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COUNTING THE MINUTES – MEASURING TRUCK DRIVER TIME EFFICIENCY

GÜNTER PROCKL, COPENHAGEN BUSINESS SCHOOL
HENRIK STERNBERG, LUND UNIVERSITY
VAHID SOHRABPOR, LUND UNIVERSITY
STEN WANDEL, LUND UNIVERSITY

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1st Author Günter Prockl, Copenhagen Business School

2nd Author Henrik Sternberg, Lund University

3rd Author Vahid Sohrabpor, Lund University

4th Author Sten Wandel, Lund University

ABSTRACT

The performance of truck drivers is crucial to the sustainability, in particular profitability, of motor carrier operations. Despite this, driver efficiency, in particular in terms of time has received scarce attention in the transport and logistics literature. Given the importance of the drivers in transport operations, the purpose of this paper is to identify and define methods on driver efficiency. This research has been inductive in its nature, departing from a literature review focused on various aspects of transport operations performance, staff time measurement and driver control. The empirical data underlying this paper has been collected over 5 years throughout numerous projects in Germany, Sweden and Switzerland related to transport efficiency and summarizes the experiences made in these projects. In total, 80 drivers belonging to 22 motor carriers were measured using different types of participant observations and driver self-observation. The findings of this synthesis revealed first that driver measurement is scarce and virtually non-existent outside the boundaries of eco-driving. The findings indicate that driver self-observation is a reliable tool for measuring driver efficiency and that tacho-meter based approaches are unreliable. Finally, this paper gives novel insights on using nomadic devices (e.g., smart-phones) as tools to interact with the driver. The research impact of this work can be identified in two separate areas. Firstly, the paper addresses the need for a broader view on drivers' efficiency, departing from previous fuel-centred approaches. Secondly the paper gives directions on how to re-interpret findings from previous literature that has used flawed tachometer-based approaches. On a strategic level, this paper advices the motor carrier industry to address drivers' efficiency on a more holistic level then what has previously been done. Practitioners addressing driver efficiency will find important principles to guide their work in measuring drivers.

Keywords: Motor carrier, haulier operations, driver control, driver performance, efficiency

INTRODUCTION

Employers, regardless of what type of business they manage, know that worker productivity is the key to an organization's success (Taylor, 1911, Drucker, 1999). Workers who are not using their time and resources effectively are costing the company money. Unfortunately, measuring productivity can prove to be quite difficult — especially in industries where work is carried out without immediate supervision.

Road freight transportation is one such area, where not only does the driver productivity impact the motor carrier firm, but also the society and the environment. Freight transportation in the EU account for 7.3% of GDP and 80% of all the transports inside the European Union (EU) are carried out by road (Pasi, 2008), accounting for 94% of the total transport cost (Schreyer et al., 2004). The relative share of road transportation will continue to increase, as capacity limitations of other transport modes are reached (Peetermans, 2006) and road freight transport continues to be by far the most flexible transport mode. Several parts of the society, e.g., hospitals, shops and gas stations are supplied on a Just-in-Time (JIT) basis and with disruptions of road transport operations the living conditions would rapidly deteriorate (McKinnon, 2006). Hence efficient utilisation of trucks is not only in the interest of motor carrier operators, but also in that of the society.

Depending on the country, time, i.e., mainly the salary cost of the drivers, represent the largest or second largest cost for motor carriers, i.e. 20-55% of the operator's total costs (Swedish Association of Road Haulage Companies, 2008, U.S. Department of Transportation, 2010). Time is also central in the utilization of the motor carriers' fleets and thus becomes a central factor in determining efficiency of motor carrier operations (Simons et al., 2004, Villarreal et al., 2009) and the various time uncertainties associated with motor carrier operations, typically have to be buffered by increased stock (Rodrigues et al., 2008).

In the air carrier industry, time is a crucial and has been extensively studied over the years in transport management literature (Morash and Ozment, 1996). Yet, despite the importance of time performance and the significant cost, time has been marginal in both practitioner and academic literature on motor carrier strategy and operations (Sternberg et al., 2012b). In particular SME motor carrier operations is a subject often neglected (Voss et al., 2011) or misunderstood (Sornn-Friese, 2005).

The typical starting point of improving any activity comes with measuring it (Shingo, 1989, Drucker, 1999). Hence it is surprising, given the large impact on cost that time constitutes, that time measurement has received only marginal attention in transport management literature. So how can time in motor carrier operations be measured? This question should, given the background above, be crucial to future research on total efficiency of freight transport operations (Simons et al., 2004) as well practically useful for managers aiming at reducing cost. "Given the impact of driver activities on how well motor carriers meet the needs of their current and potential customers, the ability of carriers to control the actions of their drivers should significantly impact the firm's competitiveness (Mello and Hunt, 2009,

p.20). This paper will establish a foundational outline based on previous related research, methodologies and techniques available, experience from previous projects on time measurement as well as an outlook on future research possibilities on time efficiency in motor carrier operations.
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This paper aims at making a methodology contribution, i.e., focuses solely on the driver measurement aspect of motor carrier performance. Though vehicle capacity utilization differs somewhat from driver time efficiency, they are very closely related (Simons et al., 2004). Our paper is organized as follows: First a literature review on the relevant constructs and existing knowledge in the field of measuring workers and time efficiency in motor carrier operations is carried out. That is followed by a section elucidating the methodology underlying this study and. The next section in sequence outlines the experiences from the driver observation studies carried out. Finally an analysis is carried out and conclusions and future research are discussed.

LITERATURE REVIEW

Generally the purpose of measuring workers is to increase efficiency. Generally efficiency is used as a relative measurement in a quota, in monetary and non-monetary terms, but there exists as of today no uniform definition of efficiency in transport. Shaw (2009, p.854) states, “Definitions of performance criteria, which may have merit when viewed individually, have evolved into a virtual semantics jungle when viewed as a whole.” Shaw (ibid) states: “Consequently, during its roughly 100-year evolution, efficiency has been defined at one time or another as synonymous with each subsequent performance criterion: costs, productivity, effectiveness and cost-effectiveness.” Another concept closely related to efficiency, is *waste*. Waste typically refers to costs that could have been avoided or to everything (resources, time, activities, etc.) that does not add value (Womack and Jones, 2003).

The remainder of this section is dedicated to measuring work activities, seen from an efficiency perspective, i.e., with ultimate aim to increase efficiency and decrease waste. Early work on measuring work activities origins from manufacturing facilities and hospitals (Drucker, 1999) and they are dedicated respective subsections. Finally literature on time in motor carrier operations is addressed.

Observing and measuring work activities in manufacturing

Frederick Taylor (1856-1915) was the first man in recorded history who deemed work deserving of systematic observation and study (Drucker, 1999). Taylor's 'Scientific management' (Taylor, 1911) formed the basis for measuring work activities and his work was continued by manufacturing pioneers such as, e.g. Henry Ford (Womack et al., 1990). Through advances in Lean manufacturing techniques, time concepts, e.g., “takt” and continuous flow have further fuelled the continuous interest in time measurements in manufacturing (e.g., Shingo, 1989, Hawkesford, 2008, Hanson and Finnsgård, 2012).

As of today, the dominating method in observing work activities is video recording (Engström and Medbo, 1997), since the confined boundaries of a manufacturing environment rends themselves applicable for that. An advantage of extensive video recordings is the general absence of the so called "Hawthorne effect" (Engström and Medbo, 1997, Hawkesford, 2008).

Whereas a product can be stored and consumed later, services are produced and consumed simultaneously. A service area that gained early attention on workers' activities is health care (Drucker, 1999) and the next section will address that.

Observing and measuring work activities in health care

Being a service, health care operations have some similar characteristics as transport operations do have. Health care operations, despite typically being carried out within the same facilities (similar to manufacturing) render themselves unsuitable to continuous video recording (due to patients and privacy). Hence researchers in health care have addressed various types of non-digital observation (Stevenson et al., 1999, Castle and Harvey, 2009).

Burke et al (2000) compared the results of direct and self-observation in a study based on eight nurses during 10 work shifts. They used mixed-effects analysis of variance determine the significance of the work measurement method on percentage of total time, number of activities, and mean time per activity by activity category. Burke et al (ibid) found that comparable amounts of total time were reported within the various activity categories using time-and-motion and self-reporting methods. They recommended continuous self-reporting as a low-cost means of quantifying allocation of time among nursing personnel.

Stevenson et al (1999) discuss the problem of re-call bias in self-reporting. In order to tackle the issue, they used self-observation by means of a pager that staff members were carrying. They found, in line with other similar studies, that ease of use of this method (self-observation by means of clicking buttons on a pager), lack of intrusiveness and need for recall contributed to accurate data about work activities (Stevenson et al., 1999).

Observing and measuring work activities in road transport operations

As outlined in the introduction, measurement of time in road transport operations has gained sparse interest, partly because of the difficulties involved in measuring road freight transport operations (McKinnon and Leonardi, 2009).

Typically two types of systems generate transport time data, i.e., indirect observations. The first type is tachometers. The use of tachometers is legally mandatory throughout the industrialized world due to enforcement and follow-up of driver time regulations. The automatic registration of start, stop and break time intervals as well as speed data, renders large amounts of data that motor carriers typically have no problem of sharing with researchers. Simons et al. (2004) and Cruijssen et. al. (2010) both used tachometer data as input to calculate transport efficiency.

The second type of system common in trucks used for freight transport, are on-board computers with telematics (Nagarajan et al., 2005). Such units are typically used monitoring and promoting eco-driving, for exchanging order information between traffic control and driver as well as monitor the position of the unit. Hubbard (2000, 2003) and Baumgartner and Leonardi (2004) have explored the positive effects on productivity by the use of such systems.

Mello and Hunt (2009) outlines the rationale and importance of driver control as well as a theoretical framework for research into driver control practices in the trucking industry. They found “that drivers can still find ways of gaming the system (Mello and Hunt, 2009, p.31)”, i.e., ICT (Information Communication Technology) in trucking has some limitations. In a near future, a strong increase of nomadic devices for controlling motor carrier operations will be a reality (Sternberg and Andersson, 2012) and offer new opportunities for data collection.

To the authors’ best knowledge, previous literature has not addressed self-observations in the context of motor carrier operations.

METHODOLOGY

As this paper aims at making a methodology contribution, the empirical data of the paper will be a description of the methodologies employed to collect data. Hence the purpose of the methodology section is to briefly outline and put the methodologies employed in a context, as well as explaining the motivation why time was measured in the first place. Elucidation of the techniques and experiences of using them is done in the empirical section.

When studying a phenomenon in its natural context, the best way is to use observations as a technique (Halvorsen, 1992). Generally a difference is made between direct and indirect observations. According to Arbnor and Bjerke (1997), “direct observation… consists of a situation of creating knowledge that, as a whole, is arranged around observing what happens in the present”. This is done when the researcher is e.g., observing while interviewing, taking a facility tour, etc. Figure 1 outlines the different types of observation in relation to the observer’s interaction and the observant’s knowledge of being observed:

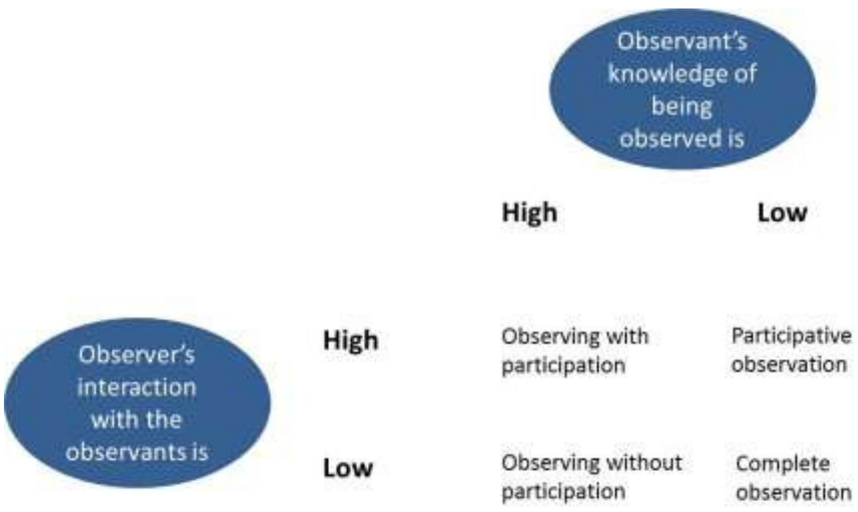

Figure 1 – Types of observation (Arbnor and Bjerke, 1997)

Observation is indirect if the researcher has to rely on the reported observations (including self-observations) of others. Due to the high resource commitment needed to collect data using direct observations as well as the sometimes confidential setting, researchers in health care have frequently used indirect observation through self-observations to collect data, as was described in the previous section. In this paper we report from two type of self-observation, driver diaries (paper) and Android app-driven driver diaries. We have collected data on driver diaries from a total of 234 drivers representing 22 motor carriers as well as 3 drivers from 3 motor carriers that have tested the Android-app. The purpose of the large driver diary study involving 234 drivers, was to investigate the effects of the new driver time regulations (Klaus et al., 2008). The driver time regulations project was reported in detail in Klaus et al. (2008) The app Stardriver was developed as an experiment to test if self-observations could be improved through the use of ICT.

Observing truck drivers' activities implies both a high level of interaction with the observant and complete awareness of the driver that he is being observed. In this paper we are reporting from 30 days of participant observation carried out by the research team at 6 motor carrier firms. The participant observations were always carried out within the scope of larger research projects and were mainly aimed at identifying wasteful activities in the respective motor carriers' operations or to measure time differences in experimental settings (Sternberg et al., 2012a). The studied motor carriers represented both trailer haulers and firms operating LTL (Less-Than-truckLoad) general cargo.

The studies were carried out in Germany, Sweden and Switzerland.

STUDIES MEASURING TIME

This section presents the actual findings from the studies involving time measurement. As driver diary accounts for the bulk of the data collected, we start by outlining the findings from that study.

Driver diaries – project "Effects of driver time regulation"

Observations were recorded either through participant observation or through driver diaries. In order to ensure valid observations, the drivers were ensured full anonymity. Initially the purpose of the study was to investigate the effects of new driver time regulations, which together with methodological approach were published in Klaus et al. (2008). Since the purpose was to investigate the at that time recently introduced driver time regulation its effects, the drivers were fully motivated to contribute with accurate diary notes and drivers were assured full anonymity.

Research staff was present both in the mornings and in the late afternoon/evenings. In the morning research staff handed out template diary sheets (See Appendix for the drivers before they departed from their respective garages or terminals. At the end of the working day, the diary notes were handed in to someone from the research team that would verify that the diary notes were properly filled out. In a second step, the diaries would be validated by a senior researcher typing them into a database. A dedicated software tool was used to check the data on gaps and also on plausibility. Anomalies such as unrecorded time intervals, unexplained leaps in driven kilometres, or an untypical low resp. high average speed per hour for driving segments have been indicated in a list and the senior researcher checked again the database and the paper records for this issues. Low average speed was in most cases explained by additional notes of the drivers such as traffic jams or accidents on the motorway. Implausible records have been removed from the database.

The drivers filled out the template by stating the start time (hh:mm) of each activity.

The template consisted of the following activities (the number code used is written before the actual activity, to help the readers understanding the template in the appendix):
01 Driving truck
21 Driving to work (with truck)
98 Driving home (with truck)
02 Waiting for loading, while moving
03 Waiting for loading, while standing still
04 Loading
05 Waiting for unloading, while moving
06 Waiting for unloading, while standing still
07 Unloading
08 Organizing documents and paper
09 Securing freight
10 Fueling, truck service etc.
11 Connect/disconnect (e.g., trailer)
12 Various (unspecified)
13 Break

For a number of reasons the template splits into more detailed activity categories as usual, especially in comparison with the tachometer input. Due to one of the major goals of the survey, i.e. to provide a sound basis for estimates on cost effects and potential means to lower them, there was for instance the requirement to separate into paid vs. unpaid driving time and as well paid and unpaid working time. Driving with the truck to work, for example in full truckload traffic, counts legally as driving time but it is no working time and it is not paid by the companies. Similarly there was a distinction made for waiting times. In cases when the trucker has to queue in a line in front of a loading ramp, he or she has to move the truck from time to time. The new legally required tachometers record such movements even if they are very short. In consequence such waiting times may not be used for taking breaks and are thus paid working time. Waiting times, when the truck stands still on a parking lot however may at least in principle and when it lasts at least for more than 15 minutes in a row, used as breaks. Thus they are treated differently. Other activity categories relate to working times that are directly related to driving and thus the drivers. Others might be separable from the driving and thus also be performed by other staff than the driver.

After the completion of the project, the database was revisited for the purpose of analysing motor carrier operations in LTL distribution. Out of the 1431 collected days, 820 days were selected for scrutiny. The 820 days were made up by 21 000 recorded activities. When the author found any not plausible record, he deleted all the records of that driver from the database, since a not plausible series of activities would imply that the driver did not fill out the diary in a correct manner. E.g., the records revealed that some drivers had measured their activities in intervals of 5 minutes and records from those drivers were deleted. Out of an initial set of 820 days, 343 days remained.

Participant observation

"Classic" participant observation in trucking operations means that an observer joins the truck driver for the duration of a work shift, taking notes and measuring the activities. The research team spent 30 days carrying out participant observations. All drivers were always promised full anonymity and were promised that individual records would not be visible outside the research team.

The granularity varied - some assistants noted the times (minutes), whereas more senior staff tended to record times in seconds. During the initial participant observations, no particular categories for the drivers' activities were used, rather the researchers wrote down a description of the activity and categorized the activities at the end of the day when entering the observations into a spread sheet. The aggregated categories were compared first internally and a model of categories of activities was used. The model was then compared and discussed with the project leader of the driver diary study reported in Klaus et al. (2008).

Participant observation proved more complex than anticipated. At one occasion, one of the authors had started a day observing, 05:30 in the morning. At 17:00 the tour was still ongoing, when he accidentially dropped the cell phone, the battery fell out and the stop watch times were lost.

How to act as a participant observer was not straightforward. Many drivers will ask for help, e.g., "Can you please hold here or please carry that", despite being informed about the role of the observer. One member of the research team was assigned to follow a driver of a large motor carrier. After the assignment, he asked the project leader: "How do I report that the driver drives all the way to the other side of the city, just for having coffee with the other drivers (*author's note: that were doing the same thing as well*)? Another driver told the observer that he is planning his route in order to pass his sister's workplace at 9:00 (to get free coffee there) and his parent's house at 12:00 (for free lunch), but because of the observer, he would change the route of the day in order to have lunch with the observer.

Common for over half of the participant observation days, was the difference between actual activities and activities entered into the tachometer. Frequently drivers prefer getting home early and will enter "break" in the tachometer, despite carrying out e.g., loading or unloading.

Project "Stardriver" – driver self-observation

Reflecting on the data collection methods previously utilized, one of the authors came up with the idea of a smartphone app that could be used to support driver self-observation (Screenshots of the app can be found in Appendix B). Based on numerous iterations and test cycles of the categories of drivers' activities, the app was offered the following nine measurement categories:

- Drive
- Wait
- Load
- Unload
- Break
- Info (administration)
- Wait
- Handle
- Service (including fueling)

To validate the functionality of "Stardriver" and ensure reliable test data, the test drivers were one friend and two relatives of the author. This created a bias in the test, since these drivers were all young and use smart phones extensively in their everyday life.

During a period of 4 months, four subsequent versions of Stardriver were tested during a total of 35 work days. Each version of Stardriver represented one or more improvements. The categories proved fully covering and the drivers (working at three different companies, with one of the companies being a driver provider, i.e., that particular driver had different types of assignments every week) had no difficulties or suggestions regarding them. What did prove difficult though, was using Stardriver in parcel distribution, i.e., when the work day of the driver contained more than approximately 15 stops. "While I'm driving I am philosophoing about various things and it is kind of lika an autopilot controlling me, making me forget to use the app", stated one of the drivers.

Sometimes drivers do two things at the same time, i.e., very often a driver will drive and do an administrative phone call at the same time. Hence they were instructed to, in case of doubt, always use the activity implying movement in case they were moving. The business rules of the app were designed to augment the measurement of activities, e.g., very short activities (less than 8 seconds) were discarded. If the truck (to be exact - the smartphone) would be standing still for more than 2 minutes while reporting "Drive", a reminder is given to the driver to verify that the activity carried out is actually driving.

Whereas previous self-observation discarded working days that were not entirely correct, Stardriver enabled discarding parts of the working days were measurement hadn't been carried out correctly.

ANALYSIS

In total the different modes of data gathering show certain properties that may be grouped to three main aspects.

A more structural aspect refers to the number of applied categories. The number may vary with respect to different underlying objectives of the sampling approach. This also relates to the required granularity and the methods flexibility to change the number of applied categories. Typically the tachograph is here rather limited to the standard categories while driver diaries allow different options. The app is in between as it requires some re-programming that may reduce flexibility.

Closely related to this is however also the distinctiveness of the categories. Sometimes driver perform different activities almost simultaneously. The more categories are asked, the higher is the risk of overlaps, confusion between categories, and as well a lack of motivation to record all the more frequent changes. This is more or less the case for all modes of data gathering. However diaries that require more handwriting efforts instead of just touching buttons might be more suspect to this challenge.

This also links to the process of the data recording - in particular in situations when the drivers are stressed or under time pressure. In such situations it appears likely that drivers forget the documentation or just focus on their main business. For diaries that might result in ex-post estimates that are then done later when the work situation is again more relaxed. These estimates could be biased in a sense that disliked activities such as paper work are overestimated. For the apps, time pressure may cause drivers to push the buttons maybe later as there is typically no such easy way of "repairing" the records. The tachograph approach should appear in principle as most exact – at least with respect to the distinction between driving and non-driving categories which is technically triggered by the control instrument. Breaks however have to be entered as well manually and it is maybe not always perfectly clear which drivers identity card is really inserted for yard operations like connecting/disconnecting or driving for re-fueling.
Especially the behaviour in stress situations may raise the question whether this could be a cause for a systematic error or if it is a source for a random error that is compensated with an increasing sample size.

Finally regarding efficiency of data gathering the different modes obviously perform different. Paper work uses different media and does not provide direct data, while data from the app and tachometer is already input digitally.

CONCLUDING DISCUSSION

Despite the fact that more than 100 years has passed since Frederick Taylor's "The principles of scientific management" was published, time measurement in motor carrier operations and in particular of drivers' activities has remained an unexplored field. This paper synthesize years of research on measurement of drivers' activities and provide initial insights and antecedents on applicable methodologies. This explorative study does not represent an adequate amount of data to support solid implications (despite collecting all material we could find), but rather gives indications and sets the scene for further investigation into driver measurement.

Comparing existing knowledge on measurement of workers' activities give indications that the methodological findings from the health care operations literature applies to motor carrier operations, i.e., self-observation is a plausible method. Our observation experience shows that in line with similar research in health care, self-observation is an applicable method, when some errors in measurement can be accepted. In line with successful experiments of staff using pagers (Stevenson et al., 1999), initial experiments with self-observation by ICT shows merit in transport contexts where the number of stops are limited.

The honesty that have characterized the method participant observations, have not proposed any significant Hawthorne effect (Hawkesford, 2008, Castle and Harvey, 2009). We do not know if there would have been an effect, if the findings of the measurements would have been reported to the respective motor carrier CEOs. On the contrary, our observation of the drivers confirms the findings of Mello and Hunt (2009) that some drivers are exerting "Maverick behaviour" (wilful behaviour, exerting tendency to bend rules). Due to "Maverick behaviour" of drivers, previous studies drawing extensively on tachometer data might give erroneous implications on motor carrier efficiency and worker productivity.

The model of nine categories of drivers' activities is the result of extensive tests in various types of observations. We recommend them as basis for further analysis both in theory and for managers looking at measuring drivers' activities. Using them will also give subsequent studies the opportunity to compare with our measurements.

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APPDENDIX A – FORM USED FOR DATA COLLECTION

Figure 2 depicts the template handed out to the drivers for measuring their activities.

Fahrer-Fahrtbericht "Regionalverkehr/Tageseinsätzer" Blatt Nr. ________ **Digitaler Tachograph?** ja nein

Firma ______________________________ **Firmen-Nummer :**

KFZ-NR.: ______________________ **2. Fahrer?** ja

Wenn Ladezustand bei Arbeitsbeginn nicht leer, Erläuterung: ……………………...……….….... **Km-Stand Fahrtbeginn** ………… **km-Stand Fahrtende** …………

	Tag	Zeit		Zeitart (Tätigkeit) Schichtzeit (bitte ankreuzen)													Bemerkungen	Ort (bitte ankreuzen)		
	Datum	von hh:min	bis hh:min	LEN-KEN	Warten auf Be-laden	Be-laden	Warten auf Ent-laden	Ent-laden	Papiere Doku-mente	Ladungs sicher ung	Hof, Tanken Fzg.pfl.	Umsat-teln/Um-pritsch.	Sonst. Rüst-zeit	Pause, Lenk-zeit-unterbr.-		z.B. Stau, Unfall, Stapler defekt Rampenzuweisung Entladung durch Fahrer usw.	Depot/ Niederlassg.	Kunde Empfänger	Kunde Abholer
				1	2	4	5	6	7	8	9	10	11	12	13				
0																diese Zeile ausfüllen, wenn Anfahrt zum Standort per LKW erfolgt			
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			
13																			
14																			

Figure 2 – Template handed out to the drivers

APPDENDIX B – STARDRIVER

This appendix contains three screenshots from the Android app used for testing driver self-observation. The left screenshot depicts activities the app measures. The middle screenshot is the login screen, where the driver can set the alarm that aims at keeping him or her aware of the self-observation. Finally, the right screenshot is from the screen the driver gets when he or she finishes the work day and has the chance to report or rectify incorrect measurements.

When an activity is selected, the selected activity turns green and time starts to elapse.


StarDriver
Drive
Wait
Load
Unload
Break
Info
Walk
Handle
Service
Stop
HELP
STARDRIVER
© Copyright 2011 stardriver
No reminder
15m reminder
2h reminder
23
Reminder(m)
Login
Continue
RESET
SEND
Start
Activity
End
Time Duration