



Satellite vehicle supervision as a management tool in a transport company

J. MIKULSKI^a, A. KALAŠOVÁ^b

^a UNIVERSITY OF ECONOMICS IN KATOWICE, Faculty of Economics, 1 Maja 47, 40-228 Katowice, Poland

^b UNIVERSITY OF ŽILINA, Faculty of Operation and Economics of Transport and Communications, Univerzitná 1, 01026 Žilina, Slovakia

EMAIL: jerzy.mikulski@ue.katowice.pl

ABSTRACT

Management in transport is mostly based on transport market observations and the person managing transport in a company must respond quickly to customers' needs and implement new solutions. At present, competition forces transport companies to look for possibilities for cost optimisation, including transport costs. Effective planning of the vehicle fleet use is a significant element influencing the company's financial result. The use of appropriate tools allows for greater savings and improvement in the effectiveness of vehicle use.

KEYWORDS: transport companies, fleet management systems, satellite vehicle supervision

1. Introduction

Nowadays, information plays a very important role in running a transport company. To be able to manage such a company efficiently and effectively, modern IT systems, which quickly provide comprehensive information on the fleet, are necessary. The more up-to-date data a person managing the company's vehicles has, the better they can use them.

In transport companies, information includes data on the current vehicle location and the distance travelled, the drivers' work (driving) time, vehicle ranges (quantities of fuel in tanks) and on the technical condition of vehicles. Fleet managers want to know where their vehicles are a given time and whether the persons they are entrusted to use them in accordance with their intended use.

In view of the above factors, it is important that special monitoring systems should be created (location, connectivity and data transmission) allowing for sending data in large areas, which, at the same time, will be a reliable source of information on vehicle location. There are a lot of solutions for vehicle location, control and protection (including passenger cars, trucks and transport

machines) and these solutions use devices installed in vehicles for this purpose. These devices combine the functions of a locator, alarm and a "black box". Thanks to them, it is possible to check where a vehicle equipped with a system is, what its momentary (or average) speed is or check the history of driving and stops. Owing to the functionality and low operation costs of these devices, transport companies buy and install such systems readily, owing to which their vehicles are under continuous control.

2. Theoretical issues of modern control and management in transport

Direct supervision of fleet vehicles is not easy as these vehicles rarely stay on the company's premises, they are usually on roads. Such services are already highly developed and systems allow for controlling vehicles in real time (following the optimum route and with an appropriate speed) and next, following appropriate reports. The safety aspect is also involved.

Modern positioners monitor vehicle operation. There are several companies on the market offering fleet management systems based on satellite vehicle monitoring combining the technologies of GPS and GSM devices [1], [2]. Using GPS satellites, the system obtains data on the location and the GSM technology is used for sending data. These companies include eg. Liberty GPS, Truck 24, [3] and CMA Monitoring [4].

Fleet vehicle monitoring systems are also offered by some truck manufacturers, e.g. Mercedes Benz (Fleetboard) or Iveco (Iveconnet).

A diagram of the operation of a monitoring system is shown in Fig. 1.



Fig. 1. Diagram of the operation of a vehicle location system [5]

The device installed in a car (or another vehicle) receives data on the exact location from a system of satellites. This information is then sent by means of a mobile network to a server when it is analysed. If a vehicle is outside the range of the mobile network, data are stored in the internal memory and sent again after connecting to the network.

Satellite phones, instead of GSM phones or at the same time as GSM phones, can also be used for data transmission. The operation of the devices does not depend on the quality of operation of the GSM network. Satellite phones are mostly used in vehicles, which are used in non-urban areas, outside the range of GSM operators.

Servers are the most significant part of the system, which continuously receive information from all monitored vehicles. These computers collect data and process them into a form legible for the recipient.

Monitoring and location systems can be divided into two groups:

- on-line solutions: for reading the position and parameters, such as: speed, driving direction, duration of stops - the GSM technology is used. The on-line notion means that the device also has integrated data transmission modules. As a result, regardless of the object location, the user is able to locate it in real time. Of course, a retrospective analysis is possible at any time,
- off-line solutions: the principle of route, speed and stop registration is identical and analyses are performed on a cyclic basis. The route recorder is the “black box” which registers all necessary information. Access to information is obtained owing to the possibility of reading it from the device and copying into an analysing programme.

A small size and weight of the device allows for installing it in various places difficult to access. Information collected by the positioner is sent to the monitoring station and next plotted onto a map available to the system user. Using the Internet, it is possible to visualise the on-going position and to generate reports and summaries, both for individual vehicles and for large company fleets.

A vehicle monitoring system allows for:

- monitoring the entire fleet of vehicles in real time,
- locating individual vehicles and drivers on the map,
- generating a journey register,
- detection of private use of company vehicles,
- analysis of vehicle use effectiveness (speed, fuel consumption, refuelling),
- vehicle servicing planning,
- report generation.

Maps with appropriate accuracy are needed for accurate vehicle positioning; today, mostly digital maps are used. The majority of digital maps available on the market are very easy to use. A laptop computer or a mobile phone with a map reading function is enough to view these maps. Digital maps are stored in the memory of the device, on which they are viewed or are downloaded directly from the Internet.

The map based on the OpenStreetMap platform is the most popular and the most accurate map in Poland. This is a system for registration and processing of information from distributed objects [6]. OSM is a project developed to create a free and easily accessible map of the world, which anybody can edit. All data are made available under an open-source licence, which allows for their further use. Fig. 2 presents a map from the OpenStreetMap system.

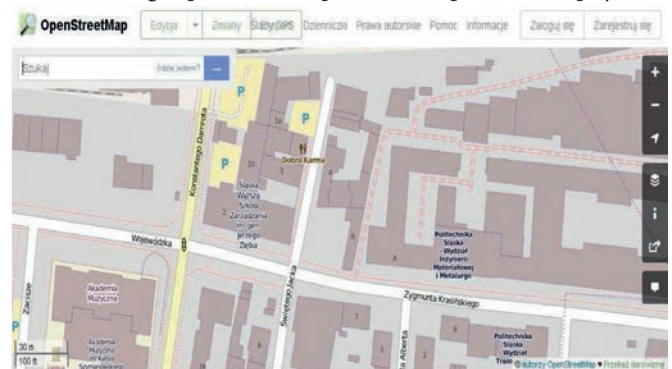


Fig. 2. A fragment of a map of the city of Katowice in the OSM system [own study based on 6]

The so-called tachographs are devices recording the driver's work. They were introduced to improve road safety and to monitor the driver's working time. There are two types of tachographs - analogue and digital ones (digital tachographs are used the most often today - Fig. 3).



Fig. 3. Siemens digital tachograph [7]

Positioners are not used only for locating vehicles. They are complex devices, which can be connected to various sensors that process large amounts of data.

The system can generate a summary of various parameters from the vehicle for a specific period. A report may contain information, such as:

- vehicle's registration number,
- total time counted from the first time the engine is started to the last time it is switched off,
- driving time, calculated as the sum of all times from the engine start-up to the time it is stopped,
- stopping time, as the difference between the total time and the driving time,
- maximum speed,
- average speed which is calculated as the ratio of the route length to the time,
- distance travelled,
- fuel use in a percentage value - the driving time to total time ratio,
- fuel used,
- odometer values at the beginning and at the end.

Positioners also allow for controlling the cargo area in the vehicle or connected to it (e.g. a semi-trailer). There are several possibilities of locating the semi-trailer. Closed cargo areas are controlled the most often (i.e. cold storage compartment or container), it is difficult to monitor open top semi-trailer.

There are many loads that are sensitive to environmental conditions (temperature, light). Positioners allow for controlling the temperature inside the cold storage compartment. To collect data pertaining to the temperature, it is necessary to install temperature sensors inside the semi-trailer. Information about the opening or closing of the cargo area is an important signal from the point of view of a transport company. This allows for controlling the time the driver devotes to the loading and unloading of goods. It can also signal the opening of the cargo area, when this area should be closed, e.g. while driving. The use of such a sensor will prevent the semi-trailer door from opening without leaving information about this fact in the system.

In transport companies, truck drivers often change semi-trailers. In a situation, in which the positioner is installed in the road tractor, the identification of the semi-trailer requires the installation of an additional device in this semi-trailer (identifier). In a situation when the semi-trailer or trailer is connected to the road tractor, a virtual trailer combination is created in the system. This status is kept until the combination is disconnected. The fleet administrator can follow the history of routes of individual combinations at any time. The time and place of leaving and taking semi-trailers by individual drivers can be checked accurately. It is particularly important when the transport company has more semi-trailers or trailers than road tractors. In this case, positioners are installed only in vehicles and identifiers are installed only in semi-trailers. It is a more economical solution than installing positioners in semi-trailers.

Companies more and more often decide to train their drivers in economical and environmentally-friendly driving. Employees, who drive company cars, do not always have knowledge and skills allowing for driving vehicles economically, which translates itself into higher fuel consumption. Fuel has the greatest share in costs of vehicle use, so companies attach a lot of importance to

economic driving. Eco-driving is driving style, which not only allows for reduced fuel consumption, but it is also environment-friendly. Eco-driving is mostly based on predicting road situations while driving. The vehicle should be driven in the highest possible gear within the optimal range of revolutions (RPM). Sudden accelerating and braking, putting a strain on the vehicle and dynamic driving significantly affects the vehicle's wear and tear.

The GPS positioner can collect data concerning the driving style. It is possible to collect basic information, such as the speed, engine RMP, acceleration and braking and additional information, such as the use of the brake pedal or the pressure on the gas pedal. These data are used in the analysis of the driver's driving style. By means of the system, the person managing the company's fleet can check how the vehicle is used by the employee. After analysis all this information, it is also possible to assess the whole driving style or its individual components.

A lot of companies have introduced a possibility of two-way communication with the driver. This system consists of two segments. The first system is installed in the vehicle. The other one is the interface, which is installed on the computer of the dispatcher or the person managing vehicles in the company. In the vehicle, this is usually a device with a touch screen, which can send and receive information. The dispatcher in a transport company can provide data to the driver on loading or unloading and set routes or check the order status.

The Law on Road Traffic [8] imposes on the driver the duty of archiving data recorded in the driver card. To make it easier for transport companies, driver card readers connected to the positioner can be installed in vehicles. A sample card reader installed in a truck is shown in Fig. 4.



Fig. 4. Driver card reader [9]

Nearly all companies offering vehicle tracking using a GPS system offer the possibility of protecting objects, in which the system is installed. In this case, the locator acts in a manner similar to a car alarm with the telephone notification function. The difference is that together with the alarm, information is sent about the current position, which reaches the monitoring station and starts the alarm-handling procedure.

If drivers are carrying valuable loads, insurers often require a satellite location system in the case of theft.

3. Practical use of positioners

To check the positioning system and confirm the manufacturer's data, an appropriate experiment was conducted. In the presented research, the author's private car was used. It was equipped with a GPS positioner, which was connected to a CAN bus. The positioner operated in the Automonitoring system by the CMA Monitoring company [4]. The system allows for controlling vehicles using the website or the mobile phone. The user who knows their individual login and password has access to the system. All data, which are presented below in tables and in drawings, were generated and converted on the basis of data from the vehicle obtained via the positioner.

Summaries generated by the system contain a lot of information. The selection of the most significant information and their presentation required the use of appropriate filters, e.g. the range of dates, data type, such as the fuel level, engine revolutions, distance travelled and vehicle speed. Fig. 5 shows a sample general report.

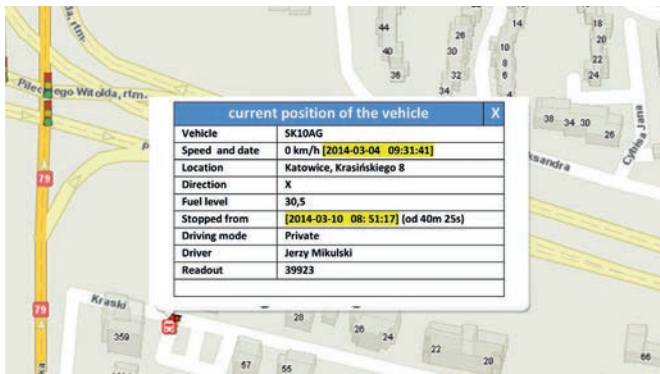


Fig. 5. Sample general report [own study based on 4]

The system also generates an eco-driving report, in which vehicle parameters and the driver's driving style are evaluated automatically while driving. The report shows the ranking of the most efficiently driving drivers and presents accurate information about the distance, driving time, fuel used, engine revolutions and the route type (city driving/road routes). The greatest value of the eco-driving report involves an advanced analysis of the driving style of individual drivers, which has a significant influence on fuel savings in the company.

Various reports can be obtained from the monitoring system, which are created from data stored in the memory. These can be summaries that included the distance travelled, the driving and stopping time, fuel consumption, operation and odometer values from specific days and even speeding. For trucks, it is very important to have a possibility of controlling the time, during which drivers spend driving - in this way, exceeding the designated working time can be prevented.

Table 1 presents a report, which was generated for the vehicle under analysis. A summary is generated for the declared period and it contains basic information, such as driving and stopping time, the number of kilometres travelled and the amount of fuel used. Also, the average and maximum speed in a given period can be read.

Table 1. Basic summary [own study]

Reporting period beginning date	04/03/2014 08:53:36
Reporting period end date	05/03/2014 11:31:25
Total time	1d 2h 37m 49s
Driving time	23h 33m 23s
Stopping time	3h 4m 26s
Average speed	98 [km/h]
Maximum speed	148 [km/h]
Distance travelled	2,314.2 [km]
Vehicle use	88 [%]
Fuel used	148.4 [l]
Average fuel consumption	6.7 [l/100km]
Vehicle odometer at the beginning	39945 [km]
Vehicle odometer at the end	42260 [km]
Distance - [business use] {private use}	{2,314.2 [km]}

A daily or weekly report is less detailed, but it covers a longer period of time. Table 2. presents such a detailed report for the vehicle under analysis. The start and end times are times corresponding to the first start-up and the last stopping of the vehicle during the day and the distance travelled by the vehicle. Owing to this summary, persons managing the fleet can settle the driver's working time with an accuracy to the second. This report is particularly useful in a situation, in which the vehicle is not equipped with a tachograph.

These data can also be presented in the form of a graph. For example, a bar graph informing about the number of kilometres travelled - Fig. 6.

With a larger number of observed vehicles, it can be seen in such a drawing how many kilometres these vehicles travelled in individual weeks of a given year. In this way, it is possible to determine accurately which vehicle in a company travels the greatest number of kilometres a week. On the basis of an analysis of such data, it is possible to balance the number of kilometres travelled by individual vehicles.

Table 2. Daily vehicle use report [own study]

Day	Time started	Time ended	Distance [km]
15/03/2014	07:30:52	17:08:04	40.38
16/03/2014	07:47:53	16:57:13	39.42
17/03/2014	01:21:10	23:53:21	45.87
18/03/2014	00:09:21	16:50:28	41.16
19/03/2014	07:42:24	15:29:01	69.18

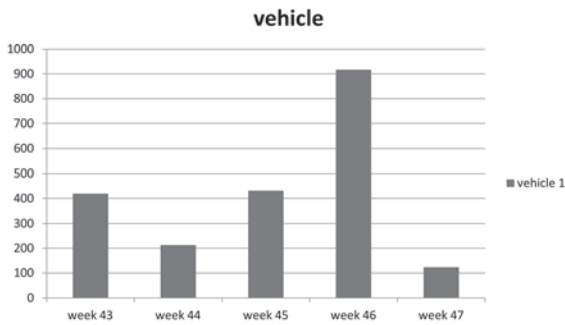


Fig. 6. Histogram of the distance travelled by the vehicle in consecutive weeks [own study]

It is equally easy to settle accounts with the driver as regards the fuel used, the working time and kilometres travelled on the basis of data received by the system. High driving speeds are connected with higher fuel consumption. As the positioner collects information about the vehicle speed, it is possible to generate a summary presenting the speed limits exceeded for a given vehicle.

A basic eco-driving report is presented in Table 3. The report was generated by the system on the basis of information collected from the vehicle under analysis.

Table 3 contains basic data pertaining to the vehicle, such as the engine capacity, fuel type and the year of manufacture. It also shows the registration number and the vehicle name in the system. These are data which are entered by the user. Other data, such as the distance travelled, fuel consumption and the driving time, are collected by GPS positioners and calculated from the vehicle's computer. The last column contains the rating of the driving style in a given period. In this case, the rating scale ranges from 1 to 10, where 1 is driving not consistent with the eco-driving principles and 10 means full compliance with these principles. Table 4 presents a detailed eco-ranking prepared on the basis of the route travelled by the vehicle under analysis.

Detailed speed, revolutions, acceleration and braking graphs allow for a more in-depth analysis of the driving style. Their analysis shows when the driver follows the eco-driving principles and which areas require improvement.

Fig. 7 presents a graph of engine revolutions as compared to the driving time in the entire period under analysis. It shows that the driver tried to keep the engine RPM on the optimal level most of the time (58%). The vehicle idled for 8% of the time. This results from longer stops with the engine running, e.g. at traffic lights or in traffic jams. Additionally, taking into consideration the engine RPM were up to 1500 28% of the time, it can be concluded that the vehicle started moving or got to traffic lights, while braking with the engine until it stopped. Higher revolutions are the result of accelerating and driving at high speeds on motorways.

Table 5. Basic eco-driving report [own study]

Vehicle	Name	Brand	Model	Engine capacity	Fuel type
SK010AG	Mikulski	Mercedes	B 180	1.8 [l]	Diesel
Year of manufacture	Distance	Fuel used	Average fuel	Driving time	Eco-ranking
2012	537 [km]	35.9 [l]	6.7 [l/100km]	3h 45m 24s	7.9

Table 6. Ranking of individual driving style ratings for the vehicle[own study]

Rating (according to the description)										
1	2	3	4	5	6	7	8	9	10	11
8.5	8.8	8.3	3	2.2	9.7	7.3	8.3	10	4.1	7.9

Rating description :

1	acceleration features	7	cruise control use
2	braking features	8	clutch use
3	keeping a constant speed	9	stopping frequency with the engine turned off
4	keeping the speed within the optimal range	10	keeping the engine RPM within the optimal range
5	exceeding speed limits	11	exceeding engine revolutions
6	time of braking with the engine and the use of the brake pedal		

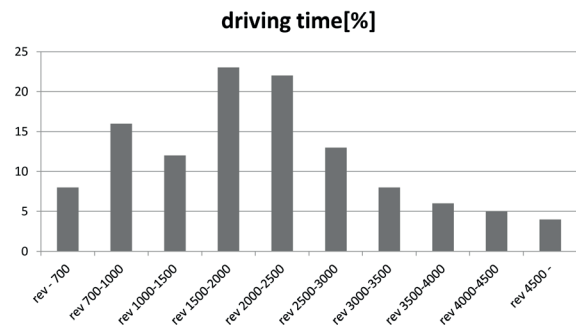


Fig.7. Histogram of engine revolutions relative to the driving time [own study]

Fig. 8 contains a similar graphic interpretation of driving speed rating. It is confirmed in this graph that the vehicle did not move or moved slowly 13% of the time and speeds of over 120 km/h constituted nearly 12%.

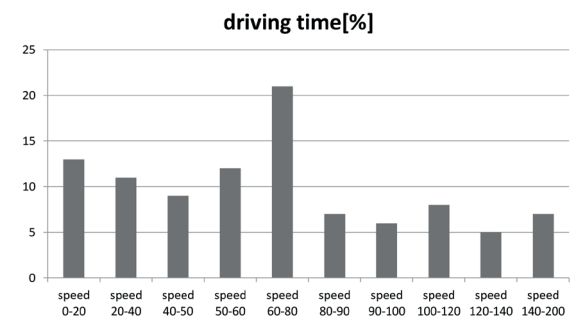


Fig. 8. Speed histogram [own study]

Fig. 9 presents a histogram of accelerating and braking relative to the driving time. It can be seen that 68% of the driving time, speed changes were at most by 1 km/h.

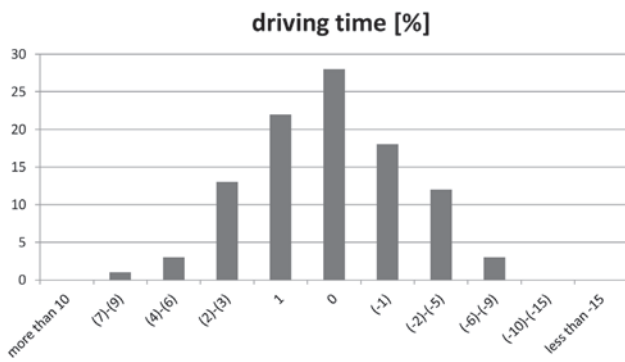


Fig. 9. Accelerating and braking histogram [(km/h)/(1s)] relative to the driving time [own study]

4. Conclusion

Generating reports, their accurate analysis and discussing their results with drivers may allow transport companies to reduce the wear and tear of their vehicles. These vehicles will use less fuel and will be less exposed to wear and tear. In this way, companies will reduce costs and vehicles will have a higher value for subsequent sale.

Considerable advantages can be gained from monitoring:

- possibility of immediate determination of the position and selected vehicle parameters,
- possibility of making vehicle users drive more carefully,
- immediate notifications about a prohibited use of the vehicle,
- full information about the way of using the vehicle,
- improved effectiveness of vehicle use,
- lower fuel consumption.

Advantages brought by the use of positioning systems according to the CMA Automonitoring company [4]:

- 30% reduction in fuel consumption in vehicles,
- 15% reduction of the number of kilometres travelled,
- 12% increase in the effectiveness of transport use,
- 10% of additional discount on the comprehensive motor insurance.

Legal principles of using monitoring systems must be remembered. It is worth knowing when the employer has the possibility of installing GPS devices in company cars and whether this can be done without the employee's consent or without informing the employee about this fact. Pursuant to the Labour Code, an employee undertakes to perform work at a place and time designated by the employer, so the employer is entitled to control the performance of duties by the employee. It should be emphasised that the company also has the right to protect its property (vehicles in this case) and can execute this right using a GPS system, but it is necessary to inform the employee about the monitoring. Such a solution creates a clear situation and prevents any accusations of infringing regulations on personal data protection.

A similar experiment is planned in Slovakia in cooperation with the University of Žilina in the near future.

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