Planning of a Cargo Control Post within an Urban Agglomeration

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Abstract. Failure of road users to comply with rules and regulations when transporting heavy and oversized cargo poses a threat to the lives of citizens. This is evidenced by statistics on accidents and deaths in road accidents. The problem in this area of research is the failure of drivers of heavy and large-sized vehicles to comply with the established requirements for cargo transportation, as well as the damage caused to state property when exceeding the permissible mass and size indicators. Current regulations do not allow the use of such a measure of coercion as the detention of vehicles in full. Many checkpoints are not equipped with special Parking lots, and the issue of responsibility for the safety of vehicles is not properly resolved. These and other economic and legal factors lead to a deliberate violation of the established rules of transportation by carriers and senders of goods. In this regard, the main event of this research work is the development of a weight control post within the urban agglomeration.

1. Introduction
A programme of weight control on roads is aimed at: ensuring safety and security of trails for General use; user compliance with provisions of legal acts in the process of transportation of goods, requirements to the quality of their services; compliance services, weight control requirements under the supervision of the carriage of goods; the implementation of the target approach in planning and use of budget resources by object of expenditure. In particular, special supervision is established for spending money on the construction and maintenance of checkpoints (primarily stationary ones). Weight control, organized in accordance with the program, allows you to reduce the specific weight of the cost of repairing and restoring tracks damaged and destroyed due to the passage of heavy vehicles on them.

Weight and size control of vehicles on the highways of the Russian Federation is carried out at the points of weight and size control of vehicles placed in order to ensure the safety of highways. Weight and size control points can be stationary, mobile, or automatic [1,2].

The weight control system provides:
1. Dynamic weighing of vehicles moving on the roadway [3,4]. Identification of vehicles from the General flow with weight parameters exceeding the allowed ones. Determination of the total mass of
the vehicle, axial loads, center-to-center distances, and speed. Automatic recognition of the state registration number of the vehicle, using the video surveillance system.

2. Transmitting data on weight parameters exceeding to the operator of the weight control post for an operational decision on stopping the vehicle, as well as transmitting the necessary text or graphic information to the information Board.

3. The ability to transmit measurement data and video recording of vehicles over a wireless communication channel and over the Internet.

4. Possibility to print out a hard copy of the vehicle image with the date, time and measurement results. Electronic storage of measurement results.

5. Storing vehicle identification data on the server with parameters that exceed the allowed parameters: weight, date and time of travel of the vehicle, registration number in the form of text and photos.

The object of the research is the field of activity in which ensuring road safety, safety of public roads and compliance by drivers of vehicles with regulations and legislation in the process of cargo transportation.

The subject of the study is the measures necessary for the implementation of the legal order in the organization of points of weight and dimensional control of vehicles.

The purpose of this work is to analyze the current situation in the field of vehicle weight control and solve existing problems in this area.

2. Theoretical part

The Belgorod region plays an important role in the economic and transport development of the Central Federal district. The most important highways connecting the Russian capital with the southern regions of Russia are laid through the territory of the region.

In Belgorod, much attention is paid to the construction of new and reconstruction of existing highways in this regard, the roads of the urban agglomeration have become the object of this study [5,6].

An important highway that connects the city with the southern regions of Russia passes through the territory of Belgorod. The M2 "Crimea" Federal highway passes through the city. The total length of all roads connecting Belgorod with other regions of the country is about 9,000 km.

For the research and development of the weight control post, 5 routes of cargo flows heading to the urban agglomeration were selected as part of this work (fig. 1).

![Figure 1. Routes of cargo flows going to Belgorod.](image)

According to the routes indicated in the figure, studies were conducted to calculate the number of trucks weighing more than 10 tons, heading to the city of Belgorod during the week. The research data is shown in table 1.
Table 1. Data on the study of cargo traffic on the main routes of freight transport.

| Weekday  | Cargo traffic on route 1, (units/hour) | Cargo traffic on route 2, (units/hour) | Cargo traffic on route 3, (units/hour) | Cargo traffic on route 4, (units/hour) | Cargo traffic on route 5, (units/hour) |
|----------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| Monday   | 284                                   | 566                                   | 380                                   | 456                                   | 396                                   |
| Tuesday  | 456                                   | 468                                   | 346                                   | 430                                   | 426                                   |
| Wednesday| 472                                   | 480                                   | 472                                   | 460                                   | 510                                   |
| Thursday | 386                                   | 568                                   | 396                                   | 454                                   | 476                                   |
| Friday   | 640                                   | 748                                   | 564                                   | 602                                   | 612                                   |
| Saturday | 596                                   | 720                                   | 546                                   | 642                                   | 598                                   |
| Sunday   | 570                                   | 650                                   | 604                                   | 570                                   | 582                                   |

On the first route, we can observe that the largest number of trucks in this direction moves on Friday (640 units/hour), the smallest-on Monday (284 units/hour).

Analysis of the second route showed that a large number of trucks are moving in the direction under study. The largest number of vehicles with cargo moves from Friday to Sunday. The lowest is on Tuesday and Wednesday (468 units/hour, 480 units/hour, respectively).

For the third route, it was found that the largest number of vehicles with cargo moved on weekends (546 units/hour on Saturday, 604 units/hour on Sunday).

Moving vehicles with a mass of more than 10 tons in the direction of Shebekino-Belgorod (the fourth route), it can be noted that all days there is a large number of movements throughout the week. However, the highest values correspond to Friday (602 units/hour), Saturday (642 units/hour), and Sunday (570 units/hour).

For the fifth route, it can be observed that the smallest number of vehicles under consideration moved on Monday (396 units/hour), the largest on Friday (612 units/hour).

Table 1 above shows the data obtained during the research. During the week, for each of these directions (Tomarovka –Belgorod, Moscow - Belgorod, Voronezh – Belgorod, Shebekino - Belgorod, Maysky - Belgorod), measurements were made of heavy trucks entering the city weighing more than 10 tons. Data received during the day is indicated in the table and displayed on the graph. They show that the largest number of trucks is moving in the direction of Moscow – Belgorod, which allows us to conclude that it is necessary to place a stationary weight and size post in this direction.

3. Practical part
In the course of the research, 4 sites for the location of a stationary weight control point were proposed (fig. 2).

![Figure 2. Proposed sites for placing stationary weight control posts.](image)

Positive and negative aspects have been identified for these sections, which in the future will allow you to choose the most suitable place for placing a stationary weight control post (table. 2) [7,8].
Table 2. Proposed locations of stationary weight control points.

| Number | Name of the section with coordinates (latitude, longitude) | Characteristics of the plot |
|--------|------------------------------------------------------------|----------------------------|
| 1      | First section 50.653451, 36.651878                         | It is located between the Moscow-Belgorod and Voronezh-Belgorod directions, near the Novosadovy district (North-Eastern bypass of the city of Belgorod). In these areas, cargo traffic is significantly higher compared to other destinations. Also, the construction of a post in the proposed location will allow you to control 2 directions at once. The area allows you to place a point with 40 Parking spaces for cargo vehicles. |
| 2      | Second section 50.669056, 36.562058                        | Located in the area of p.Northern. In the direction of Moscow-Belgorod (route M2). The area of this section will allow you to place small-sized SPVS, control and supervision measures for cargo vehicles will be carried out only in one direction. |
| 3      | Third section 50.635689, 36.466954                        | The proposed site is located near the village of Streletskoe. In the vicinity of the roadway there are a large number of residential buildings and other structures, which does not allow you to place the necessary size of the SPVC. Also, the cargo flow in this direction is significantly lower in comparison with other directions. This situation will not lead to a payback for the construction of the post in the next few years. |
| 4      | Fourth section 50.504265, 36.441587                       | Located near the village of Maysky (highway M2). The location of the post in this place is not appropriate, since there is a weight control at the customs crossing in the village of nehoteyevka on the border of Russia and Ukraine, which oversees compliance with the permissible requirements for cargo transportation. |

Based on the results of research conducted to determine the number of vehicles with a load capacity of 10 tons passing through the city of Belgorod in five directions during the week, it can be concluded that the largest number of trucks under consideration moves in the directions Moscow-Belgorod and Voronezh-Belgorod. Therefore, in this area, it is necessary to place stationary and exit weight control posts in order to prevent drivers from violating traffic rules, comply with the established standards for permissible load capacity and ensure road safety.

The purpose of the planned stationary weight control point on the territory of the urban agglomeration will be:
1. detection of unauthorized driving on highways;
2. identification of vehicles whose actual weight with or without load and / or axle load exceeds the values defined by the norms of axial loads and total weight;
3. identification of vehicles approved in accordance with the established procedure and (or) established by the relevant road signs.

According to research, the most suitable site is site 1 (table 2).
The construction site is located in the area of the North-Eastern bypass of the city of Belgorod, between the routes M2 and 14K-1 (50.653451, 36.651878) in the North-West of the Novosadovy district. The transport access roads to the weight control point are the existing road. The post is a complex of buildings, structures, technical and software tools necessary to ensure the operation of the system around the clock and year-round.

At the stationary weight control point, there will be: unfunded car scales, as well as scales with a load capacity of up to 100 tons, the building of the weight control point, Parking spaces for detained cars (40 Parking spaces).

The entire territory of the stationary weight control point is provided to be fenced with a metal fence. The project provides for the installation of two fiberglass tanks for storing water to extinguish the fire for three hours.

The stationary point will have to meet the characteristics shown in table 3.

**Table 3.** Geometric parameters of the projected stationary weight control post.

| Parameter                        | Value          |
|----------------------------------|----------------|
| Road category                    | 2              |
| Number of lanes, units           | 4              |
| Lane width, m                    | 3.75           |
| Cover                            | asphalt-concrete |
| Post area, m²                    | 110920         |
| Building area of the post, m²    | 1300,0         |
| Number of parking spaces, units  | 40             |
| Amount of weight                 | 2 (24 m)       |

Figure 3 shows the design of a stationary weight control point located on the North-Eastern bypass of the city of Belgorod between the directions Moscow-Belgorod and Voronezh-Belgorod.

**Figure 3.** Proposed project of a stationary weight control point: 1-scales with a load capacity of up to 100 tons; 2-construction of the post, m² (1300); 3-Parking for cargo vehicles, m (3.50×25); 4-Parking for employees; 5-lighting of the post; 6-impound lot; 7-size control scanner, surveillance video camera.

In case of possible overloading, the potentially overloaded vehicle is sent to site K for static weighing and accurate determination of its weight. On-the-go weighing is performed using piezoelectric sensors installed in the roadbed. Overloaded trucks are sent to a special area for detained vehicles, where they are supposed to be unloaded, after which the unloaded vehicles are sent for re-
weighing on the control scales. The stationary weight control post is supposed to work around the clock. There are 3 Parking spaces available for transport and service personnel at each of the points.

4. Implementation result
On the basis of data on traffic flows, was proposed several locations of the stationary points of weight control. The analysis of all the presented sites was carried out, on the basis of which the most suitable territory for the location of the weight control post was selected. The first location was chosen on the territory of the North-Eastern bypass of the city of Belgorod.

The analysis of existing models of scales for heavy-duty vehicles and software is carried out. From the above models, the most suitable ones are selected for the designed control point.

Taking into account all the necessary geometric characteristics: the road category, the number of lanes, the width of the roadway, as well as taking into account the existing cargo flows, it is advisable to place a weight control point designed for 40 Parking spaces for heavy vehicles.

The presented weight control point will meet all the necessary requirements for such objects.

5. Conclusions
When building a stationary weight control point, it is necessary to calculate all economic costs. These include: the cost of car scales, other equipment, namely, software, video recording systems, construction and installation work, other costs, design and survey work, as well as wages for employees [9-11].

To determine the amount of damage caused by lorries to state property, take into account many parameters: class of pavement (laminated road coverage); the type of road – highway, highway, urban infrastructure, bridge, embankment, ring road, etc; the location of the plot of distance traveled in the country; the length of the path, which made supercharged car (way lightweight car is not taken into account); the number of trips attributable to the same vehicle; the vehicle category; the distance between the axes; the actual weight load on the axles; the total weight load of the car (in fact); the excess load (in tons); the permissible weight load of the axles and the entire car as a whole; the rate of excess weight of the axles – in each region, it is set its own.

When all the above parameters are taken into account, the damage caused to state property is calculated: road surfaces, road objects, etc.

To compensate for this damage to cargo vehicles exceeding the permissible weight and dimensions, fines are established.

For a week in the Belgorod region, about 490 penalty orders are issued at mobile weight control posts (52 weeks – 25480 fines) with an average amount of 44 thousand rubles, a total amount of 1,121,120,000 rubles per year. Of these funds, approximately 3 million rubles are allocated for road repairs. The remaining funds are used for payback of weight control points, for the necessary expenses for the operation of posts. The total amount of expenses for the construction of post in the city of Belgorod is about 214 million rubles.

As a result of the research, the main types of weight and size control posts were determined. The main routes of cargo transport in the Belgorod region are determined, and the traffic of the weekly cargo flow in the studied directions is determined. The main locations of stationary posts and the main equipment for the arrangement of the post under development have been established. The economic costs of setting up a stationary weight and size control post are calculated.

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