Suggestions for automation of document flow system at railway freight classification yard

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Abstract. Upon condition of the mandatory application of the traffic safety management system in the railway transport system, as well as to add the demands for the carrier of cargo, amendments to the draft law on the railway transport operation have been introduced, which include new requirements: carriers of cargo are required to operate the traffic safety management system. The parameters and quality indicators of the railway transportation process include: the accuracy of the timeline travel time, the value of the service speed, the amount of energy consumed, the cost of maintenance work, the preservation of cargo commodity qualities, etc. In addition to the common problems that attract the attention of railway science, comprehensive automation of processes is a critical task. To address the delay in sending documents, the authors have designed and modeled a device that ensures the automatic redirection of documents by pneumatic tubes. Automation of the pneumatic tubes operation will make it possible to speed up the process of transferring documents to prepare for the departure of freight trains, improve the performance quality of the freight classification yard, increase the capacity of the freight classification yard, as well as eliminate human interference and improve the safety of trains. The project's technological performance indicators have been determined. This practice will have an economic impact of 4,439.2 thousand rubles per year. The payback period is 2 years.

1. Introduction
The railway transport system is entering a new phase of structural digital reform, without which it is impossible to manage increasing volumes of transportation and technically refit and develop the industry. The basis of the reform is to centralize the management of the industry, and one of its basic principles is to preserve and develop the railway network as a single production and technology complex, using advanced technologies [1, 6]. In today's environment, a great deal of attention is paid to the introduction of new equipment and automated control systems in the field of cargo transportation. The automation of commercial inspection of rail cars at stations with heavy workload is of great importance [3-6, 7, 8].

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critical task. Each enterprise, regardless of ownership, scale and structure, strives to improve its performance. In the context of rapid progress, market relations and a competitive economy, a timely and correct solution to strategic and tactical tasks determines the viability of the organization. An important step towards achieving this goal is to optimize basic management procedures, in particular, to create modern systems of workflow management and document flow organization in the enterprise. [9, 10] The new concept is focused on a number of objectives. For example, to refine the algorithms of existing stationary devices and security systems, improve their functional reliability by upgrading or replacing assemblies; develop and implement qualitatively new devices improving the diagnostic system [11].

2. Document flow system of the railway freight classification yard

It is the technological basis for its decision making and their execution. Thus, any improvement in the efficiency of the structural unit with accompanying transport documents directly affects the functional efficiency of the railway station and solving the main tasks aimed at reducing the costs of the industry and increasing the estimated capacity of the railway facilities [12, 13].

In order to transfer documents to cargo trains inside the structural unit, freight classification yards are usually equipped with pneumatic tubes, the work of which is based on the air pressure difference artificially created between the starting and end points of the transport pipeline. Let us consider the proposal to automate document flow by the example of the Irkutsk-Sortirovochny station of the East Siberian Railway.

In the pneumatic tube system of the down gravity sorting yard of the Irkutsk-Sortirovochny station there is a receiving and departure station, which is connected by pipeline with the receiving and departure stations of the down receiving yard, the down departure yard, the interlocking cabin and the railway freight office [14-16, 17]. In the course of researching the technology of the interlocking cabin of the station technology center (hereinafter - the STC cabin) there have been non-productive temporary losses found in the sending or redirection of documents by pneumatic tubes, see figure 1.

![Figure 1. Detention of a transit rail car without yard operation at the freight classification yard.](image)

The main reasons for the failure to perform the detention of transit rail cars without yard operation at the yard were: detention of rail cars waiting for departure due to unprepared documents for the departure - 42%, waiting for the locomotive - 24%, detention of rail cars at train stations - 18%, the regulation of the train dispatcher - 16%.
3. Device that automatically redirects documents by pneumatic tubes

To solve problems with the delay in sending documents, the authors have designed and modeled a device that ensures the automatic redirection of documents by pneumatic tubes (ADRP). Automation of the pneumatic tubes operation will make it possible to speed up the process of transferring documents to prepare for the departure of freight trains, improve the performance quality of the freight classification yard, increase the capacity of the freight classification yard, as well as eliminate human interference and improve the safety of trains [18, 19].

The author-developed ADRP device is a rail-mounted platform (figure 2, table 1). An equal leg angle U-63x5mm will serve as rails. The platform may be made of standard metal structures: a U-profile No. 20aP, rolled steel, sheet of metal with dimensions of 200x650x15 mm. The name and the estimated amount of material required to manufacture the proposed device is presented in table 1.

On the platform, it is advisable to place a rotary device of feeding pneumatic tube canisters installed on the rack. The rack may be made of metal pipes with a diameter of 160 mm. A geared transmission and a low-power electric motor will be used to rotate the rack against the platform, as well as a group of contacts to lay the rack into the right position. To insert documents and take them out of the cabinet of pneumatic tube system on the rack, it is supposed to have a device that delivers the canister into the cabinet, as well as a group of contacts for two extreme positions. It is advisable to arrange it on the platform on which an electromagnet will be installed. The platform, in turn, will move relative to the device by installing a helical gear drive actuated by a low-power electric motor. It is planned to install a metal plate on each side of the canister for interaction with the ADRP electromagnet. The platform will be moved relative to the pneumatic tube cabinets by means of four wheels located on a specially mounted rail track. The trolley movement is provided by a gear train and

![Figure 2](image-url). The proposed design scheme of ADRP.
a low-power electric motor, as well as by installing a group of contacts to place the platform in the right place on the rail track.

| Item | Designation                                      | Number |
|------|--------------------------------------------------|--------|
| 1    | Frame, U-profile No.20aP, L=1000 mm              | 2      |
| 2    | Wheel                                            | 4      |
| 3    | Plate 200x650x15 mm                              | 6      |
| 4    | Metal sheet 650x200x15 mm                        | 3      |
| 5    | Gear-wheel drive                                 | 3      |
| 6    | Angle piece 63x63x5 mm, L=5000 mm                | 2      |
| 7    | Feed device actuator                             | 1      |
| 8    | A 160 mm diameter pipe, L=920 mm                 | 1      |
| 9    | Canister feed actuator                           | 1      |
| 10   | Shutter device actuator                          | 1      |
| 11   | Shutter plate                                    | 1      |
| 12   | A 160x6 mm receiving tray                        | 1      |

For the ADRP to work, it is necessary to develop the same type of pneumatic tube cabinets and install them equidistantly from the rail track, which will allow unhindered redistribution. When remodelling cabinets, it is necessary to provide for minimal changes in the design of the pneumatic tube line. In order to eliminate the indicated changes in the design, in our opinion, the cabinets must be equipped with a hole with a diameter of 160 mm and a flap-type shutter, which will ensure the necessary air tightness for sending the canister. The shutter actuating will be provided by means of a gear train and a small motor and small power. In a circle of rotation of the shutter on the cabinet, it is necessary to install a group of contacts for fixating two positions for opening the cabinet and closing it [20, 21].

4. Automation of the procedure for verification check of cargo rail cars in set out trains

One of the main responsibilities of the operator of the interlocking cabin of the freight classification yard (operator of the station technology center (STC)) is to work with pneumatic tubes. Using automation, it is possible to reduce the load on the operator of the station technology center by delegating the responsibility of performing verification check of rail cars via a rail car list to a watch officer of the station interlocking cabin (WOSIC) by installing surveillance cameras and a monitor at the station interlocking cabin to perform the verification check of rail cars in cargo trains arriving from the western direction. The automation of the procedure will make it possible to reduce the position of the operator of the railway station technology center. This, in turn, will reduce the detention of rail cars during paper processing at the freight classification yard, increase labor productivity and savings in operating costs of the industry, reduce the production cost of work at the station, and increase the throughput and estimated capacities of the structural unit. When rail cars of a different direction are detected, it will also allow applying operational measures to uncouple them before the train is set out to the departure yard, thereby increasing the station work safety and work performance quality.

To perform the verification check of rail cars of set out trains, provided that the responsibilities of the station technology center are delegated to the watch officer of the station interlocking cabin, it is necessary to install eight surveillance cameras, four of which should have a four-fold image zoom. The estimated location of the cameras is indicated in the diagram in figure 3.

At the first downyard shunting, on the left in the direction of setting out the trains at a distance of 5600 mm from the track axis, it is necessary to install a metal rack on which two surveillance cameras will be mounted. The rack is installed due to the technical characteristics of the camera, according to
which the camera should be located at a distance of five meters from the rolling stock. In our opinion, installation is possible in the intertrack space, which will ensure its maximum performance [22, 23].

The lower camera is installed perpendicular to the draw-out track controlled by it at a height of 950 mm from the rail top to record the numbers of rail cars located on the backframes of rail cars, as well as on the side sills of platform rail cars. The second camera is installed at a height of 2600 mm from the rail top and has an angle of rotation relative to the lower camera by 20-25 degrees to the east to record the numbers of cargo rail cars located on the rail car body. To the right, in the process of setting trains from the first group of the up classification yard, the video camera rack must be placed in the area of the M-82 repeater signal. It is advisable to mount the cameras perpendicular to the first draw-out track, maintaining a distance of 950 mm for the lower camera and 2600 mm for the upper one in height. To monitor the 2, 3 and 4th draw-out tracks, we propose to use video cameras with a four-fold zoom. Two cameras from the left facing the train setting out will be mounted on a rack at a height of 950 mm and 2600 mm, respectively, the rack should be installed in the area of the M-82 repeater signal at right angles to 2, 3 and 4th draw-out tracks. On the right side, it is advisable to install the rack between signals M-88 and M-104 near the fencing of the rail car depot. The cameras will be installed at a height of 950 mm and 2600 mm from the rail top of the lowest track. The possibility of a fourfold zoom of the video shooting will allow covering the draw-out tracks 2, 3 and 4 with four cameras. The observation point must be mounted at the electric centralization station No. 8 directly at the workplace of the watch officer of the station interlocking cabin by installing a monitor with a large diagonal and a system unit with the ability to archive setting out records for a specified period.

![Figure 3. The proposed layout of the cameras of the station technology center cabin.](image)

According to the drawn up design estimate, the total one-time investments will amount to 1858.05 thousand rubles. Additional annual operating costs are 951.52 thousand rubles per year. This practice will have an economic impact of 4,439.2 thousand rubles per year. The payback period is 2 years [24].

5. Conclusion

The efficiency of introducing a device, automatically redirecting documents by means of pneumatic tubes, into the technological process of the freight classification yard will increase the level of control over ensuring the traffic safety of cargo trains, the safety of transported goods and the safety of the rolling stock by increasing the operational efficiency, and will increase the railway station throughput capacity and estimated capacity, reducing goods delivery time, improving working conditions and improving the personal safety of workers, as well as reducing cases of failures in the operation of technical equipment.
The technological performance indicators of the project are shown in figure 4.

![Figure 4. Indicators of technological efficiency of the ADRP system.](image)

**Figure 4.** Indicators of technological efficiency of the ADRP system.

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