An Electronic Waybill in Planning Goods Road Transportation

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Abstract: Under the conditions of the ongoing transition to electronic document management in goods transportation by road, of particular relevance will be the use of an electronic waybill not only as a primary accounting document, but also as a planning tool for transport operations. The waybill is transformed into a software tool to calculate all the necessary indicators of the vehicle performance, both planned and actual, based on the results of transport operation performed. The obtained results have elements of scientific novelty and are of practical interest to companies operating a fleet of trucks and transporting their own goods or as a commercial activity.

1 INTRODUCTION

Depending on the transportation conditions, documents for the goods accepted by the transport company are prepared differently in the countries over the world (Rushton et al., 2017). The documents used include a transport waybill, a consignment note, a bill of lading, a transport manifest, a truck manifest, etc.In international road transport in Europe, Russia, Turkey and other countries being the parties to the Convention on the Contract for the International Carriage of Goods by Road (Convention relative au contrat de transport international de marchandises par route, CMR), a CMR consignment note is applied. Carriers in the United States use the Standard Truck Load Bill of Lading as an accompanying document.

There are various approaches to the public administration bodies participation in the goods transportation documentation arrangement. The waybills and consignment notes used in all cases of economic turnover in Russia are approved by regulatory and legal acts. When the transportation services are paid for by the U.S. Government or on behalf of the U.S. Government, goods transportation forms are approved by government agencies, e. g., U.S. Government bill of lading form, Standard Form 1103 (Standard Form 1103, U.S. Government Bill of Lading – International and Domestic Overseas Shipment) (The General Services Administration, 2012). Under commercial company orders, these forms are not used and are not approved by the government.

The common thing for all of these documents is their execution for the carriage of the submitted goods. The main distinction of the transport law system in Russia is that document is issued not only for the goods being transported. A special document — a waybill — is also to be executed for a vehicle used for the goods transportation before it starts its journey.

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2 STUDY METHODS AND MATERIALS

The authors have used the methods of full-scale passive experiment and statistical research, analysis and synthesis, as well as techniques of comparison and visualization of quantitative information about traffic flows on the road network within a settlement and fuel consumption during goods transportation by road. Regulatory and legal documents governing the use of the waybill in road freight transport were analysed, on the basis of which, the prospects of electronic document management in this area were determined.

2.1 Experience in Executing Electronic Documentation of Goods Transportation by Road

The first experiment to test the execution of the waybill and the consignment note in electronic form was conducted by the Ministry of Transport of the Russian Federation from October 1 to October 30, 2020 (Ministry of Transport of the Russian Federation, 14 April 2023). As a preliminary result, it can be noted that, under real conditions with a limited participants number and government agencies participation, the fundamental possibility of paperless document management in transport has been tested (Golubchik, 2022).

The pilot project on the use of an electronic waybill and, in general, the expansion of electronic document management options in the road transport company activities to a certain extent resulted from the trend of Russian economy digitalization (Larin & Kupriyanovsky, 2018), which is associated with global tendencies (Mashkina & Veliev, 2020). Opportunities are emerging to build efficient and reliable supply chains (Lukinskiy et al., 2014) and cargo transportation management systems (Kozlov, 2007) based on the system approach (Kurganov et al., 2021a) and implementation of multi-loop feedbacks (Kurganov et al., 2021b). As a result, reduction of transport costs (Villarreal et al., 2016; Kurganov et al., 2018a) and improvement of the transport service quality are expected (Ertman et al., 2021).

The next stage in the development of information systems for road transportation management is likely to be the increased use of the "digital twins" concept (Riss et al., 2021; Ivanov et al., 2019). One of the concept elements is the Process Mining procedure, which analyses the business processes performed by the company personnel (Voronova & Zakhodyakin, 2020). This is especially significant in relation to the waybills, as the procedure for their issuing to drivers is strictly regulated (Kurganov et al., 2021c).

In general, this contributes to a more comprehensive use of the possibilities of electronic waybills and digital management systems for road transport companies to improve the efficiency of their activities.

2.2 Waybill Functionality in the Transportation Management System

The inspectors of the Traffic Police and the Federal Service for Transport Supervision have the right to check the vehicle driver's waybill. This is one of the specific features of Russian road transport legal and regulatory framework.

The waybill has several essential functions. One of them is to ensure road safety. Before starting the trip, the technical state of the vehicle is checked. Driver pre-journey medical examination, which is also governed by regulatory and legal documents, is mandatory. Check of the vehicle condition and driver's health, which shall be noted in the waybills, reduces the likelihood of accidents.

Moreover, the waybill performs a number of other functions. The driver confirms the authority to receive the cargo for transportation by showing the driver's license and the waybill, i. e., the waybill is used as a power of attorney to accept the cargo. The waybill can be used to confirm the transportation cost, if, for example, the cargo owner transports cargo with their own rolling stock, in connection with which the consignment note is not executed for the transportation, because it is be filled out only if there is a contract of carriage. Since a cargo owner using their own vehicle cannot enter into a contract with themselves, the consignment note is excluded from the package of supporting documents.

However, in many cases, the opportunities of a waybill as a tool for planning work on the route are not fully implemented. This circumstance is of particular relevance in the case of the transfer of road transport document management in electronic form, because the waybill can be used as a software tool to calculate all the necessary vehicle indicators, both planned and actual, based on the results of transport work performed.

2.3 An Electronic Waybill in the Transportation Management Information System

Since a waybill belongs to the primary accounting documents, according to the law on accounting, it is a part of the company accounting policy, and its form is approved by the company head order. The company has the right to develop its own form of a waybill, provided it has the mandatory details required by law. This is a very important circumstance.

The electronic waybill, as a primary accounting document (Mitrofanov, 2011), can also be used as a central planning document of the Transportation Management System (Fig. 1).

Then, when processing queries, an electronic document will be automatically created where the

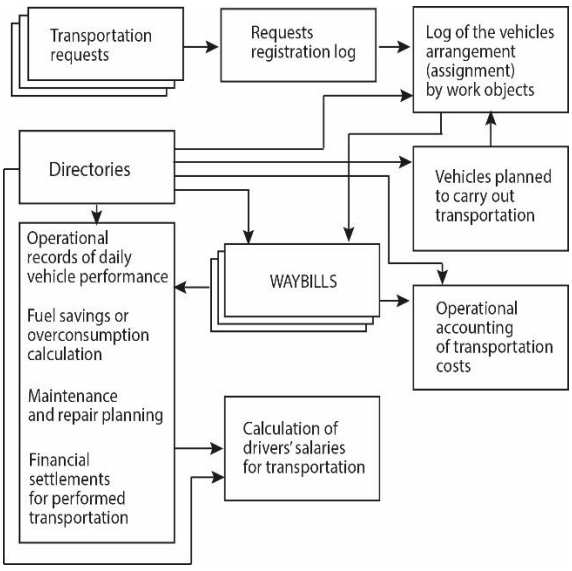

Figure 1: An electronic waybill in the digital management system of the road transport company.

software calculates the planned parameters of the transport process:

- vehicle's mileage between route points;
- start and end times of loading and unloading at each point;
- planned fuel demand and cost of refueling;
- work shift duration (scheduled time of work on the job);
- scheduled time for the vehicle to return to the parking place;
- planned quantity of cargo to be transported during the shift, etc.

Among the tools to solve the vehicle scheduling issues, it is necessary, along with other software products, to use route optimization tools in urban, suburban and intercity traffic. The calculation of the planned work parameters should be compared with the actual results. In performing a shift job, the electronic waybill includes actual transportation parameters: real mileage, actual time of vehicle arrival and departure to and from route points, and fuel flow during transportation.

The next stage is summing up the shift work (Fig. 1): automatic calculation of the performed transportation, the cost of transportation services for the customer, driver wages for the shift, as well as operational (management) cost accounting, etc. Transportation plan preparation and task formation for drivers in the waybills is based on three groups of initial data:

- cargo transportation queries, i. e. cargo type and number, as well as initial and final points of transportation;
- transportation network where the vehicles will operate;
- working fleet, i. e. types and number of vehicles available to carry out queries accepted from customers.

Directories of the digital transport management system should, in particular, contain:

- transportation route distance directory;
- speed assignment directory;
- loading and unloading downtime rate directory;
- directory of fuel consumption rate taking into account the vehicle operation features in specific work conditions on the routes;
- drivers' work and rest schedules directory;
- company's vehicle fleet directory.

This information is not exhaustive of the entire contents of Directories. It should also have regulatory data for planning and carrying out repair and maintenance on the vehicle fleet, for customer settlements (in particular, a list of tariffs used for transportation services), data for the calculation of wages, allowances, bonuses and premiums for drivers and other categories of workers, etc.

2.4 Average Technical Speed of the Vehicle in Transportation Planning

Availability of the average technical speed standard and information about the distance between the route

points is necessary to calculate the travel time between these points:

$$t_{dv} = L_m / V_{tn} \quad (1)$$

where

t_{dv} is the time of the vehicle movement between the route point, from the departure from one point to the arrival at another point, h;

L_m is the distance between the route points, km;

V_{tn} is the standard average technical speed of the vehicle, taking into account the travel time and all traffic-related delays: because of traffic control (e. g., downtime in front of traffic lights, compliance with the traffic controller requirements, etc.), when passing intersections and railway crossings, because of detours of road repair and accident sites, the need for regulated breaks, due to adverse weather conditions and other reasons of a similar nature, km/h.

The distances between the route points are determined based on the queries of transport service customers, which include departure and goods receipt addresses. In addition to traffic conditions on the transport network, the standard of average technical speed takes into account the time of a special rest break. As refueling on the route is associated with the vehicle movement, the calculation of the standard average technical speed also includes the refueling duration at fuel stations.

The average technical speed is influenced by a number of factors, of which the most significant can be distinguished the following:

- pavement condition;
- traffic flow composition;
- traffic intensity;
- vehicle dynamics;
- driver qualification and psychophysiological features;
- time of day;
- season of the year.

The actual average technical speed shows the real cost of time for which the vehicle can cover the distance between the route points.

The formula for calculating the actual average technical speed for the allocated time of work, for example, for the shift worked or for another period, is as follows:

$$V_{tr} = L_r / t_{dvr} \quad (2)$$

where

V_{tr} is the average technical speed of the vehicle during operation, km/h;

L_r is the vehicle mileage during operation, km;

t_{dvr} is the time during which the vehicle is in motion during operation, including all traffic-related delays, h.

2.5 Operating and Commercial Speed of the Vehicle

The calculation of vehicle operating speed not only takes into account the time of the vehicle movement and related delays, but also downtime at loading and unloading points to receive cargo from the shipper for shipment and delivery to the consignee.

The standard operating speed is used to calculate the round trip (vehicle tour) duration. A round trip (tour) involves vehicle loading, driving with cargo, unloading at the recipient, and returning to the route starting point. Payment for a round trip is usually agreed with the transportation customer, especially when delivering goods in intercity and international traffic. The customer pays for the actual mileage in the forward and reverse directions. The round trip (tour) time is calculated according to the formulas:

$$t_{kr} = t_{dv} + t_p + t_r \quad (3)$$

or

$$t_{kr} = (L_p + L_o) / V_{en} \quad (4)$$

where

V_{en} is the standard operating speed of the vehicle during the work on the route, taking into account the movement time, cargo acceptance by the carrier from the consignor and delivery to the consignee, km/h;

L_p is the vehicle mileage on the route in the forward direction, km;

L_o is the vehicle mileage on the route in the reverse direction, km;

t_{dv} is the time during which the vehicle on the route is moving, including all traffic-related delays, h;

t_p is the downtime at loading points on the route, h;

t_r is the downtime at unloading points on the route, h;

The formula for calculating the actual operating speed per shift is as follows:

$$V_{es} = L_s / T_N \quad (5)$$

where

V_{es} is the vehicle operating speed per shift, km/h;

L_s is the vehicle mileage per shift (including runs in the forward and reverse directions), km;

T_N is the time of the vehicle on the job including the period of vehicle movement and downtime at loading and unloading points during the shift minus the time for the driver to eat and rest in accordance with labor law, h.

Commercial speed of cargo delivery is more often of interest to the cargo owner interested it controlling the fulfillment of its obligations to the goods recipient. It is calculated by dividing the transport distance by the time from the end of loading at the sender to the beginning of unloading at the recipient. It also includes the time to perform all operations during delivery, involving customs clearance, inspection of cargo quality and completeness of accompanying documents, cargo storage at intermediate warehouses, etc. Commercial speed is not often used in transportation planning.

2.6 Standardization of Average Technical Speed in Intercity Freight Transportation

This section must be in two columns. uite often, companies set corporate standards, guided by their own experience. For example, one of the major express delivery companies has a corporate speed limit of 50 km/h in intercity traffic. There are other examples. In one of the regional transport companies, based on observations of specific route transportation, a corporate standard of average technical speed in intercity traffic of 60 km/h was established.

The average technical speed standard is often used as its value developed at a particular enterprise for a certain period of work, preceding the planned one. If there are collected statistics for the selected period, the calculation is made according to a formula similar to formula (2). In the current conditions, the actual value of the average technical speed can be determined on the basis of satellite monitoring of vehicles on specific routes. This value can be the basis for standard setting. However, it is necessary to carefully analyze the results of satellite monitoring and identify cases where the driver violated the established speed limits for the vehicle.

Accepted speed standards shall take into account travel delays for various reasons and will certainly be lower than the limits set by the road traffic regulations.

2.7 Standardization of Average Technical Speed in Intercity Freight Transportation

The availability of a standard average technical speed can solve not only the issue of calculating the time of arrival at the destination (Larin & Almetova, 2012). In many cases, it is relevant to calculate the delivery radius during the day. If the driving time is 9 hours, then the cargo delivery radius will be equal to the product of the driving time by the standard (planned) value of the average technical speed. For example, the company has adopted a corporate standard of average technical speed of 50 km/h. Then, the planned daily cargo delivery radius in intercity traffic is 450 km. After the end of the regulated driving time, the driver shall be given a daily (inter-shift) uninterrupted rest of the specified duration.

If on the basis of calculations or on other grounds, the carrier and the customer have agreed on a daily delivery distance, it shall be included in the contract of carriage. Otherwise, if the contract does not specify terms, goods in intercity traffic are delivered in accordance with the rules of transportation of goods by road at the rate of one day per every 300 kilometres of transportation distance.

2.8 Standardization of Average Technical Speed in Urban Cargo Transportation

The intensity and density of traffic have a decisive influence on the actual speed in urban areas. Accounting for variations in traffic speed during the day, associated with fluctuations in traffic intensity, presents significant difficulties. For this purpose, it is necessary to conduct a special survey for specific conditions. The results of field observations on the example of the road passing along Karl Marx Avenue in Magnitogorsk (Gryaznov et al., 2017) are shown in Fig. 2.

Knowing the information about fluctuations in the actual traffic speed, it is possible to reasonably assign its value in a particular period of the day for the planning calculations. If the driver task, for example, supposes vehicle movement in a straight direction along Karl Marx Avenue in the interval from 9 to 11 hours, then to calculate the time of arrival to the customer, it is necessary to take the average technical speed of not more than 32 km/h, and not more than 28 km/h in the range from 18 to 19 hours.

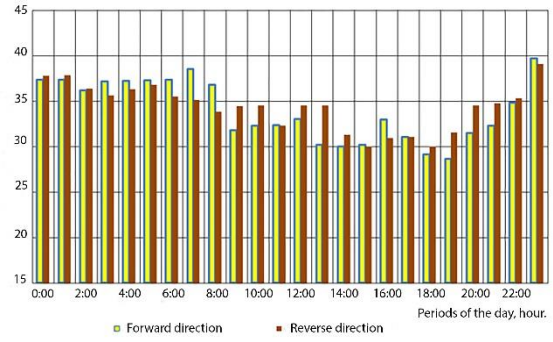

Figure 2: Speed of the traffic flow on Karl Marx Avenue on weekdays (Magnitogorsk). Karl Marx Avenue is one of the main thoroughfares of the city with a length of 9.5 km and three lanes of traffic in each direction. Forward direction means the movement from north to south (Gryaznov et al., 2017).

2.9 Standardization of Downtime at Loading and Unloading Points

To draw up a planned schedule of the vehicle operation, it is not enough to calculate the duration of the movement between the route points based on the standard average technical speed and distance information. It is essential to have reasonable downtime rates at loading and unloading points.

There are two main options to standardize downtime at loading and unloading points. The first option involves the use of regulations contained in the rules of transportation of goods by road approved by the government. The second option involves timing measurements of the vehicle interaction with loading and unloading points. The timing measurement results identify the necessary time spent on receiving cargo for transportation and delivery to the recipient. They are, in fact, the basis for setting the downtime standards. All non-productive time costs are eliminated: idle vehicles in the queue, waiting for loaders, crane operators or slingers, etc. The standard downtime agreed between the carrier and the customer of transport services is specified.

2.10 Fuel Consumption Rate

Please The amount of fuel needed to perform the task is automatically calculated in the corresponding columns of the electronic waybill. The calculation takes into account the remaining fuel in the vehicle tank when it returns to the garage after the previous shift. The cost of the required fuel amount is calculated. It is possible to determine the optimal place and time of refueling at the filling station, based on the vehicle schedule.

Both in Russia (Kurganov et al., 2019, Kurganov et al., 2018b) and abroad (Yao et al., 2020), attention is paid to the use of information technology for fuel consumption standardization. Satellite monitoring systems are now being introduced everywhere providing more accurate measurement of distances and controlling the vehicle route on the electronic map. The approximate sequence is as follows.

On the transportation routes, “control sections” (“route modules”), are allocated differing in the available conditions of vehicle operation. Such conditions may include, for example, road section location (in or out of town), road surface type (crushed stone or asphalt), roadway condition (requiring repair or flat and smooth), traffic density, presence of controlled and uncontrolled intersections, etc.

To get the standards, it is necessary to calculate the average values of actual fuel consumption by different drivers for the same vehicle brands for a certain period of time by “control sections”. This uses an array of statistical information on vehicle mileage and fuel consumption collected by the satellite tracking system. The average values of the actual fuel consumption will give a reference point for standard setting. They should be assigned for different seasons of the year (winter and summer standards), for laden and unladen vehicles, and taking into account the mileage from the beginning of operation (vehicle age).

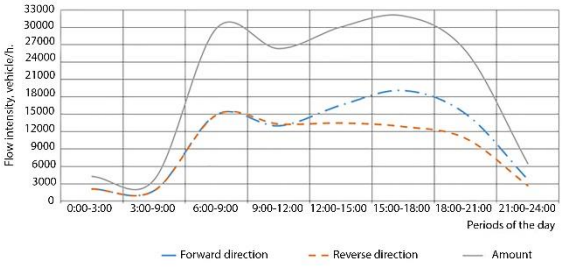

Figure 3: Intensity of the traffic flow on Karl Marx Avenue on weekdays (Magnitogorsk). Karl Marx Avenue is one of the main thoroughfares of the city with a length of 9.5 km and three lanes of traffic in each direction. Forward direction means the movement from north to south (Gryaznov et al., 2017).

When calculating corporate standards and compiling the Guides used in the planning of vehicles operation in TMS and entering the planned fuel consumption in the electronic waybill, it is necessary to take into account some aspects. For example, even when driving the same vehicle on the same route, different fuel consumption may be recorded.

One of the reasons is the traffic flow fluctuation at different hours of the day (Fig. 3) resulting in varying vehicle speed. Fuel consumption is also affected by the task nature: if there are many pick-up and drop-off points along the route, the average operating speed will be low, and the fuel consumption will be higher because of this. The traffic lights number on the route has the same effect.

3 CONCLUSIONS

The study has elements of scientific novelty in terms of determining the electronic waybills use in road cargo transportation planning and the necessary requirements for the development of information and reference base being a component of road transport company management system. The obtained results are of practical interest to companies operating a fleet of trucks and transporting their own goods or as a commercial activity. From the results of the study, the following conclusions can be drawn:

- the processes of Russia's economy digitalization predetermine the transition to electronic documentation of road transport activities. Today, it is already allowed to electronically apply (order) for transportation services;
- the Ministry of Transport of Russia has implemented a pilot project on the use of electronic forms of waybills and consignment notes. traffic flow composition;
- the electronic waybill refers to primary accounting documents; however, its potential as a tool to improve planning is currently underutilized; at the discretion of road transport companies, for these purposes, it is possible to add a plan to the waybill, in addition to the mandatory necessary details to specify the task of planned transportation.
- the feasibility of planned tasks in the electronic waybill is ensured by entering justified corporate standards into the information and reference database of the motor transport company; the most important corporate standards include: 1) values of average technical speed, taking into account the specific features of transportation within settlements and in intercity traffic; 2) downtime duration at loading and unloading points; 3) fuel consumption standards per 100 km of mileage by vehicle brands depending on the season of the year, age of the fleet and other factors.

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