Tracking of Trucks Using the GPS System for the Purpose of Logistics Analysis

Peter Trebuňa, Marek Mizerák(✉), Miriam Pekarčíková, Marek Kliment, and Matúš Matiscsák

Technical University of Košice, 9, Park Komenského, Košice 042 00, Slovak Republic
marek.mizerak@tuke.sk

Abstract. This article deals with and describes the issue of truck logistics analysis using GPS localization technology. Nowadays, it is still a progressive technology that works on the principle of data collection in real-time, so its results are up to date. The Mapon program is used for the evaluation and analysis of this issue. It analyzes selected monitored parameters such as route planning, fuel consumption, driver behavior, breaks, breakdowns, etc. Based on this program, it is possible to optimize parameters and preferentially reduce the costs associated with the transportation of cargo or avoid the movement of freight vehicles empty, which results in inefficient transport and underutilization of resources, and economic loss. Creating a report is the main task of this program, which will be described in the article. The article will discuss a GPS tracking system's other uses and benefits: operational planning, anti-theft, assistance services, and real-time truck location. Thanks to this option, the ability to guide the driver according to the requirements and also faster assistance in an emergency.

Keywords: Technology · Data · Vehicle · Reporting · Sustainable Transportation

1 Introduction

Today, without optimal management models, optimizing all processes of movement of goods, services, resources and other objects would be extremely difficult. With the advent of information technology and systems that process large amounts of information, various mathematical formulas and techniques are being developed to simplify logistics tasks. At the same time, the main goal of any logistics system is to reduce the total cost of delivering goods, services, and end users.

In economics, the primary role of logistics can be defined as the effective management of material flows. The turbulent development of this science was in the 1930s in the United States. At this time, scientists, economists, and business people primarily devoted themselves to logistics as a science that effectively coordinates the interaction of logistics, production, distribution, transportation, communication structure, and market. The basis of the development was the idea of the need to integrate supply, production, and distribution systems, in which the optimal function would be to supply the company with raw materials [1], and supplies would be coordinated by production, storage, and distribution [2].

V. Ivanov et al. (Eds.): DSMIE 2023, LNME, pp. 162–171, 2023.
https://doi.org/10.1007/978-3-031-32767-4_16

2 Literature Review

Industrial engineering is built on the principles of Industry 4.0. It includes both localization technologies and the principles of GPS systems, which nowadays are essential parameters for tracking logistics on our roads [3]. Nowadays, even in transport companies, great emphasis is placed on an overview of the driver's behavior when driving and transporting loads, as well as parameters such as fuel consumption and driver breaks [4]. All this also affects distribution networks and stops on routes [5], as described in the articles [6, 7]. The ideas of these authors partially inspired this post. The article explains the term GPS scientifically and its meaning for transport companies in case of traffic accidents or vehicle theft [8]. As part of route analyses, the freight forwarder can determine route plan changes, evaluate the route's optimality, or change parameters [9].

It is necessary to accept the risks associated with transport [10], as described in the article [11]. This means that the freight forwarder and the driver should always know the nature of the transported cargo and pay attention to, for example, the consumption of materials, the method of transportation for flammable materials, etc. [12]. These are all risks of trucking on roads and highways.

Mapoon intelligent software reacts to all these risks and parameters. The article derives all analyses from its working environment cooperating with fuel gauges. It thus creates accurate and realistic driving information. Of course, driver cards also contribute to this, as described in the post [13].

3 Research Methodology

With the help of truck tracking via GPS, the use of the vehicle fleet can be significantly optimized. The truck tracking system serves for safety and provides a better overview of the vehicle fleet. Truck trackers are easy to integrate and offer a wide range of features. However, there are legal and technical issues involved in truck tracking systems – for example, whether GPS tracking of trucks is allowed and how the data can be downloaded.

GPS trackers are the means of choice for locating vehicles in fleet management and tracking their movements. Susceptible devices can be easily installed in any vehicle. The truck tracking system can be programmed with geofencing and a virtual fence. In this case, the vehicle automatically triggers an alarm when the truck leaves the planned route. Figure 1 shows a GPS device used to track trucks [14].

When installing a navigation device on a vehicle, a navigation unit with sensors is used, which is connected to the vehicle's onboard computer. Installation of this device takes approximately 3–4 h. After that, the serial number of this navigation device will be added to the program, and it will start displaying the data.

Fig. 1. GPS device - which is installed in the truck.

3.1 Operational Planning

In a vehicle fleet or a logistics company, optimal operational planning is essential for trouble-free operation. However, observing the maintenance dates is necessary to avoid unforeseen vehicle breakdowns. Proper offenses such as speeding should ideally be traced back to the driver. In the end, effective protection of the vehicle fleet against theft is also necessary.

GPS truck tracking realizes all these scenarios. Such truck tracking systems consist of a GPS module and software that can be installed on a desktop computer, smartphone, or tablet. GPS is a satellite global positioning system that transmits the vehicle's exact location. Driving direction and idle times can also be checked in real-time. A GPS truck tracker has many uses.

3.2 Real-Time GPS Truck Tracking

Fleet managers can use GPS to track trucks to determine when a vehicle will arrive at customers, partners, or suppliers and give them an exact delivery date. These, in turn, have the advantage of coordinating their operational planning accordingly. GPS truck tracking saves time and money and significantly increases customer satisfaction.

Since driving times can also be checked, a GPS tracker in the truck is used for easy and efficient billing. Data can flow into payroll systems through an interface in the truck tracking system, and payroll can be created more easily and with fewer errors [15].

3.3 Protection Against Theft and Assistance in Road Traffic

In case of a theft, the truck's GPS tracking status or driving data may be sent to investigative authorities. In most cases, the systems allow you to set the alarm, which immediately informs the responsible employees in case of unwanted or suspicious vehicle

movement. The quick action triggered by a truck tracking system can significantly assist in investigating theft or other unauthorized vehicle use.

Ultimately, it also helps drivers if their truck is equipped with GPS: it can recognize traffic jams and other traffic obstacles in time and display new routes. The driver's driving times are fully recognized based on the truck's GPS location, and the system warns of legally prescribed and necessary break times [16].

3.4 Data Processing of GPS Systems of Tracked Trucks

In addition to route data, high-performance GPS tracking for trucks also records other data that helps companies manage their fleet effectively:

- tank content and fuel consumption,
- mileage and operating hours,
- tire pressure,
- speed.

With recorded tank content and fuel consumption, it is possible to identify the necessary refueling times and initiate measures in case of increased consumption. This may indicate a vehicle malfunction, and a service visit may be required. This also applies to falling tire pressure, which can be dangerous for drivers. Early information can interrupt the journey.

Mileage and operating hours make it easy to follow scheduled maintenance. Since the data flows into the software, the responsible personnel are informed about it in time - so they can schedule vehicles from the fleet for the maintenance period.

If the truck is equipped with GPS, there is a small module in the engine compartment or the driver's cabin. It transmits data permanently and in real-time via radio and enables GPS tracking of the truck. These are also stored locally in the digital tachographs and can be downloaded or sent to the fleet software automatically. A fixed interval can be set for this, for example, once a week or once a month – depending on the company's individual needs.

3.5 Mapon

Mapon provides the possibility to monitor the fuel consumption of its fleet, digitizes the inspection of vehicles, and monitors, with the help of its software and hardware, the driver behind the tachograph. Mapon can also offer solutions for construction activities, courier companies, passenger transport, corporate fleets, agriculture, set up various reports, etc.

The program allows one to see exactly where the vehicle is currently located. You can get information about the vehicle's location 24/7, the current fuel consumption, and the driver's mode of operation. The program also has an application for smartphones and tablets. When planning and assigning tasks, it helps to see the current driving time, distance, rest time, and tachograph forecast for drivers. Mapon provides device status monitoring, so you are always informed if something goes wrong and the device loses signal or stops data transmission.

3.6 Fuel Consumption Analysis Using Mapon Program

Figure 2, given below, shows the device with which the forwarder can determine the fuel level in the tanks.

Fig. 2. Fuel level measurement sensor.

For example, Fig. 3 shows the refueling schedule of a separate transport unit from 03/30/2022 to 04/01/2022. According to the schedule, we can see when and how many liters the truck refueled. The program also provides data for the beginning of the period and the end date. In addition, the report shown in Fig. 3 provides information on the fuel consumption for the given period, the average fuel consumption per 100 km, and the number of kilometers driven.

The parent company needs such information to analyze fuel costs, as fuel costs are the most significant cost sector for carriers. On average, a truck can travel 600 km per day and 12,000 km per month. The average fuel consumption is normally 30 L per 100 km, so one truck per month requires at least 4 tons of diesel.

It will also play an important role in pricing. If the customer orders transportation from Budapest to Košice and his cargo of 86 m^3 weighs 10 tons, the transportation price will be different from the price of cargo with the same volume and route but with a weight of 25 tons.

Another factor affecting truck fuel consumption is the driver's experience.

Experienced drivers have a slower truck driving pace and fewer hard braking and gas moments. While a driver with short work experience spends more fuel due to lack of experience – experienced drivers have a slower truck speed and fewer moments of hard braking and gas. At the same time, a driver with short work experience will spend more fuel due to shortage.

Another factor that affects fuel consumption is weather and season.

In winter, a truck (as well as a car) needs more fuel. The reason is the low temperature. The truck has to warm up and heat the cabin where the driver sits or the strong incoming

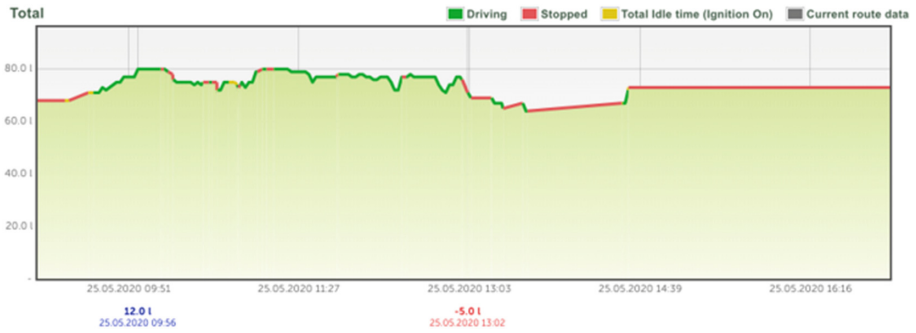


Fig. 3. Fuel level monitoring.

wind. When driving against the wind, the truck consumes more fuel than when driving into the wind.

Therefore, it is a priority for carriers to have the correct information about fuel needs.

4 Results and Discussion

Figure 4. Shows the truck report on 03/16/2022. The system informs about how the vehicle moved. The pause lasted from 00:00 to 00:41, and the truck started moving in Romania. The program shows us the truck's route and the numbering of highways. From this report, it is possible to analyze how quickly the truck got from A to B, using toll roads or bypassing them. You can also see where the driver deviated from the route. Based on these reports, travel documents are created, which are submitted to the accounting office for invoicing the business trip. The information on which country and how long the driver stays is particularly important for accounting to calculate allowances correctly. This program instantly generates such information that saves a lot of time. In addition, in logistics, shippers or consignees often ask carriers for this type of reporting to see if their goods have been delayed without good reason.

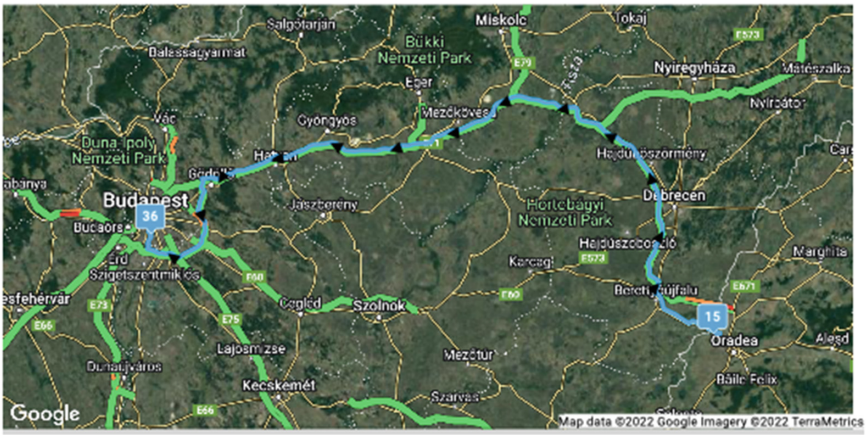
You can see a "ranking" of the trucks in its fleet using the report analysis. Here, the Mapon program shows which trucks use fuel sparingly and which exceed the norm. This will help to solve the problem of unnecessary costs. If the truck suddenly exceeds the fuel consumption standard, replacing the filters or providing other services and replacement parts may be necessary. Excessive fuel consumption can also be related to the transport of heavy loads or inappropriate placement of the load on the semi-trailer. The main task of this type of analysis is to show the deviation from the norm.

In Fig. 5, given below, we can see the table for monitoring the activity of the selected driver with the designation of the greatest and least efficient. As part of anonymity, providing comprehensive information in the contribution is impossible.

09.05.22, 17:34 Route history

Route history

TV009EI Volvo FH
16.03.2022 - 16.03.2022



	Addresses	Time	Date
1	Calea Borşului 58, Oradea 410605, Romania (41min)	00:00 - 00:41	16.03.2022
	198 m (2min)	00:41 - 00:43	16.03.2022
2	E60 58, Oradea 417272, Romania (10min)	00:43 - 00:53	16.03.2022
	317 m (7min)	00:53 - 01:01	16.03.2022
3	Calea Borşului 53c, Oradea 410605, Romania (14min)	01:01 - 01:15	16.03.2022
	141 m (2min)	01:15 - 01:18	16.03.2022
4	Calea Borşului 53, Oradea, Romania (13min)	01:18 - 01:32	16.03.2022
	208 m (1min)	01:32 - 01:33	16.03.2022
5	Sântion, Oradea, Romania (12min)	01:33 - 01:46	16.03.2022
	234 m (<1min)	01:46 - 01:47	16.03.2022
6	E60 70, Sintion 417078, Romania (10min)	01:47 - 01:57	16.03.2022
	454 m (1min)	01:57 - 01:59	16.03.2022
7	E60, Sintion, Romania (10min)	01:59 - 02:09	16.03.2022
	25 m (<1min)	02:09 - 02:09	16.03.2022
8	E60, Sintion, Romania (8min)	02:09 - 02:18	16.03.2022
	40 m (<1min)	02:18 - 02:18	16.03.2022
9	E60, Sintion, Romania (5min)	02:18 - 02:23	16.03.2022
	551 m (2min)	02:23 - 02:26	16.03.2022
10	E60, Romania (11min)	02:26 - 02:38	16.03.2022

https://mapon.com/pro/online/print?id=89954&from=2022-03-16 00:00:00&to=2022-03-16 23:59:59 1/4

Fig. 4. Reporting the operation of the truck on 16.03.2022.

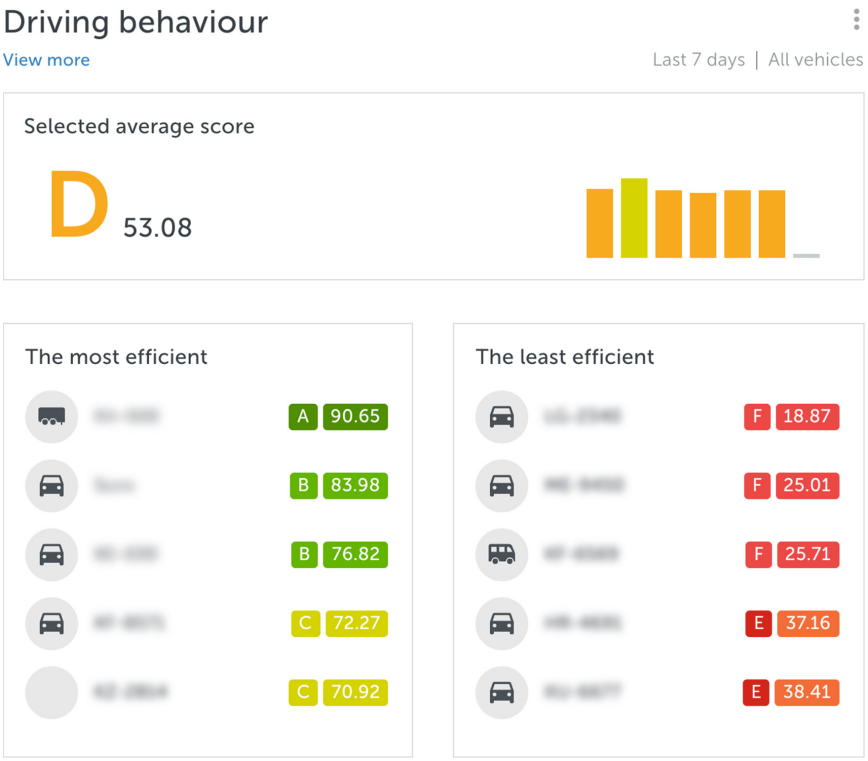


Fig. 5. Behavior of the driver while driving.

5 Conclusions

There are no limits to development and improvement. Every day in the world, people work to improve the development of various technologies. It also applies to logistics and navigation systems and programs in it. Ten years ago, to find out where the truck was, the dispatcher had to call each driver and ask where they were. As a result, the company suffered significant financial losses for international calls, and the process took quite a long time. Today, logistics managers can see the real-time location of all their trucks by simply opening a navigation service provider's website.

The Mapon program constantly adds new functions to expand the range of services. Navigation systems are one of the components of the logistics industry. In addition, there are programs for searching loads, a program for accounting costs for the company, and separate programs for the service of tractors and semi-trailers for reporting drivers. Then you can make a general analysis of all the data. A possible proposal for the future would be for one platform to provide all these services in one information package.

Acknowledgment. This article was supported by projects VEGA 1/0438/20 "Interaction of digital technologies to support software and hardware communication of an advanced production system platform", KEGA 001TUKE-4/2020 "Modernization of industrial engineering teaching to develop the skills of the existing training program in a specialized laboratory", APVV-17–0258

"Digital engineering elements application in innovation and optimization of production flows", APVV-19–0418 "Intelligent solutions to enhance business innovation capability in the process of transforming them into smart businesses", VEGA 1/0508/22 (2022–2025) "Innovative and digital technologies in manufacturing and logistics processes and systems".

References

1. M Demissie L Kattan 2022 Estimation of truck origin-destination flows using GPS data Transport Res E-Log 159 1 1 5 https://doi.org/10.1016/j.tre.2022.102621
2. SI You SG Ritchie 2018 A GPS Data Processing Framework for Analysis of Drayage Truck Tours KSCE J. Civ. Eng. 22 4 1454 1465 https://doi.org/10.1007/s12205-017-0160-6
3. Prester, J., Buchmeister, B., Palčič, I.: Effects of advanced manufacturing technologies on manufacturing company performance. Strojniski vestnik – Journal of Mechanical Engineering 64(12), 763−771 (2018). DOI:https://doi.org/10.5545/sv-jme.2018.5476
4. V Pavel M Maleki M Kargar 2022 A cluster-driven classification approach to truck stop location identification using passive GPS data J. Geogr. Syst. 24 4 657 677 https://doi.org/10.1007/s10109-022-00380-y
5. R Aziz 2016 Identifying and Characterizing Truck Stops from GPS Data P Perner Eds Advances in Data Mining. Applications and Theoretical Aspects ICDM 2016 16th Industrial Conference, ICDM 2016, New York, NY, USA, July 13–17, 2016. Proceedings New York, NY USA 2016 07 18 2016 07 20 Lecture Notes in Computer Science (Lecture Notes in Artificial Intelligence) LNCS (LNAI) 9728 Springer Cham 168 182 https://doi.org/10.1007/978-3-319-41561-1_13
6. KD Corro T Akter S Hernandez 2019 Comparison of Overnight Truck Parking Counts with GPS-Derived Counts for Truck Parking Facility Utilization Analysis Transp. Res. Rec. 2673 8 377 387 https://doi.org/10.1177/0361198119843851
7. D Yuniar L Djakfar A Wicaksono A Efendi 2020 Truck Driver Behavior and Travel Time Effectiveness Using Smart GPS Civil Eng. J. Tehran 6 4 724 732 https://doi.org/10.28991/cej-2020-03091504
8. JJ Bartholdi A Lasso HD Rarliff Y Oliver 2019 Using GPS to measure truck service times in a container terminal Marit. Econ. logistics 21 1 146 155 https://doi.org/10.1057/s41278-017-0097-1
9. P Trojanowski J Trojanowska 2021 Reliability of Road Transport Means as a Factor Affecting the Risk of Failure – The Transport Problem Case Study V Ivanov J Trojanowska I Pavlenko J Zajac D Peraković Eds Advances in Design, Simulation and Manufacturing IV DSMIE 2021 Proceedings of the 4th International Conference on Design, Simulation, Manufacturing: The Innovation Exchange, DSMIE-2021, June 8–11, 2021, Lviv, Ukraine – Volume 1: Manufacturing and Materials Engineering Lviv Ukraine 2021 06 08 2021 06 11 Lecture Notes in Mechanical Engineering LNME Springer Cham 253 261 https://doi.org/10.1007/978-3-030-77719-7_26
10. Arunmozhi, A., Park, J.: Comparison of HOG, LBP and Haar-like features for on-road vehicle detection. In: 2018 IEEE International Conference on Electro/Information Technology (EIT), pp. 0362–0367. Rochester, MI, USA (2018). https://doi.org/10.1109/eit.2018.8500159
11. V Ivanov I Pavlenko I Kuric M Kosov 2019 Mathematical Modeling and Numerical Simulation of Fixtures for Fork-Type Parts Manufacturing L Knapčíková M Balog Eds Industry 4.0: Trends in Management of Intelligent Manufacturing Systems EAI/Springer Innovations in Communication and Computing EICC Springer Cham 133 142 https://doi.org/10.1007/978-3-030-14011-3_12

12. MI Asborno S Hernandez T Akter 2020 Multicommodity port throughput from truck GPS and lock performance data fusion Marit. Econ. logistics 22 2 196 217 https://doi.org/10.1057/s41278-020-00154-7
13. P Camargo SY Hong V Livshits 2017 Expanding the Uses of Truck GPS Data in Freight Modeling and Planning Activities Transp. Res. Rec. 2646 68 76 https://doi.org/10.3141/2646-08
14. EA Nevland K Gingerich P Park 2020 A data-driven systematic approach for identifying and classifying long-haul truck parking locations Transp. Policy 96 48 59 https://doi.org/10.1016/j.tranpol.2020.04.003
15. T Soroúorpte A Sumalee HW Ho 2020 Statistical estimation of freight activity analytics from Global Positioning System data of trucks Trans. Res E-Log 140 101986https://doi.org/10.1016/j.tre.2020.101986
16. L Filina-Dawidowicz D Możdrzeń S Stankiewicz 2020 Integrated Approach for Planning of Intermodal Food Transport Chains Considering Risk Factors G Rodriguez Morales ER Fonseca C. JP Salgado P Pérez-Gosende M Orellana Cordero S Berrezueta Eds Information and Communication Technologies TICEC 2020 8th Conference, TICEC 2020, Guayaquil, Ecuador, November 25–27, 2020, Proceedings Guayaquil Ecuador 2020 11 25 2020 11 27 Communications in Computer and Information Science CCIS 1307 Springer Cham 319 332 https://doi.org/10.1007/978-3-030-62833-8_24