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DRIVER ACTIVITY TRACKING SOFTWARE SUPPORTING ANALOGUE AND DIGITAL TACHOGRAPHS

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ABSTRACT: Adopting European Union legislative in Croatia and other countries in the region brought new rules for all professional drivers. Despite some existing tachograph software solutions being available, we decided to develop a completely new tool enabling simple collection of data about driver activities from both analogue and digital tachographs. The obtained data is archived, visualized on-demand and used to create required reports and make advanced analysis in order to find specific infringements.This article gives an overview of the main implementation steps, including both analogue and digital tachograph support. Some of the obtained results are shown and discussed.
KEYWORDS: tachograph, analogue, digital, AETR, driver activity, road transport, public and cargo transport

INTRODUCTION

Safety in public and cargo transportation has always been of utmost importance. Public transport safety regulations are directly related to driver capabilities that enable efficient and safe accomplishment of certain work activities (driving) and have prompted the development of devices that record work activities of mobile workers - tachographs. There are two types of tachographs available - analogue in older and digital in newer vehicles. Even though laws require all new vehicles registered in Croatia since January 1st 2009 [1] to be equipped with digital tachographs, in most transition countries, including Croatia, Bosnia and Herzegovina and other neighboring countries, fleets of many transport companies include older vehicles, so the share of analogue tachographs is quite high and must be taken into account when talking about data acquisition and collection.

EU legislative defines certain rules related to driver activities that should be fulfilled by all professional drivers and their companies - the goal of minimizing specific infringements is directly related to public and cargo road transport safety.

In order to track and analyze activities fulfillment in accordance with those rules, data from tachographs should be digitalized and archived using available software tools. Based on requests by transport companies, we decided to develop a completely new software solution featuring all the required tracking and analysis functions. Our tool supports simple collection of data from analogue and digital tachodevices, data archiving, visualization, reporting and activity analysis. Additional features related to driver activities like creation and record keeping of AETR agreement/attestations of activities is also implemented.

This article describes the development process of our tool for driver activity tracking supporting analogue and digital tachographs. It starts with an overview of driver activity definitions and a short description of tachograph devices. Main part of the article covers features of our software tool, including detailed descriptions of certain implemented functions. A rich and informative user interface is shown, visualizing all the required data. The article concludes with some remarks about future development and ideas.

DRIVER ACTIVITIES AND TACHOGRAPHS

In public and cargo road transport, drivers, co-drivers and crew members perform certain activities through day. Legislative rules define four types of driver activities - driving, availability, other work and rest. Driving activity is related to period of time when the driver drives his vehicle (co-driver activity in that period is usually set to availability). Availability is the time when the driver is not required to remain in his workplace but must be available to start or continue driving or do other work. It is also the time spent as a co-driver during driving, waiting at borders, time spent in vehicle when it is being transported by ferry etc. Other work relates to any activity by the driver, other than driving - for example loading, unloading, vehicle cleaning or maintenance, helping passengers get in or out of the vehicle, working on administrative formalities (police, customs etc.). Rest is the time the driver

spends outside of the vehicle or in a stopped vehicle, provided that it is equipped with a bed. [2]
There are limits defined in legislative rules - the maximum time of driving without a break is limited to 4.5 hours and to 9 hours daily. The weekly limit is 56 hours of driving. Rest has a minimum of 11 continuous hours within 24 hours time, or 12 hours if it is split in two parts, the first part being 3 continuous hours of rest and the second 9 continuous hours. Details in Croatian [1] and EU legislative [3].
During driving and work on their vehicles, driver and co-driver activities are recorded on special devices called tachographs. Each activity has a symbol related to it as shown in Table 1. A start and an end time of each activity period is recorded by the tachograph. This is the information that must be read from digital or analogue tachographs and then stored into the driver activity record by the driver activity tracking software.

Table 1 - Activity record

Activity	Symbol	Start	End
Rest		05:15*	06:24*
Driving		*the start and end of the activity period	
Availability			
Other work			

Digital devices that record information about work activities - digital tachographs - are being installed in all new cargo and passenger transport vehicles. Data storage and retrieval are standardized - a digital card which must be used during driving is given to each driver by an authorized agency - all the information is stored on that card and the card is an essential part of the control system. This article provides a description of the program solution which has been developed for downloading and interpreting data from the cards by using standard smart card readers.
An important issue in the logistics of transport companies is efficient tracking of driver activities. It is directly related to public transport safety regulations, and therefore all companies are obligated to provide required information. Since fleets of many Croatian transport companies include older vehicles equipped with analogue tachographs, digitalization of analogue tachocharts becomes highly important. This paper presents a process for tachochart digitalization and describes a few solutions used in our analogue tachochart digitalization tool.

ANALOGUE AND DIGITAL TACHOGRAPHS

Professional drivers and mobile workers perform certain activities while working. There are rules that are defined by law concerning safety in public transportation and transportation of goods and passengers. These rules define, for example, the maximum time duration of driving without stopping and resting, obligatory rest periods for drivers etc. Tachographs are devices which are used to record driver activities. There are two types of tachographs - analogue and digital. Both will be described in this chapter.

Analogue tachographs

Analogue tachographs are older types of tachographs which used to be installed into cargo and passenger transport vehicles. Figure 1 (left) shows one type of analogue tachograph - it is built into the dashboard of a vehicle and provides buttons related to different types of activities (in addition to the speed indicator). There are different models of analogue tachographs, as shown in Figure 1 (right) - a standalone device that can be installed into the dashboard of a vehicle.

Figure 1 - Analogue tachographs

Analogue tachographs record driver activity data on round paper forms which are 12.3cm in diameter - called tachocharts. The most used type of tachochart in Croatia is shown in Figure 2 on the left. However, lately, due to an obvious need for tachochart scanning and digitalization, a new type of a tachochart (shown in Figure 2 on the right) has been introduced to the market - one that has a clear center crown. This center crown is used to record driver activity and since it is clear (it does not contain any printed symbols) there is nothing to interfere with the reading of the tachochart. Drivers are required to manually write their name and surname, vehicle registration mark and the starting odometer state before inserting the tachochart. After tachochart removal the driver must write the current time (important in cases of night driving when the drive starts on one and ends on another day) and the current odometer state.

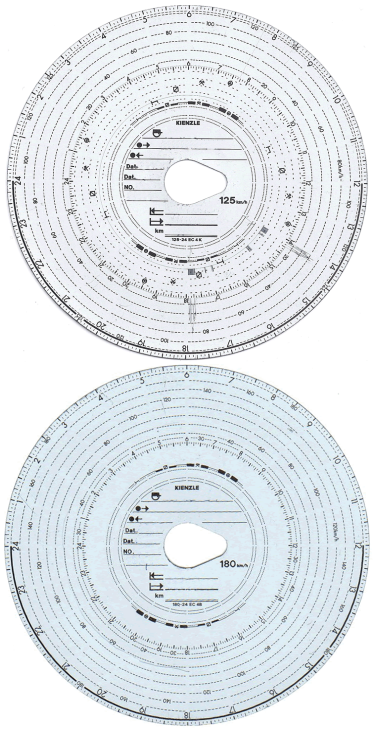

Figure 2 - Standard tachochart and tachochart with clear crown

Since the majority of tachographs in use in Croatia and neighboring countries are still analogue, the share of analogue tachographs is quite high and reading of the tachocharts should be made as simple as possible.

Digital tachographs

As previously stated, it is required by law that all new vehicles registered in Croatia since January 1st 2009 be equipped with digital tachographs. One model of a digital tachograph (manufacturer: VDO) is shown in Figure 3 (left) (downloaded from [4]).

For use with digital tachographs, an unique identification card [3] that has its own memory for storing driver activity is issued to every driver. The cards are issued for a period of five years. Figure 3 (right) shows an example card - as issued in Croatia (generic look, missing photograph, downloaded from [5]).

There are three more types of cards in use - transport company card (company/owner), workshop cards (for authorized workshops which service tachographs) and supervision card (for supervisory bodies such as police etc.). While driver cards are used only for storing data related to driver activity, other cards can be used to retrieve additional information from the tachograph (data on all drivers, locations and drive speeds, details on tachograph usage etc.).

Figure 3 - Digital tachograph and driver card

Each driver card must contain obligatory data fields and have minimum available capacity, as defined in [3].

AETR attestations of activities

Drivers are also required to have AETR attestations of activities in their vehicles. These are related to the times when they are not driving and have become obligatory in Croatia since January 1st 2010. They contain data about the driver (such as name, surname, date of birth, driving license or identity card or passport number) as well as the start and end of the period in which the driver was not driving and the reason why the driver was not driving (was on sick leave, was on annual leave, was on leave or rest, drove a vehicle exempted from the scope of Regulation (EC) 561/2006 or the AETR, performed other work than driving, was available).

It is now clear that all the input data is contained on analogue tachocharts, digital driver cards and attestations of activities. The goal then is to merge all this data into one record and process it. That is precisely what the software tool described in the next chapter does.

Software Tool Features and Implementation's

As stated before, we need to merge all the data (from analogue and digital tachographs and attestations of activities) into one record and process it. Each part of this procedure will be explained separately, key problems that arose during implementation will be stated and solutions for these problems will be provided. The procedure used for recording driver activity can be seen in Figure 4.

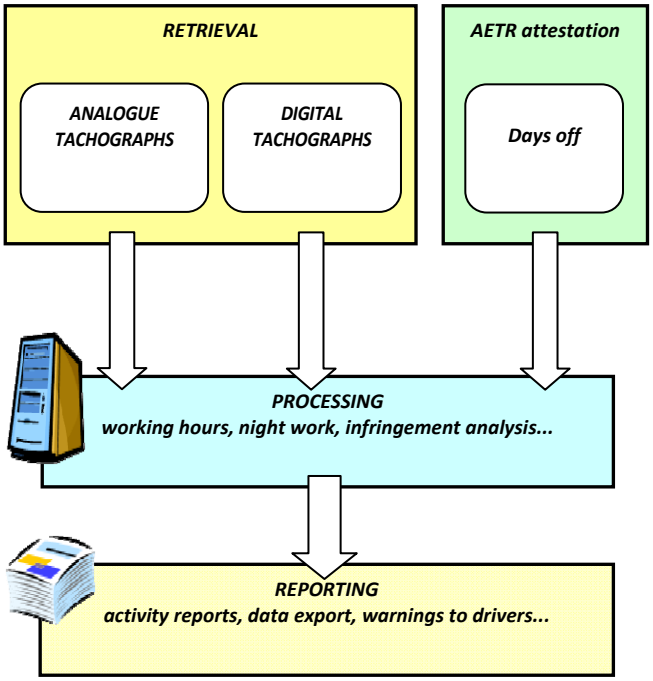

Figure 4 - Activity recording procedure

To start the collection of data we need to have the digital driver cards and/or scans of analogue tachocharts ready for use.

Chart digitalization module

Once the scans of analogue tachocharts are ready for use, the process of digitalization can begin. Prior to linearization and orientation detection, other algorithms [9] should be used to locate tachochart on the scan. All the algorithms were implemented in our tool, allowing detection of tachocharts being scanned one at a time or two charts per one A4 scan. The driver activities can now be retrieved from the tachochart, imported into a database and used with other data. Determining the type of activity is based on the width of the line used to record activities on the tachochart as shown in Table 2. Driving is recorded using the thickest line and rest using the thinnest line.

Table 2 - Activity record lines

Activity type	Symbol	Line width
Rest		
Driving		
Availability		
Other work		

To determine the start and end of the period of a single activity, it is necessary to determine which time of the day is recorded on a certain position within the crown of the tachochart. Since it is a circular record, the 24 hour period (a day) is recorded within 360 degrees, so 4 minutes of an activity can be represented within a single degree.

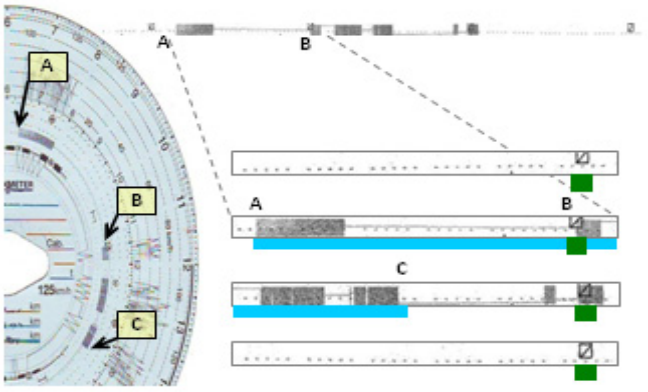

Figure 5 - Example of linearization of part of the crown of a tachochart

Retrieval of driver activities is done directly from the scanned image of a tachochart - the crown is linearized and converted into a rectangle - as modern digital tachographs do not offer retrieval precision below one minute [7], the crown is linearized into a rectangle which is 1440 pixels wide - in which case, every dot (line) of the linearized record represents one minute. The principle of this is shown in Figure 5 - three positions (A, B and C) that are marked on the tachochart can also be seen on the enlarged linearization view.

Once the linearization is complete, the retrieval of driver activities starts - for every minute (every column of dots) dark pixels are counted and categorized - if dark pixels are prevailing the activity is surely driving and if there is a small number of dark pixels, it is the rest activity. The remaining two activities are more precisely processed and categorized.

Every tachochart has a time scale (0-24 hours) on its edge. To correctly determine the time of a certain activity, an angle of rotation for the tachochart in question has to be determined. Once that angle is known, it is translated and applied to the time axis (which is a result of linearization) and the correct time can then be determined. The first part of this algorithm uses the central cavity of a tachochart - the peaked part of it always points to 12 hours, and opposite to that is the 24 hour point.

Figure 6 (left) shows this cavity and the angle marked β_0. This method alone was determined not to be precise enough.

Right beside the time scale on the edge of a tachochart, there are markings which can be used for a more precise determination of the angle of rotation. Shown on Figure 6 (right) is the edge of a tachochart and a circle can be seen - this circle is bolded on one half of the tachochart and can therefore be used to determine the start of the time scale. The angle β is found here. The search for this bolded circle break (which is the second part of the algorithm) is limited to the surrounding area of the angle β_0 which was determined by using the central cavity of the tachochart. The user is given the option to manually adjust the rotation angle, but since the algorithm was upgraded with this second part the need for user intervention has almost completely been eliminated. In depth coverage of most algorithms used in tachochart analysis is given in [9].

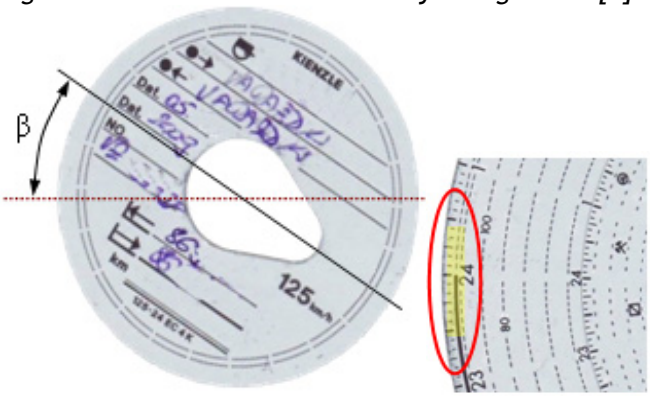

Figure 6 - Angle of rotation based on central cavity and bolded circle break

Driver card reader module

Data from the driver cards (which must comply with ISO/IEC 7816) used with digital tachographs can be retrieved by using standard smartcard readers, with the use of standard communication and transfer protocols.

The tool for this data retrieval only copies data from the driver cards into readable .ddd files. Once retrieved, the data is structured and binary coded in accordance to precisely defined rules [6] and has to be interpreted and shown in a more acceptable form. Figure 8 shows both a graphical and table view of driver activities for a selected date.

An unexpected problem has appeared during the development of the program for interpreting and showing data. Digital tachographs record time based on GMT0 time zone. Since Croatia and neighboring countries are in GMT+1 time zone and apply daylight savings time, an intelligent model has to be introduced to determine when the daylight savings time is applied. Even with that problem solved, there is still the question of what to do with one hour extra or one hour shortage on the day when the daylight savings is applied. Since it is only a single hour, it has been decided that it should be left in the calculation.

The digital tachograph system includes a security subsystem which prevents unauthorized manipulation and access to data. It also provides detection of subsequent change of activity data. A digital signature is used to insure data integrity (i.e. the data which was retrieved has not been changed). This security aspect was ignored during the development of the described software solution.

Vehicle unit reader module

Tachograph manufacturers usually offer devices (USB sticks and similar products) which can be used to retrieve the so called VU (vehicle unit) .ddd files which contain all data on vehicle activity for a certain period (drivers, infringements, speeds...). Our tool includes a module which can be used to retrieve and visualize such data, as well as to enable data exporting to .xls file format.

Visualization and software modules

The software offers a graphical and table view of driver activities as shown in Figure 7 (left), as well as a calendar view of driver activities as shown in Figure 7 (right).

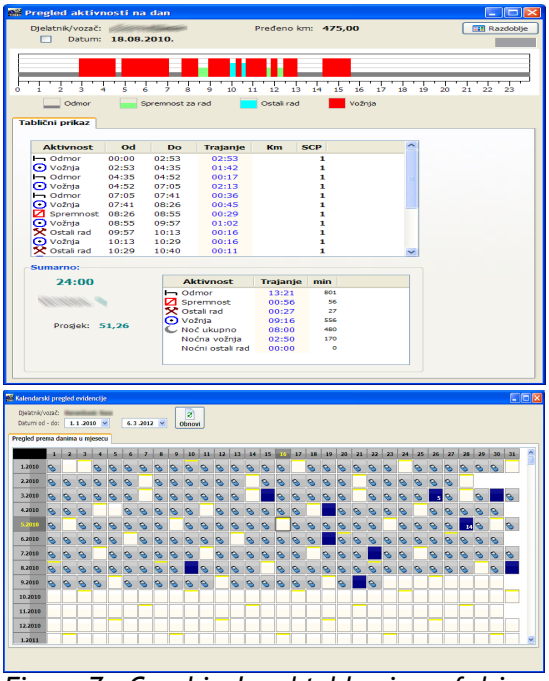

Figure 7 - Graphical and table view of driver activities for a selected date and calendar view of driver activities and data collections

A graphical view of driver activities for a selected period is shown in Figure 8 (left), showing integrated AETR attestations of activities visualization. Statistical analysis module is depicted in Figure 8 (right).

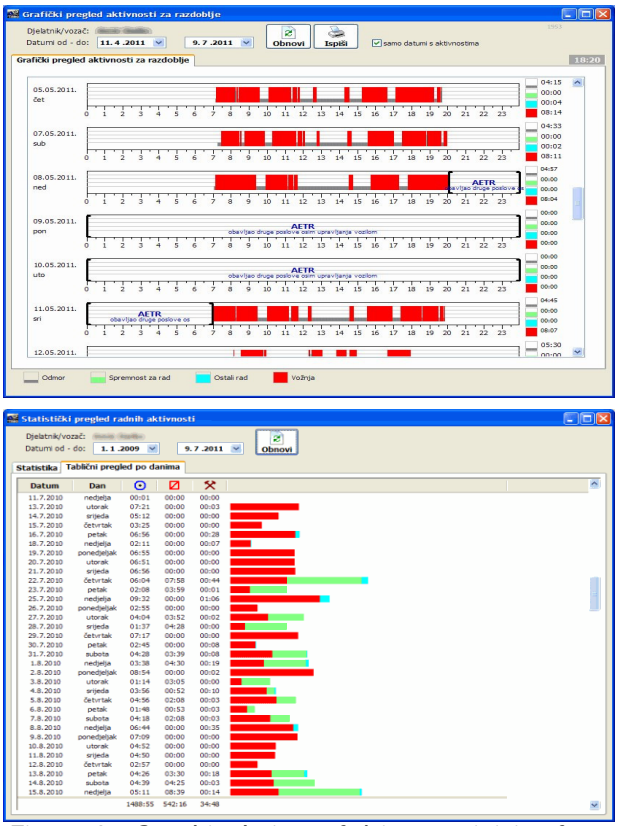

Figure 8 - Graphical view of driver activities for a selected period and activity analysis module

The latest implemented module in our software tool is used to analyze and detect driver infringements due to valid regulations [3]. It includes creation of reports delivered to drivers in order to inform them about potential infringements.

Conclusions

Our software was developed from scratch, in accordance to customer requests, and tailored specifically for the Croatian market and its requirements (the majority of tachographs in use are still analogue types).

The software is functional and enables simple retrieval, interpretation and showing of data. User reactions are very positive. A version of our software meant for use by companies which offer data retrieval and storage as a service is also available. The difference compared to the standard version is that it enables use for driver activity retrieval for an unlimited number of companies.

In future development, there are some things that could be improved. Reading more data from tachocharts (distances, speeds) could be implemented. The security aspect of driver card data retrieval, related to the digital signature control is also something that could be implemented in the future. Usage of web for data retrieval and delivery (primarily in cases when a company offers these as a service) is also being considered - in which case, the data would be read-only for users, and that data would remain property of the company.

Constant communication with our customers and further development based on their requests is one of our most important goals. Some even more detailed views of activities could be created and other ways to export data could be introduced. Increased interest in our software tools shows that transport companies are very well informed about new regulations and their obligations related to driver activity tracking.

Hopefully, that means that our custom made solutions could impact the market and find a place among other solutions developed by larger foreign companies.

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