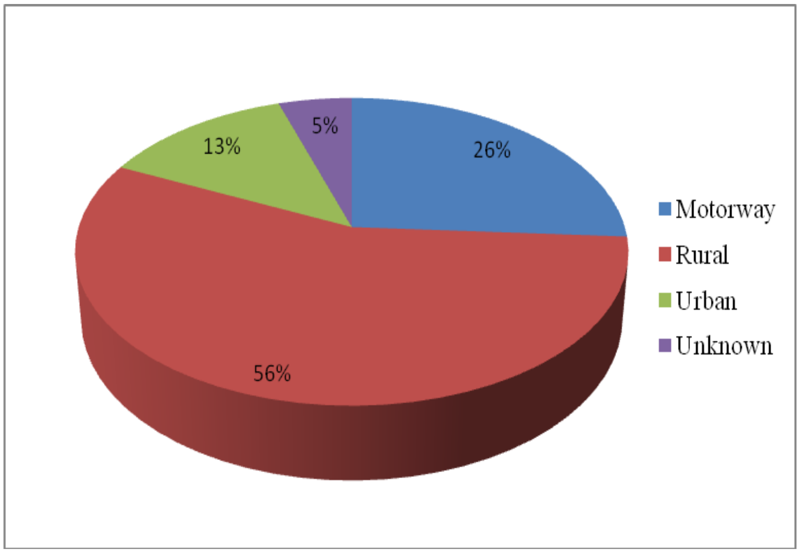

Figure 4.28: Fatalities in accidents involving HGVs by road

Furthermore, the most critical period of the year (according to 2008) for occurrence of fatalities on accidents involving HGVs are months of June and August (Figure 4.29). In Figure 4.30, the weather conditions contributing to accident are examined. Up to 83% fatalities occurred in good weather conditions. Excluding adverse weather there is a higher probability of human errors that could be caused by fatigue. Otherwise, the rain contributes to fatalities at most.

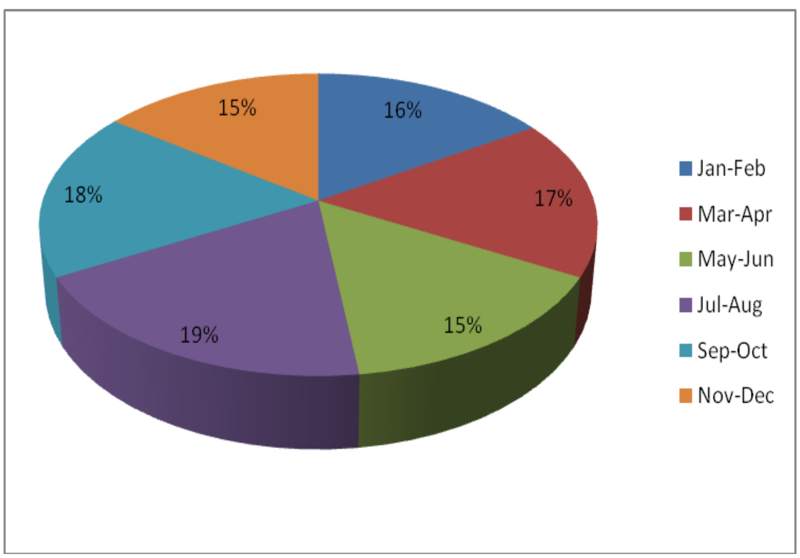

Figure 4.29: Fatalities in accidents involving HGVs by months

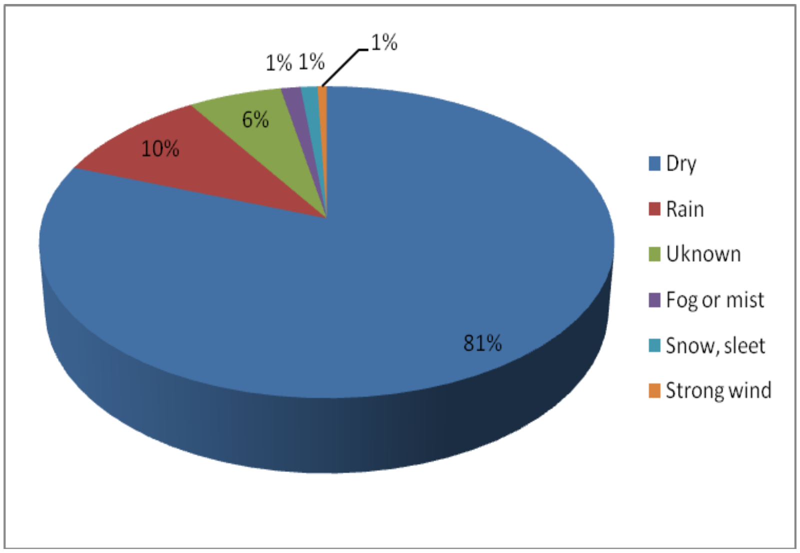

Figure 4.30: Fatalities in accidents involving HGVs by weather conditions

A Scientific Study “ETAC“ (European Truck Accident Causation, 2006) shows the main causes that made the greatest contribution to accidents involving trucks. The result is illustrated in Figure 4.31. Human error was determined as a main cause of accidents, either on side of truck driver, car driver or pedestrians (it is represented by 85,2% of cases of accidents). However, out of the 85.2% of the cases where human failure played a role, 25% of accidents were caused by truck drivers.

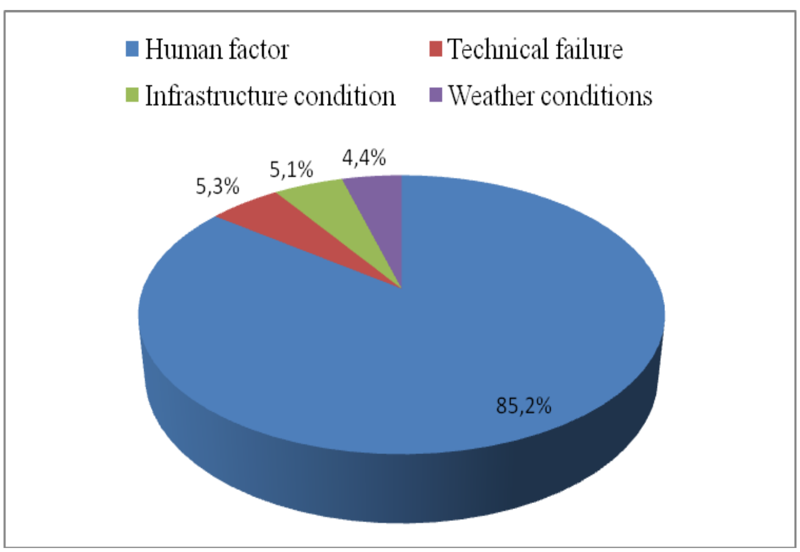

Figure 4.31: The main causes of accident involving HGVs

In terms of fatigue, there were 6% of accidents caused by tired drivers and 37% of these were fatal. In the cases when fatigue played a significant role in accident, there were two critical time periods of day indicated. Most accidents happened between 2:00 and 2:59 a.m., and then between 3:00 and 3:59 p.m.

Another study Road Safety Report HGV (Dekra, 2009) also deals with causes of accidents involving HGVs mainly on German roads, which are shown in Figure 4.32. This report also pointed out that 24% of disturbance of sensory perception, as a cause of accidents, constitutes falling asleep. The reason can be irregular working hours with varying waking and sleeping hours because many drivers have to deal with night driving and day sleeping which may not be in accordance with circadian rhythm of human being. This all can result in development of sleeping disorders.

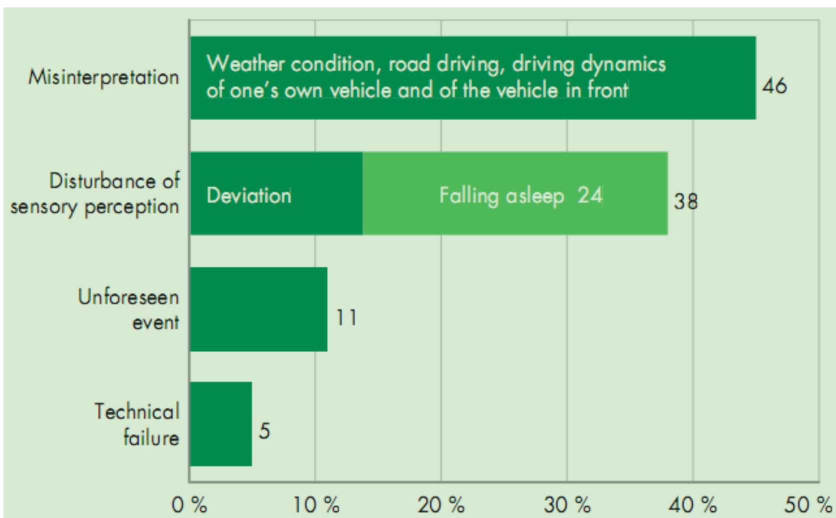

Figure 4.32: Events giving rise to accidents (Dekra, 2009)

4.2.1 The Summary and Conclusion of Analysis of Crash Data from the EU

In this analysis, it was found that the uniform database dealing more detail with accidents involving HGVs is still missing. Fortunately, there are several working groups in area of transportation that deal with those accidents. Based on the previous analysis, it can be concluded that there is the

positive trend in accidents involving HGVs in the EU. The most accidents occurred on rural roads and during summer months of June, July, and August. In terms of weather conditions, 83% of the accidents occurred in dry weather conditions. Otherwise, the rain was indicated as the second most common reason caused accidents. It was also found out that there is considerable proportion of human factor as cause of accidents. It should be noted that the fatigue can be one of triggers for human failure. Furthermore, it can be concluded that there is time of day when fatigue plays a significant role in accidents. For this time is typical period between 2:00 – 2:59 a.m. and 3:00 – 3:59 p.m.

Chapter 5: The Conclusion and Recommendations

This thesis deals with condition monitoring of truck drivers in the EU and U.S. Based on the analysis of requirements of social legislation for the work of truck drivers, it was found that differences exist in policies of both the EU and the U.S. (Table 3.1 and Table 3.2). It was concluded that those rules have different effects on daily truck driver's performance, whether driving tasks or rest periods, during single trip as shown in Figure 3.1 – 3.5. Focus was also on factors such as behavior of truck-drivers, driving conditions as well as causes of accidents. In closing, these mentioned factors differ amongst the five U.S. states, purposely chosen from different areas of the U.S. In the EU, it was impossible to conduct such analysis since there is no uniform database of crash data of the same extent as in the U.S. Based on crash data analysis from U.S. (Figure 4.12 – 4.16), it is possible to suppose that the driver's performance is not the same throughout the day, rather, it varies depending on circadian rhythm of human being and time of day. The same conclusion was also accomplished in reviewed studies from the EU. In terms of analysis of crash data from the five chosen U.S. states, it could be seen that the largest deterioration in driver's performance associated to the fatal accidents constitutes time period between midnight and 6:00 a.m. Results from other studies can bring a more evidence for the confirmation of this assumption.

The study by Freund and Vespa (1997) and by European Transport Safety Council (2001) identified the high risk of accidents between midnight and 6:00 a.m., with peak period between 2:00 – 5:00 a.m. It was also pointed out that the risk of accident is ten times higher in this period than during day-driving. The higher frequency of accidents between midnight and 6:00 a.m. was found in study by Häkkänen and Sumala (2001) and more severe accidents at that time by Blower and Campbell (1998). The study by Horne and Reyner (1995) reached the same conclusion what is shown in Figure 5.1.

Based on the previous facts, it may be concluded that the time between midnight and 6:00 a.m. is a significant time in terms of accidents and, hence, constitutes possible ways of improvements in the legislation of the working conditions of the truck drivers in the EU as well as in the U.S. Both policies

should limit driving at that time and force the drivers take rest periods which would include the mentioned time.

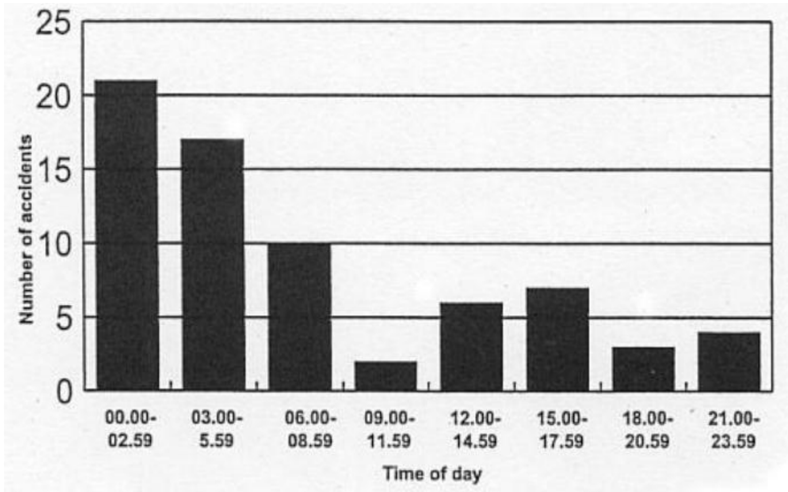

Figure 5.1: Number of accidents in terms of time of day (Horne and Reyner, 1995)

In the European Union, there are frequent cases of driving bans on the weekends or holidays which affect driver's circadian rhythms negatively and that force the drivers to start their "working day" at late night hours. The following are examples of driving bans in some states:

- Spain: on Sunday from 8:00 a.m. till midnight
- France: from Saturday at 10:00 p.m. till Sunday at 10:00 p.m.
- Austria: from 3:00 p.m. to midnight on Saturday, and from midnight to 10:00 p.m. on Sunday
- German: from midnight to 10:00 p.m. on Sunday and public holidays

Because of this, it would be appropriate to implement uniform law to extend driving bans, for example, until to 6:00 a.m. on Monday and so the drivers would not be forced to start their journey at late night hours by their employers.

Another area in which improvements in policy of working conditions of truck drivers can be found is the duration of driving tasks and related breaks. There were several studies performed in this area. Elvik et al. (1997) indicated that the risk of accidents is increased about three times after driving more than nine hours. In another study by Lin et al. (1994), the lowest risk of accidents was found out to

occur in first four hours of driving. This also increases from the fourth to the seventh hour by about 50 % more than in the first mentioned four hours. There is an increase in risk accidents by 130% after the ninth hour of driving. The study by Mackie and Miller (1978) showed deterioration in driving performance after 8 – 9 hours of driving; the probability of crashes begun to rise after the fifth hour of driving. In this area of improvements in policy of working conditions of truck drivers, there is a need to pay attention to regular breaks mainly in the U.S. These breaks should be taken after a maximum continuous five hours of driving with respect to road safety.

As it was expected in Chapter 2 the system of driver's wages can also affect their working environment and occurrence of crashes. Based on the comparison of system of driver's wages between the EU and the U.S., there is a clear indication of a severe disadvantage in the U.S. law which allows wages by the mileage. Thus, this restriction may exhibit very severe economic pressures on truck drivers who may often tend to violate the hours-of-service. This will rapidly increase the level of the driver's fatigue and the risk of accidents.

5.1 The Future Research

For better insight to the problem of truck driver's work, it would be appropriate also to analyze the requirements for qualification of driver's performance in both communities, the EU and the U.S. Certainly, it can be said that there are the differences. For future work, there is also the possibility to analyze the working conditions of truck drivers from others countries, for example, from Australia, and compare them with reviewed ones in this thesis. In EU, it could be seen that there is no uniform database of accidents involving HGVs and so the behavior of truck drivers as well as causes of accidents cannot be understandable clearly. It would be appropriate to propose the uniform structure for recording those accidents in all EU states.

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Appendix A: The Daily Driver's Logs for Particular Example According to European Union Rules

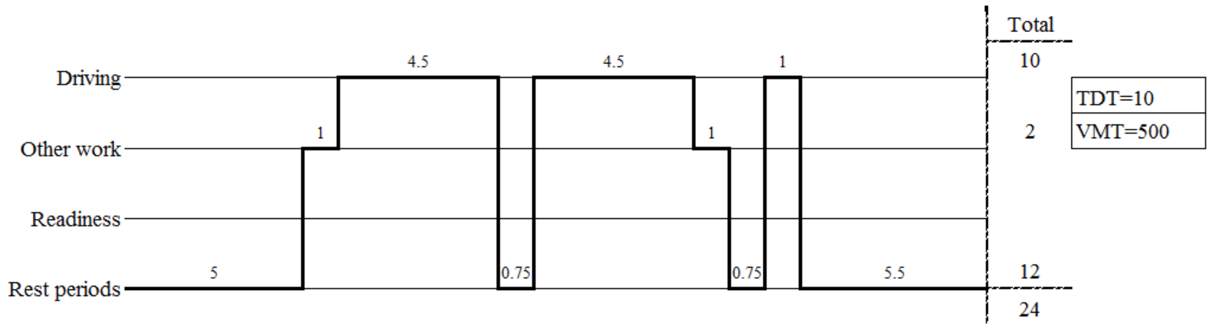

Figure A.1: The log from Day 1 - Monday

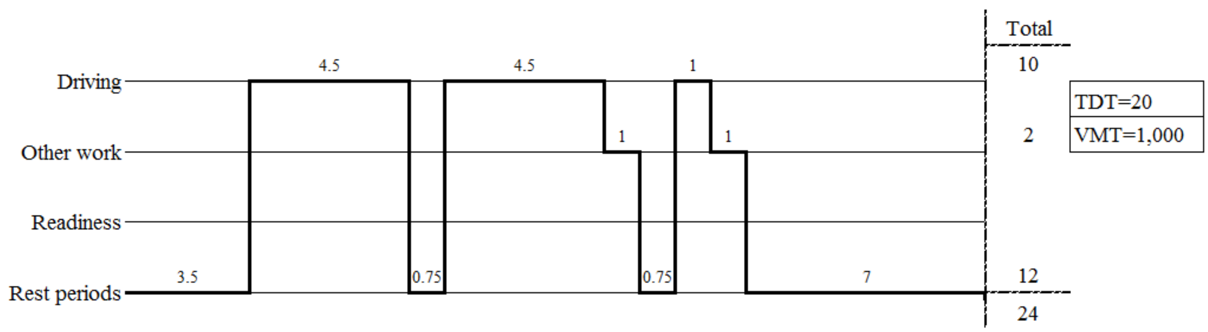

Figure A.2: The log from Day 2 - Tuesday

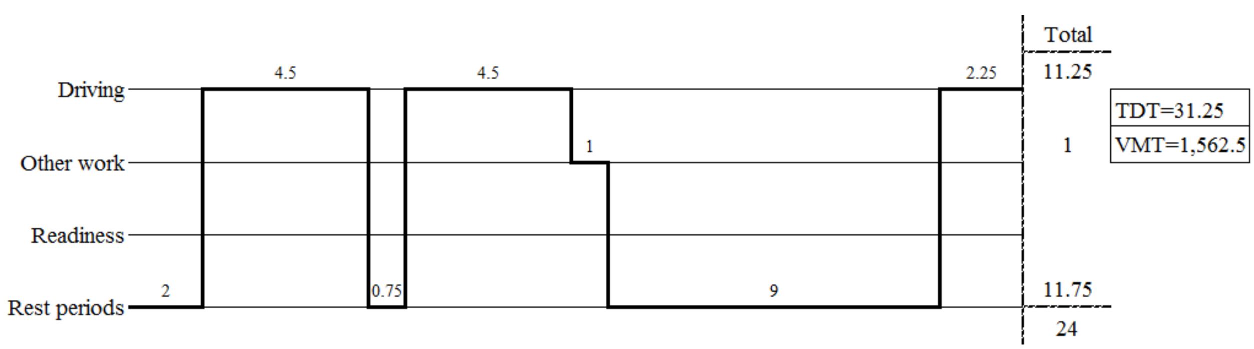

Figure A.3: The log from Day 3 - Wednesday

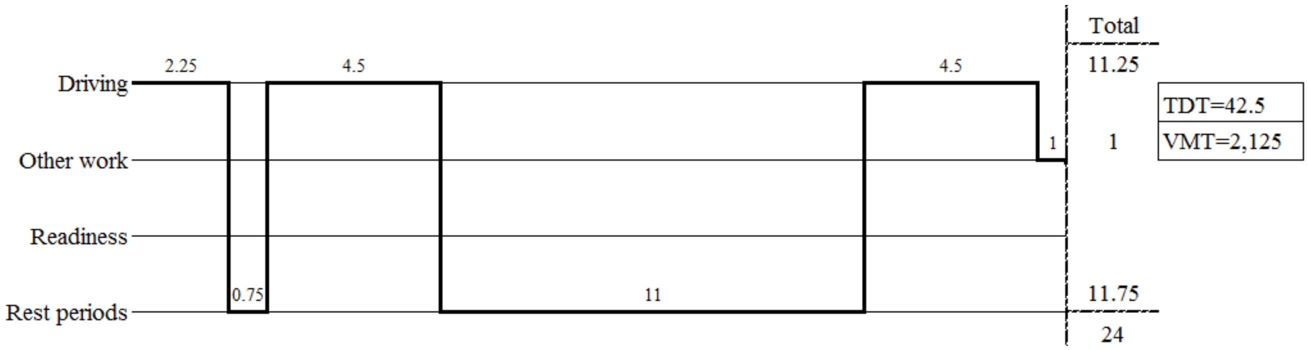

Figure A.4: The log from Day 4 – Thursday

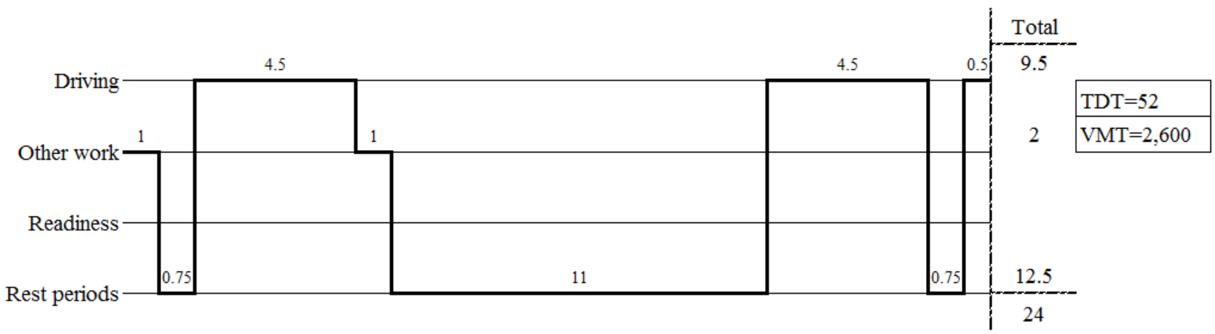

Figure A.5: The log from Day 5 – Friday

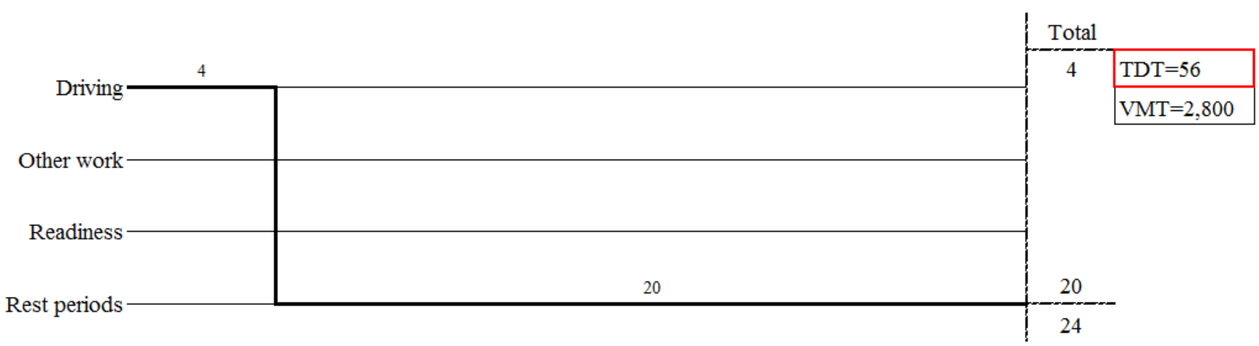

Figure A.6: The log from Day 6 – Saturday

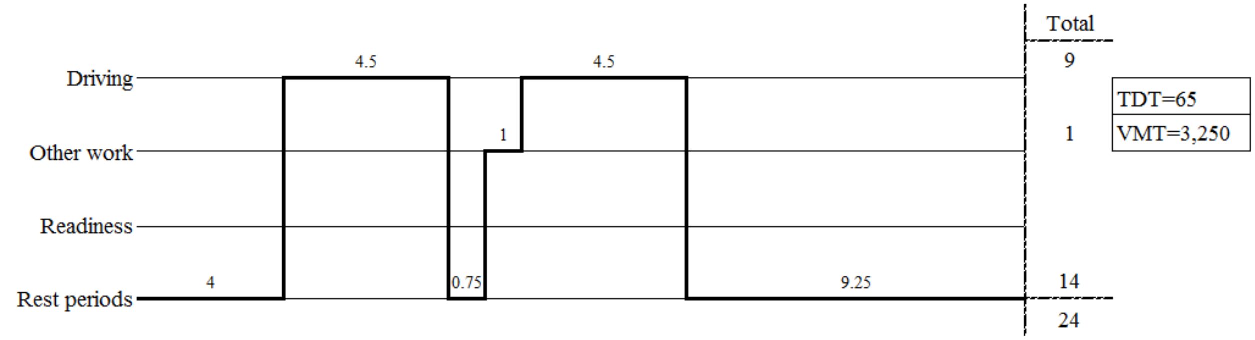

Figure A.7: The log from Day 7 – Sunday

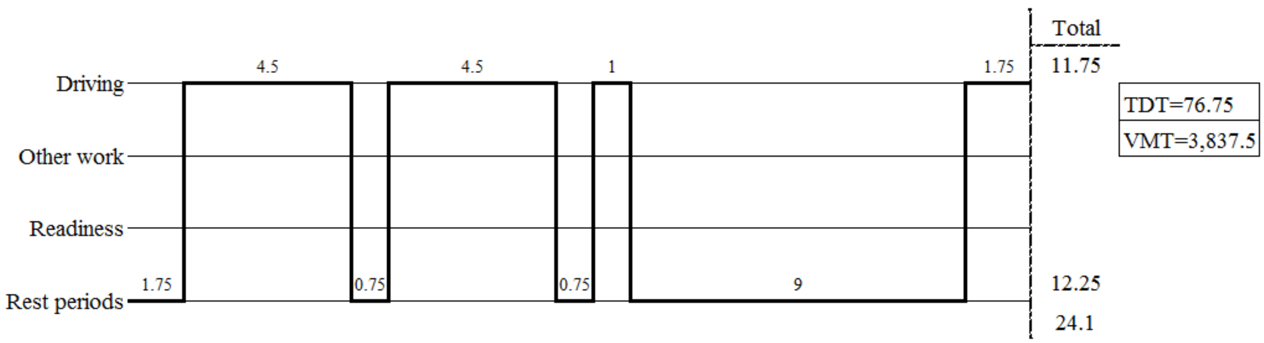

Figure A.8: The log from Day 8 – Monday

Figure A.9: The log from Day 9 - Tuesday

Appendix B: The Daily Driver's Logs for Particular Example according to USA Rules

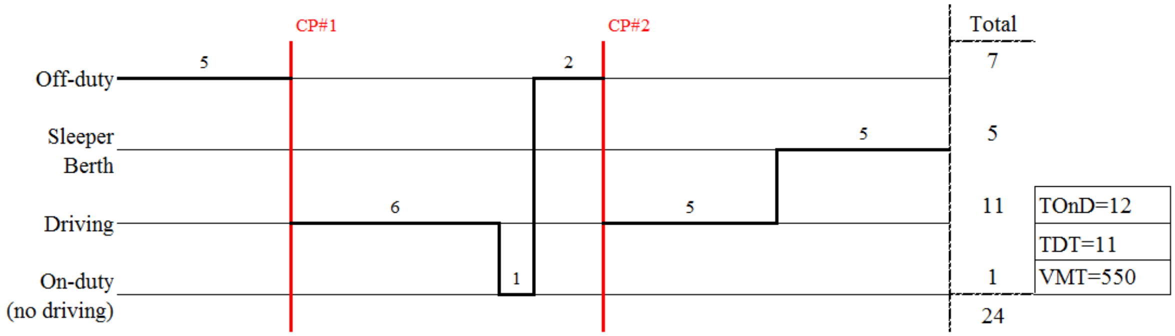

Figure B.1: The log from Day 1 – Monday

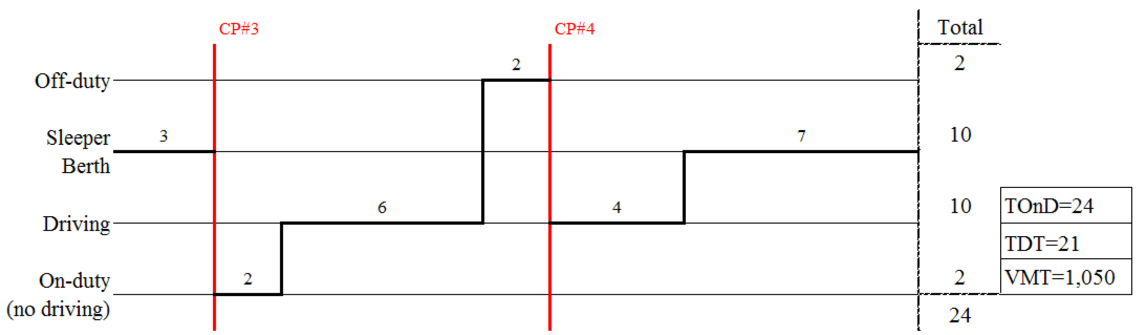

Figure B.2: The log from Day 2 – Tuesday

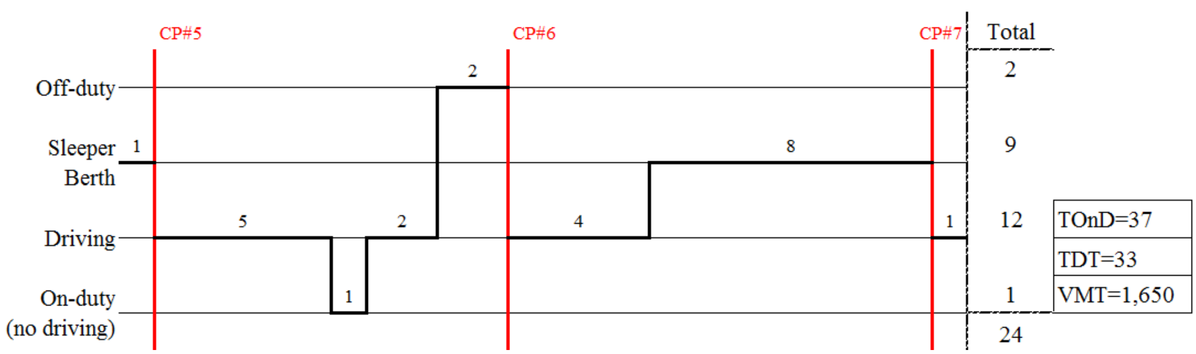

Figure B.3: The log from Day 3 - Wednesday

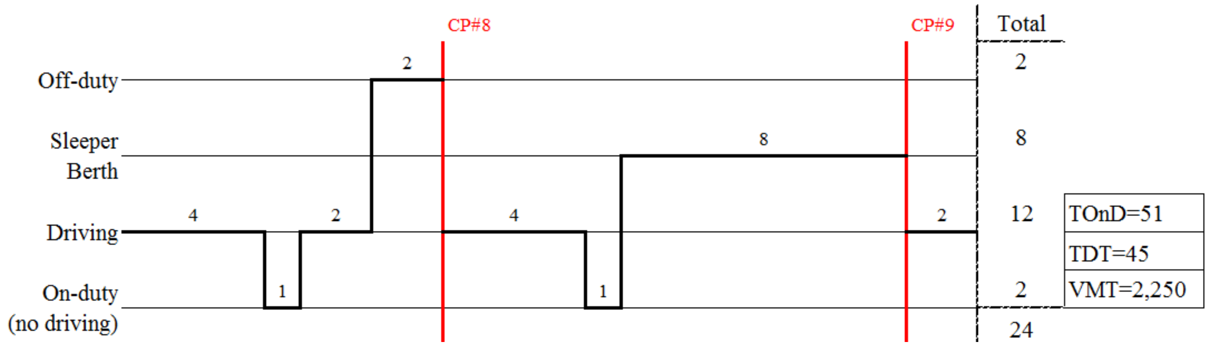

Figure B.4: The log from Day 4 – Thursday

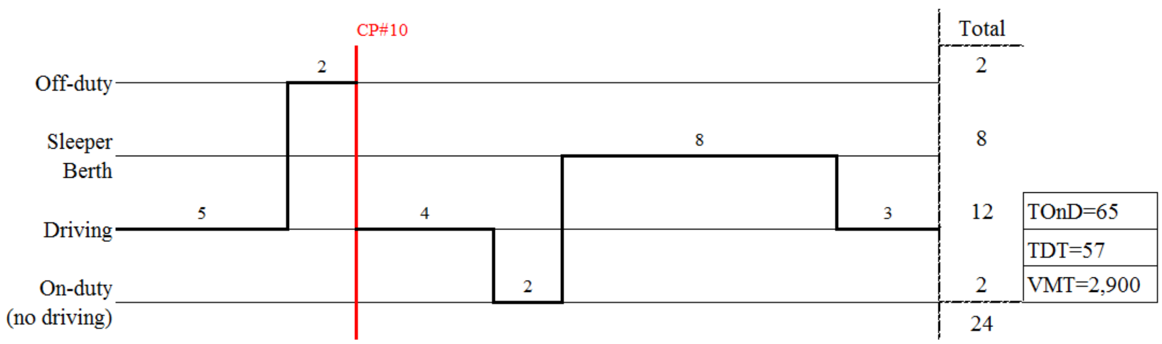

Figure B.5: The log from Day 5 – Friday

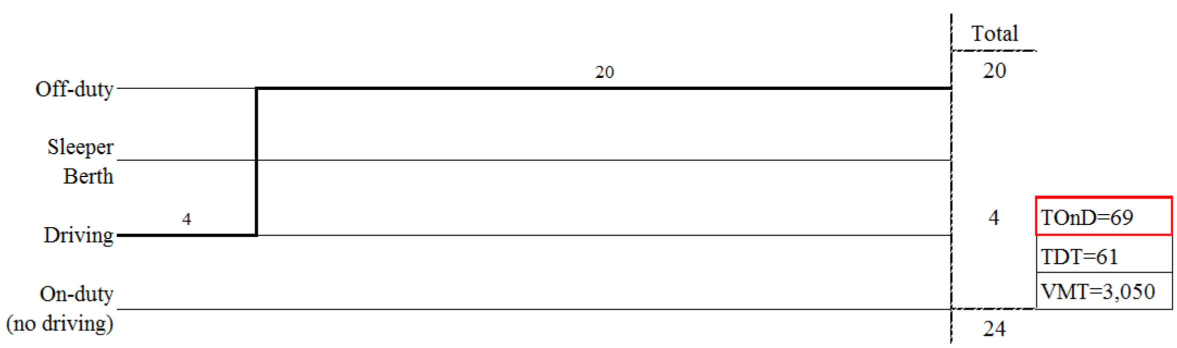

Figure B.6: The log from Day 6 – Saturday

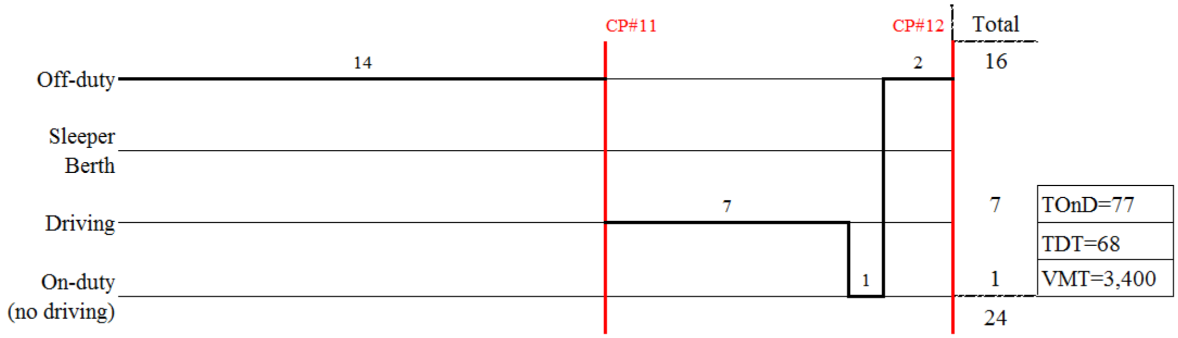

Figure B.7: The log from Day 7 – Sunday

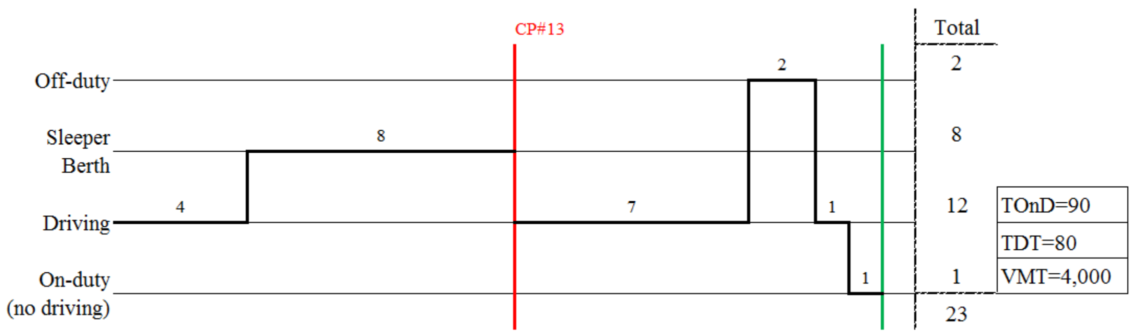

Figure B.8: The log from Day 8 – Monday

Vita

Stefania Semanova was born on 26th of December in Kosice and raised in Skaros, Slovakia. She is the second born child from Stefan Seman and Maria Semanova and she grew up with her two brothers. She attended High School of Transportation in Kosice, where her major was Operation and Economics of Transport – Logistics. After four years of attendance High school, she graduated on May 2007. From September 2007 she was enrolled for University of Zilina in Zilina, Faculty of Operation and Economics of Transport and Communications. In May 2010 Stefania Semanova obtained her Bacheolor's degree (Bc.) in Forwarding and Logistics major. Then, she continued in doing of Engineering degree in University of Zilina in Zilina, major of Forwarding and Logistics. Due to her academic achievements, she received the scholarship from European Union for studying at University of Texas at El Paso in Civil Engineering major. She became a participant of The Atlantis Dual Master Degree Program (Ing. & MSCE.).

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