LONGER COMMERCIAL VEHICLES – WORKLOAD INVESTIGATION OF DRIVERS AND OTHER ROAD USERS

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Abstract

To overcome the challenges of the prospected further growth of the freight transport market longer commercial vehicles are one approach to increase road freight transport efficiency. Even though these vehicles were already introduced in some Member States of the European Union and experiences in field tests have been made, there is a lack of robust scientific knowledge regarding the impact of these vehicles on the workload of its drivers and of other road users. Therefore, this paper summarises the existing knowledge on workload investigations and describes a scientific approach on how to investigate in a sound methodology the workload of LHV drivers and other road users within a field test. This methodology is proposed to be used within the German field test of Longer and Heavier Vehicles (LHVs).

Keywords: Longer commercial vehicle, LHV, simulator test, field test, Directive 96/53/EC

1. Initial Situation and Existing Knowledge

1.1 Motivation

Backed by the economic recovery in the European Union the prognosticated increase of freight transport volume of up to 50 % in the EU 25 between 2000 and 2020 can still be assumed as accurate (Ickert 2007). To face the challenges this growth poses, politics, industry and science are working on different commercial vehicle innovation paths towards an increase in efficiency of the road freight transport system (cf. Figure 1). This work includes considerations on adapting the rules of weights and dimension of heavy commercial vehicles in the European Union as established within directive 96/53/EC.

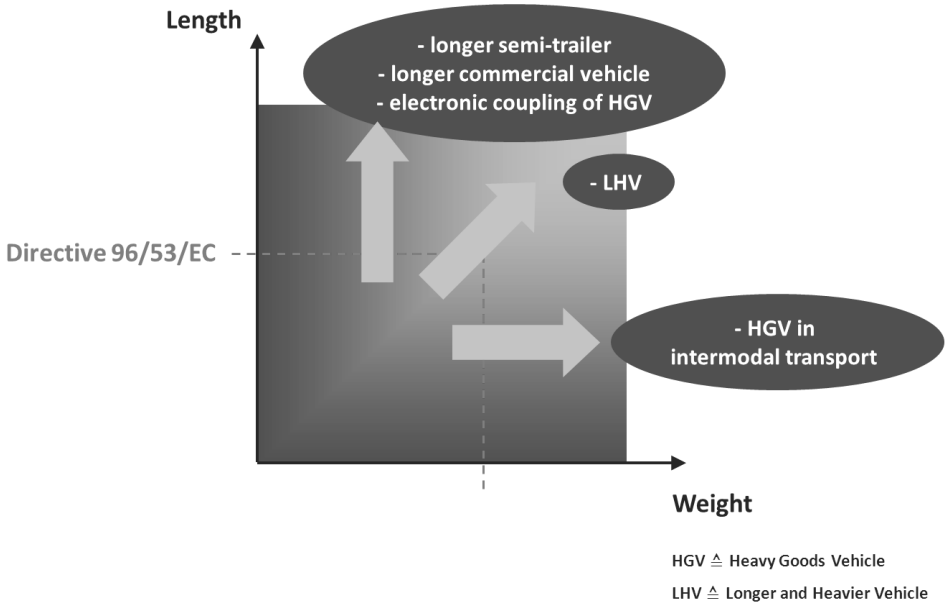

Figure 1 – Commercial Vehicle Innovation Paths

The possible introduction of longer and/or heavier commercial vehicles across the European road network is basis for a controversial debate. In Germany it is subject of the coalition agreement of the current federal government and a large five years lasting field test to evaluate chances and risks of the introduction of so called "Lang-Lkw", namely longer commercial vehicles has been started in the beginning of 2012 (CDU/CSU; FDP coalition agreement 2009). This field test will be accompanied by a scientific evaluation of the results starting at the beginning of 2012. In addition to the German field test, several other surveys have been conducted on European and national level (e.g. Klingender et al. 2009; Vierth et al. 2008). However, most of the present research focuses on technical and traffic related aspects of longer and heavier commercial vehicles. In contrast, the work described within this paper focuses on the impacts of longer commercial vehicles drivers and on other road users.

A crucial criterion for the European-wide introduction of such longer commercial vehicles is their impact on road safety and on the safety of traffic participants in particular. One concern regarding the issue of traffic participant safety raised within the debate about adapting directive 96/53/EC has been that longer commercial vehicles might cause a higher workload

for other road users. Until now scientific robust data to confirm these concerns is rare. Statements published so far are mainly based on surveys rather than on real-life experiences (cf. Wangrin et al. 2009; Schaffhausen 2006). This paper therefore especially addresses the workload of drivers and other road users induced by longer commercial vehicles. The presented research methodology deals with the questions of what workload car drivers experience if they interact with innovative commercial vehicles in traffic situations and of what workload experiences the driver itself.

Under the direction of the German Federal Ministry of Transport, Building and Urban Development (BMVBS) a field trial with LHVs is carried out throughout Germany since the beginning of 2012. The field trial will last over five years and is divided into three phases. The whole field test is scientifically supervised by the Federal Highway Research Institute BASt (2012).). One part of the scientific supervision is the investigation of workload aspects of the use of LHV, including the effects of LHVs on the truck drivers on the one hand, and on the surrounding traffic on the other hand. The aim is a scientifically robust analysis of the effects of the use of LHVs in the German motorway network. Among other things the workload effects that can occur from longer overhaul times, at motorway interchanges or junctions as well as from lane change manoeuvres will be considered.

1.2 Existing Knowledge on Workload Investigations for Longer Commercial Vehicles

There have already been several projects and surveys which analysed the impact of innovative vehicle concepts. Most of them focused on the effects to safety, traffic flow, infrastructure and environment. For example Vierth et al. (2008) conducted a survey against the background of a discussion whether or not the actual law allowing longer and heavier vehicles in Sweden should be adapted to European standard. The analysis has been based on actual Swedish accident statistics. It is assumed that longer vehicles might be more often involved in overtaking-related accidents. This assumption is backed by data that reveals the time gap in relation to oncoming vehicles in overtaking manoeuvres is shorter for longer vehicles, making overtaking manoeuvres more risky. The difference however seems not to be big enough to make overtaking-related accidents more common for longer vehicles and thus, inducing a higher workload for drivers and other road users. In addition, the assumption that longer vehicles might be more often involved in overtaking-related accidents is not backed by statistical accident data.

Within the project KONVOI (Henning et al. 2009; Kunze et al. 2010a) first simulator studies have been performed to investigate the workload and driver behaviour of drivers and other road users when interacting with electronically coupled commercial vehicles (Kunze et al. 2010b; Lank et al. 2011). Within the project KONVOI up to four commercial vehicles has been coupled in a distance of 10 m (Henning et al. 2007). Even though a KONVOI is a special case of a longer commercial vehicle (it is not physically coupled, but due to the short distance between the commercial vehicles in the KONVOI it can be recognized as one), the results of these investigations have certain implications for other longer vehicle concepts and the experiences benefits the recent studies. Driving simulator studies offer the advantage to assess future traffic scenarios with longer commercial vehicles on road prior their market introduction. Benefit of driving simulator studies is also that the interaction of other road users with these commercial vehicles can be implemented reproducibly. Thus, different test persons can experience the same traffic situations/scenarios.

During the simulator studies within the project KONVOI each test person (driver or other road user) performs the same testing procedure. Aim is to identify in particular the workload on the drivers of a KONVOI as well as on other road users. This investigation is conducted by the Rating Scale Mental Effort (RSME) of Zijlstra (1993). It demonstrates on a one-dimensional scale the subjective perceived workload of the test driver. The scale ranges from 0 to 150 and is divided into steps of ten that range from statements like “almost no effort” to “extreme effort”. The driver can easily state how exhausted he is in current situation during the run. The advantage of the use of the RSME-scale for the workload investigation is that the drivers driving behaviour is not impaired and the survey is practicable with small effort. To back these survey data the test persons are equipped with heart rate sensors to measure physiological effects. After an introduction the test persons receive a briefing. The functionality of the mock-up is explained and within this adaption phase the test person get used to driving in the simulator, but also to use the identification inventory. Than the test person executes the actual driving task. The test drive is accompanied by completing a RSME workload and acceptance questionnaire survey. The driving tasks contain clear run on motorways and rural roads as well as joins and leaves on motorways (cf. Figure 2).

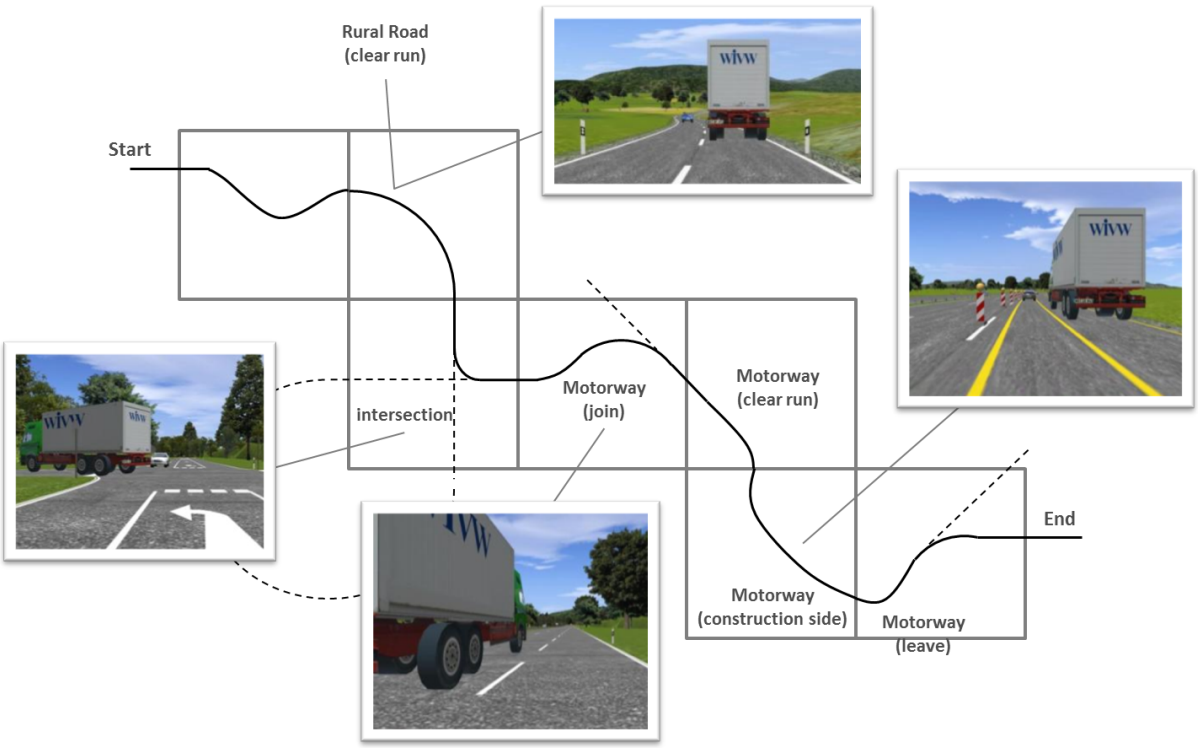

Figure 2 – Commercial Vehicle Innovation Paths

The subjective workload of KONVOI drivers during the simulator tests was slightly lower than of conventional truck drivers. The measurement of physiological workload parameters as the electro dermal activity, mean heart rate and heart rate variability showed no difference to the measurement of the same parameters before the tests. Both, the subjective and objective workload investigation therefore indicate that driving in KONVOI does not lead to a high workload for the truck drivers (Lank et al. 2011) and it can be assumed that during longer experiences with such a system like KONVOI the workload of drivers will remain on a low level.

The workload investigations with other road users carried out revealed a higher workload in some situations with the presence of a KONVOI compared to the same situations without a KONVOI (cf. Figure 3). This involves especially situations where the drivers tried to enter a motorway (join) when a KONVOI was present. But, overall the workload is still on a rather low level in these situations and there is only a very slight difference in situations where the drivers meet a KONVOI while driving on a motorway normally or exiting (leave) the motorway.

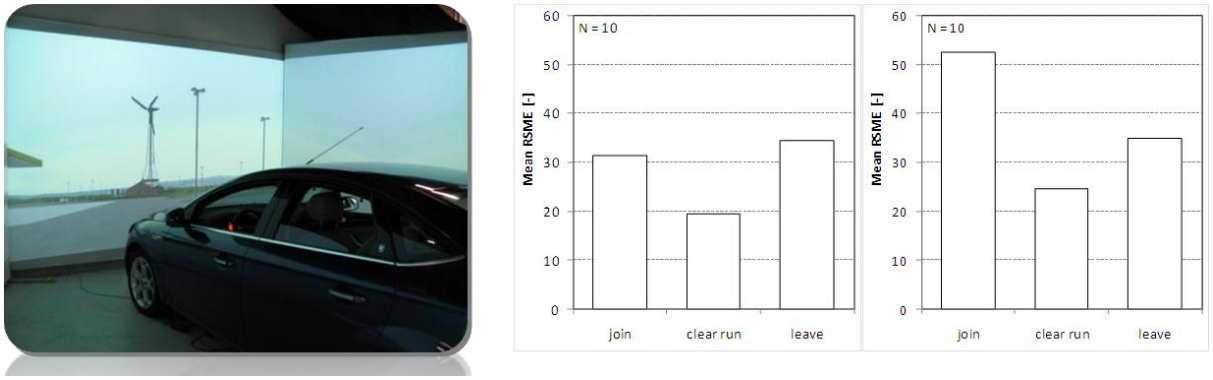

Figure 3 - Workload Investigation within KONVOI

Besides these knowledge on workload of drivers and other road users experiences from field tests, e.g. in Germany and the Netherlands exist (Wangrin et al. 2009; Rijkswaterstaat 2011). Within the German tests in the state of North Rhine-Westphalia LHV test person state the driving to be without stress in regular traffic situations (Wangrin et al. 2009). According to the Dutch LHV drivers there can be difficulties while changing lanes and reversing with an LHV. Besides the longer time for other road users to overtake an LHV and the fact that LHVs are not permitted to make sufficient space when other road users are changing lanes can irritate the surrounding traffic. The truck drivers have to be trained specifically for driving LHVs to cope with those situations and specific attention should be paid to these manoeuvres. Thus, those difficulties described by the Dutch LHV drivers can be overcome.

Regarding the workload effects of the use of LHVs on the surrounding traffic both studies revealed that the length of LHVs is often misjudged by other road users and that LHVs are not properly identifiable as such (especially at night) (cf. Wangrin et al. 2009; Rijkswaterstaat 2011). Though the opinion of other road users was not specifically enquired, some of the drivers in North Rhine-Westphalia gave some neutral feedback to the LHV drivers. They were rather interested than refusing (cf. Wangrin et al. 2009). Apart from that some of the Dutch road users did not notice any issues involving the use of LHVs, because they were unaware of it (cf. Rijkswaterstaat 2011). As a result there were no complaints about LHVs and it can be assumed that there are no negative workload effects.

In a few cases, car-drivers in North Rhine-Westphalia had problems with changing from the acceleration lane to the continuous lane of the motorway (cf. Wangrin 2009: 58). However these issues cannot be causally ascribed to the length of LHVs because they could have occurred in situations with common vehicles as well.

1.3 Interim Conclusion

To meet the challenges of the growing freight transport demand the European wide introduction of LHVs is one promising option. Backed by the experiences from several Member States like Sweden, Denmark and the Netherlands these commercial vehicles are practical. Along with the European debate on adapting Directive 96/53/EC the road safety issue is concerned. Obviously, by an introduction of LHVs road safety shall not be diminished.

The driving quality is determined among others by the experienced workload of the driver (Hoyos/Kastner 1986). By the introduction of LHVs on the one hand, the workload of these truck drivers may differ from the workload of conventional truck drivers. On the other hand, other road users interacts with new commercial vehicle concepts and thus there workload may differ as well. To analyse these workload effects surveys and simulator tests were conducted. However, the knowledge gathered so far is lacking of robust and unequivocal data (Klingender et al. 2011). If essential and complex coherences of the object of investigation are not clearly describable field tests offers more robust results compared to laboratory data (Hoyos/Kastner 1986). Thus, the following section provides a methodology for sound workload investigations of LHV drivers and other road users within a field test.

2. Research Methodology for the Analysis of Workload Aspects of the use of LHV

The methodology to investigate the workload aspects of the use of LHV presented in this paper is divided into the three phases: definition phase, data collection and analysis (cf. Figure 4). Below, the procedure in the specific phases will be explained in detail.

2.1 Definition Phase

At the beginning relevant preliminary work is reviewed regarding the workload effects of LHVs to form a basis for the examination to be performed. This includes not only findings of an earlier field trial that was realized in Germany but also experiences from other European countries where LHVs are already allowed or attempted. Since many of the already conducted examinations did not primarily focus on the workload effects of LHVs but on issues like vehicle safety, impacts on the infrastructure etc. interviews with experts from science and practice are conducted to directly detect the relevant aspects concerning the workload effects of LHVs.

The comparative analysis of analog extreme users is another important part of the definition phase. Therefore, experiences of drivers of overlong buses (25.25m) of the Aachener Straßenbahn und Energieversorgungs-AG (ASEAG) are determined through a semi-standardized survey. The focus of the survey is the inquiry of issues of the road safety and the workload aspects of driving overlong vehicles in urban traffic. Findings of users from analog usage situations can be attained this way. The results of the comparative analysis provide an indication about which factors are particularly relevant for the survey of LHV drivers and other road users.

Following the review of the former findings of other examinations as well as the conducted examinations with the analog users research hypotheses for further examinations are

generated. With the help of the research hypothesis the further process of the analysis of workload aspects of the use of LHV is structured.

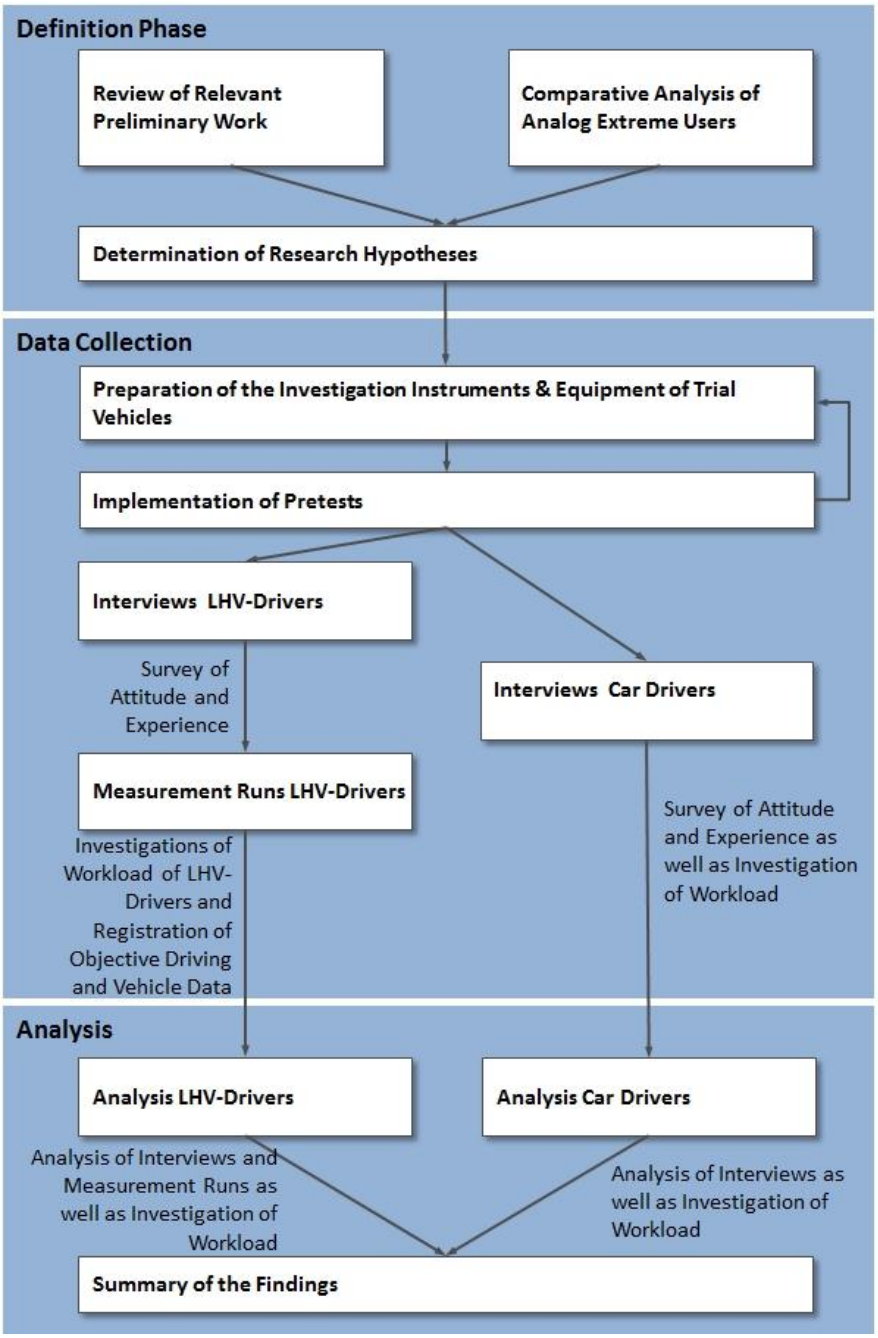

Figure 4: Research Methodology for the Analysis of Workload Aspects of the use of LHV

2.2 Data collection

At the beginning of the data collection phase an extensive research of national and international relevant literature is conducted to detect current topics and problem areas relating to the use of LHVs. To further specify the findings experts from different disciplines are identified and invited to an expert-workshop where the collected topics and problem areas are discussed in more detail. Thus, the safety-related impacts and workload aspects of

introducing LHVs to the existing infrastructure in Germany can be further analyzed and discussed on basis of the in the literature research detected issues. The gained knowledge helps to conceptualize and optimize the measurement tools that are to be used in the progression of the project.

To comprehensively investigate the workload aspects of the use of LHVs the survey has to take several stakeholder groups into account. Thus questionnaire and interview guidelines are developed for the LHV drivers and the other car drivers. The different tools are used to measure the acceptance and general workload of the stakeholders as well as the truck driver's workload in specific situations (e.g. intersections, slip roads etc.). After the development of the measurement tools for the different surveys pretests are conducted in which the measurement instruments, the test procedure and the test evaluation are tested. This way it is possible to further optimize the developed instruments as well as the test design and the test evaluation if necessary whereby a smooth process of the actual surveys is guaranteed.

In order to investigate the truck drivers attitude and their experience with LHVs interviews with approx. 200 LHV drivers are conducted before the workload investigations during the actual measurement runs. Through a mixture of semi-structured and standardized questioning instruments it is on the one hand possible to discuss the reviewed issues with the respondent in detail and on the other hand to achieve a higher comparability of the data because the wording and the word order are clearly set before.

In a next step measurement runs and examinations of the traffic flow are conducted. This includes observations of at least 40 LHV drivers and of the traffic in the direct neighborhood of LHVs. For the driver observations the truck drivers are equipped with different technical measuring tools (e.g. heart rate monitors) and are accompanied by scientist. To register objective data the physiological stress of the drivers while passing specific situations (e.g. road works, closure of traffic lanes, intersections) is recorded. Moreover the reactions and the behavior of the drivers are observed by the scientist accompanying the driver and are recorded on video for a more detailed analysis of specific situations. The observation of the truck drivers during the measurement runs is conducted with the help of particularly developed observation logs. This way the observer can register conspicuities and specific situations during the measurement runs for the later analysis.

The analysis also includes a comparison between the behavior of the drivers of LHVs and regular trucks. For example, parameters like the number of times the driver looks into the side-view mirrors per 10 minutes of free ride are contrasted with the driving behavior while within road works. To enable a comparison with standard trucks the same parameters are ascertained for a small group of conventional trucks. In addition the analysis of the speed-indicator for LHVs as well as for standard trucks can provide objective data (exceeding the permissible speed, average speed or speed at road works), which can then be used for a comparative reflection.

For the detailed analysis of the interaction of LHVs with the surrounding traffic the LHVs are equipped with appropriate measurement technology (cf. Figure 5). On prior determined routes the surrounding traffic (overtaking behavior, distance keeping behavior, behavior on ramps etc.) is observed via camera systems and the collected data is afterwards evaluated and compared to that of regular trucks. The spatial appropriation of the particular data is carried out through a synchronous record of the GPS signals of the observed vehicles. Besides all

applied measurement instruments are synchronized per radio-controlled clocks to especially ensure an interference of the single measurement systems.

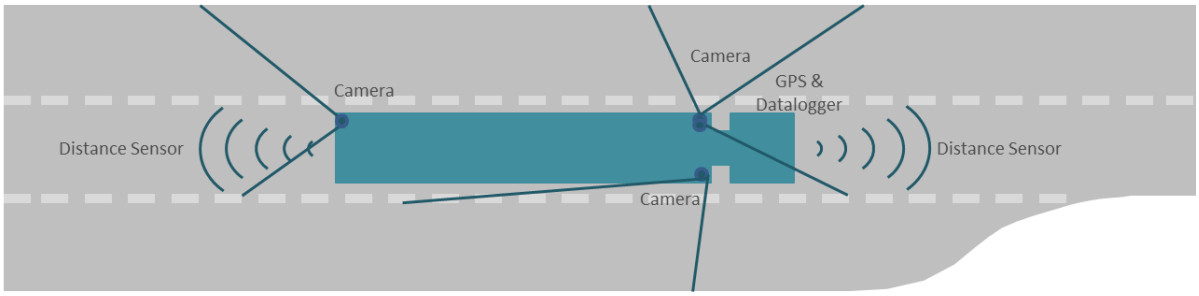

Figure 5: Camera System for Observation of Surrounding Traffic

In addition to the collection of objective vehicle and driving data, the observation of the truck drivers and the measurement of objective driver data the workload of the drivers is measured by means of two different subjective inquiry methods. Before the runs these methods are outlined to the drivers intensively to give them enough time to familiarize with the survey methods.

During the run the Rating Scale Mental Effort (RSME) of Zijlstra (1993) is used to record the subjective perceived workload of the test driver on a one-dimensional scale. The RSME scale ranges from 0 to 150 and is divided into steps of ten that range from “almost no effort” to “extreme effort”. Thus, the driver can easily state how much effort the driving tasks is for him in the current situation during the run.

To break down the different factors which possibly influence the workload of the driver the workload is measured again directly after the measurement run. The second collection of the drivers workload is acquired through the Driving Activity Load Index (DALI). DALI is a subjective method which is often used in association with other workload examination methods. It is a modified version of Hart and Stavelands (1998) NASA-TLX which was especially adapted for investigating the workload of driving tasks. Using the DALI the probands state their stress concerning the following dimensions: effort of attention, visual demand, auditory demand, temporal demand, interference and situational stress

Through the combination of one-dimensional and multidimensional inquiry methods advantages as well as disadvantages of the used examination methods can be balanced and/or compensated. Hence an exact determination of the workload of the drivers concerning the effort and the different workload factors during the driving task is possible.

Analogously to the investigations of the workload effects of LHVs on the truck drivers the attitude and the experience of the other road users regarding LHVs on motorways are investigated with the help of semi-structured interviews. To gather the workload of the car drivers who gained experience with LHVs their stress is ascertained through the DALI, too.

2.3 Analysis Phase

The gained findings will be analyzed after the examination through different methods of the empirical social research. The observation logs will be quantitatively evaluated with the help

of an appropriate category system. Especially the behavior of the drivers in critical traffic situations is considered in this context. These critical situations during the measurement runs are reported by the accompanying scientists. The standardized questionnaires are analyzed with the analysis-software SPSS, the results of the guided interviews with the help of a content analysis. Thus a comprehensive picture of the workload effects of the use of LHVs on LHV drivers and on other road users emerges.

3. Conclusion

To overcome the challenges of the prospected further growth of the freight transport market longer and heavier commercial vehicles are one approach to increase road freight transport efficiency. Backed by the experiences from several EU Member States like Sweden, Denmark and the Netherlands these commercial vehicles are practical. Prerequisite of an European wide introductions of LHVs is the verification that these commercial vehicles do not diminish road safety. The experienced workload of drivers is one criterion which determines driving quality and thus road safety (Hoyos/Kastner 1986).

The existing knowledge on such workload investigations, summarised in the first section, might suggest that longer commercial vehicles do not induce inacceptable higher workload for its drivers and other road users (Lank et al. 2011; Rijkswaterstaat 2011; Vierth et al. 2008; Wangrin et al. 2009). However, it is concluded that the existing knowledge is lacking of robust and unequivocal data (Klingender et al. 2011). Therefore, in the second section of the paper a methodology for workload investigations for LHV drivers and other road users is developed to overcome this lack of information. In detail, the necessary steps are explained, containing a definition phase, the data collection during measurement runs and the analysis of the collected data. Based on this approach, the authors propose the execution of the workload investigation within the German field test. If applied, this approach may deliver scientific robust data and benefits the decision-making on adapting Directive 96/53/EC.

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