

Application of digital technologies in rail transport

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Abstract. Against the backdrop of increasing digitalization, the demand for innovative solutions continues to grow, even in such conservative industries as the railway industry. Today, businesses increasingly need effective and reliable transformational solutions, the results of which directly determine the success of enterprises. This paper discusses issues related to the use of digital technology in rail transport, analyzing its advantages and disadvantages. The introduction of digitalization in the transport process will reduce costs while increasing the prestige and safety of rail transport, which will have a positive impact on the competitiveness of rail transport. To this end, the economic effect of its implementation in rail transport is determined.

Keywords: *rail transport; equipment; railcar identification; read range; freight transportation; railway; economic effect*

1. INTRODUCTION

Rail transport currently occupies one of the leading places in the transport system. Based on a comparative analysis of the mode of transport used in the transport services market, it can be concluded that rail transport is considered cost-effective for the mass movement of goods and passengers over long distances.

The advantages of rail transport over other modes of transport are economic efficiency, resource efficiency, environmental preference (in terms of noise, environmental safety) and traffic safety. The use of modern digital technologies in transport will improve the efficiency of internal processes in terms of customer orientation, economy and safety [1-4].

Currently, digital technologies such as RFID (RFID stands for Radio Frequency Identification, a method of automatic contactless identification of objects through a radio signal) are being introduced in rail transport. Abroad, primarily in Finland, these technologies have been used for several years in various industries. Studies conducted by foreign scientists have shown [5-8] that the use of RFID technology reduces the risk of human errors in the transport of goods and increases labor productivity, which has a positive impact on productivity and competitiveness of companies. RFID technology is essentially a digital transformation of the processes of reception, accounting and repair not only of wheel sets, it is also organization of parts inventory at car repair plants, mobile readers and specially developed software equipment. RFID equipment is an effective tool for creating tracking systems for locomotives, passenger and freight cars and their components, such as wheel sets.

One of the main objectives of RFID technology is to store information about an object with the ability to read it easily. In addition, it ensures the accuracy and reliability of the information when used in the transportation process [9-12]. Fig. 1 shows a schematic of such a device.

2. RESEARCH METHODS AND RESULTS

If we analyze the use of RFID technology in rail transport, we can see that each car has its own inventory number that includes certain information about it, which can be read both manually and automatically. There can be some problems with the tags during the reading process: the tags can rub off or fade, making it difficult to read. When loading, unloading or reloading, reading the information is also difficult, resulting in reduced productivity and speed of railcar handling. As a result, one of the important criteria of freight transportation, that is, time of cargo delivery, worsens.

In addition to allowing quick access to information about railcars, an RFID system allows monitoring the movement of the rolling stock along the entire route. With the help of this system, it is also possible to detect the location of railcars and determine the direction of the rolling stock movement. Furthermore, the problem of inventory control is effectively solved, as the system ensures efficient inventory accounting, monitoring the movement of goods in the warehouse and reducing personnel errors during order picking [13-15].

A similar digitalization system has not yet been established in Uzbekistan. The managing bodies of the Uzbek railways are still only engaged in digitization of the flow of information corresponding to the railroads, in particular, digitization covers such activities as exchange of information between stations, ticket sales, rolling stock repair records, etc.

The aim of this study is to develop a framework for the use of unified digital technologies in the Trans-Caspian and the so-called Middle corridor of the Asia-Europe line.



Fig. 1. Schematic of an RFID system: 1 - onboard encoder; 2 - reader in the infrastructure; 3 - data hub; 4 - company data center; 5 - wheel sensor.

In order to achieve this aim, the following **tasks** were solved in the work:

- a critical analysis of the digital technologies used in the countries located on the trajectory of the Asia-Europe line;
- theoretical and partially experimental research of the specifics of implementation of digitalization processes in the system of Uzbek Railways JSC;
- assessment of the cost-effectiveness of the implementation of the digitalization system.

3. METHODOLOGY AND SPECIFICS OF RFID APPLICATION IN RAIL TRANSPORT

As for RFID equipment and tags recommended by international organizations, they have different parameters depending on the purpose.

RFID tags can be made in the following forms:

- in different climatic variants;
- with different IP levels in terms of dust and moisture protection;
- in a vibration-resistant design.

All types of tags have a common parameter, which is an excellent read range, especially when installed on metal surfaces. Many tags are also tested for vibration and shock resistance. Fig. 2 shows the appearance of some RFID tags used by foreign companies.



Fig. 2. Appearance of tags used in rail transport to identify various objects

An RFID system typically consists of the following elements:

RFID tag attached to the object of identification (a railcar or its component parts);

RFID reader device;

RFID antenna.

The reader works either on its own (logs RFID tags with the time of detection, can control a relay or a digital port) or is controlled by a computer that is part of the IT-infrastructure of the company.

When an object needs to be identified by means of an RFID tag, the antenna of the RFID reader is activated (or the reader is always in reading mode). In response, the tag transmits a unique Electronic Product Code (EPC) or TID (Tag ID), or additional data recorded in the tag's memory. The data is then sent to a computer, and then the system processes the data, following the algorithms implemented in it (Fig. 3).

This technology has the following advantages and disadvantages.

The advantages of using RFID in rail transport are as follows:

- ❖ RFID tags (passive RFID tags) do not require batteries;
- ❖ scanning antennas can be permanently attached to the surface of a railcar;
- ❖ there is no need for physical contact between the tag and the reader;
- ❖ simultaneous identification of several tags;
- ❖ tags have writable memory for mixed use;
- ❖ functionality under extreme conditions (including all weather conditions).

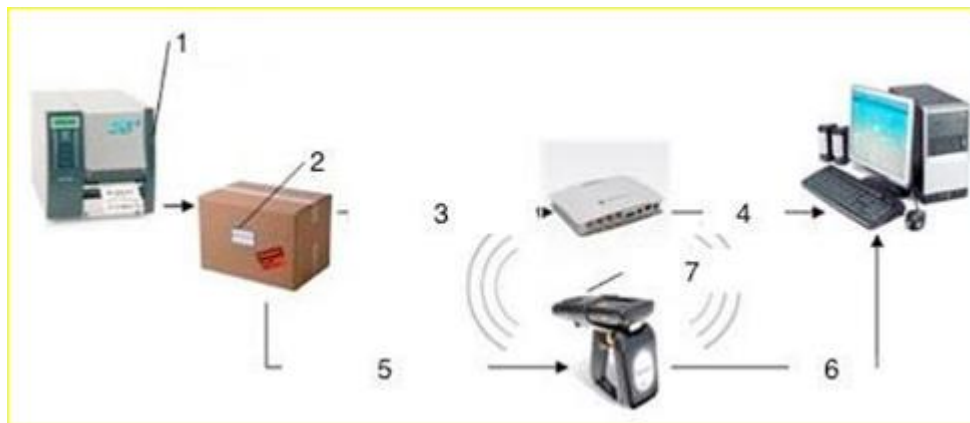


Fig. 3. Device operation: 1 - RFID tag printer; 2 - RFID tag; 3, 5 - data from RFID tag; 4, 6 - data; 7 - RFID tag readers.

The disadvantages of RFID technology are:

- ✓ high cost of implementation (tags, antennas, readers);
- ✓ operation is only possible with the full installation of the system (for the reader and the antenna).

In turn, RFID technology can reduce rail transport accidents, using additional information in a unique RFID tag linking critical measured values (detected failure) and a specific vehicle, wheel set, axle, brake and suspension. RFID can also be used to identify in advance which parts need improvement. In addition, RFID offers the following advantages:

- reduced maintenance costs;
- reduced emergency maintenance costs;
- improved planning due to real-time information about the condition of the car using RFID, as well as trackside train monitoring systems;
- increased availability of rail transport and improved operational reliability.

All of these advantages minimize human error in railroad maintenance and keep accidents to a minimum.

4. METHODOLOGY AND SPECIFICS OF RFID APPLICATION IN RAIL TRANSPORT

Rail transport statistics, particularly data on accidents in Uzbekistan, are somewhat difficult to obtain. Therefore, the authors noted that according to Russian Railways, only in 2022 Russian Railways JSC incurred a total of 1.18 billion rubles worth of damage, including 59 crashes and 17 accidents, which caused great losses in terms of credibility.

Therefore, in this study an attempt is made to calculate the cost-effectiveness of the introduction of RFID tags and RFID readers, where the latter will be installed at a distance of more than 2.5 meters on special frames. Thus, the savings due to automation of cargo processing and data collection in a certain area can be calculated as follows:

$$E_e = N_e * (12 * S * K_{ss} + \frac{C_{ss}}{W}) \quad (1)$$

where N_e is the number of employees freed due to productivity growth, persons; S is average monthly wage in the transport company; 12 is number of months in the year; K_{ss} is coefficient of social insurance costs (1.31) (vacation payment and 31% of social insurance costs); C_{ss} is current social infrastructure costs of the transport company, thousand rubles; W is average number of employees in the transport company during the accounting period, persons.

The number of employees freed due to productivity growth is calculated as follows:

$$N_e = \overline{W} - \overline{W} \frac{I_V}{I_P}, \quad (2)$$

where: $\overline{W}$ is the average number of employees of the transport company in the accounting period, persons; I_V is index of growth of production volumes or automation process; I_P is index of growth of labor productivity (output per person).

5. RESULTS AND THEIR DISCUSSION

The experiment was conducted on the example of the railroad section connecting the cities of Tashkent and Angren. The section included nine stations (operating personnel: 38 persons with an average salary of \$250). If we calculate the cost of implementing RFID readers and tags in this section, the cost per RFID tag will be between USD 0.2 to 0.6, the installation of RFID readers – USD 2,200, the installation of equipment for collecting, storing and transmitting information – USD 120,000. This technology will provide instant data processing, which will lead to a threefold increase in labor productivity, and have a positive impact on the speed of data processing during the arrival and unloading of freight railcars (Fig. 4).

It was determined that the payback period of the technology is about 1-2 years if the RFID tag is attached to each freight car (an average of 70 cars) and a frame with RFID readers is installed at the entrance to and exit from the station, which will automate data processing and storage.

Increased labor productivity through the implementation of RFID technology is one of the important components of economic efficiency. This technology will also reduce the damage from unscheduled delays and downtime in the section due to train stoppages at stations and hubs. RFID readers, or RFID frame readers, allow recorded data to be transmitted at train speeds of 40 kilometers per hour to a receiving point and then to a large data center. Thus, this technology reduces downtime and damage from scheduled and unscheduled delays.

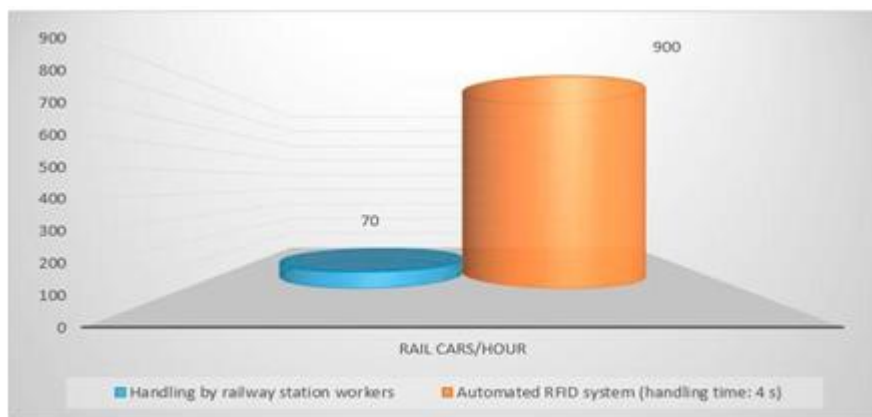


Fig. 4. Speed of handling of freight cars at the station

$$D_{t.d.} = e_{h.t.(p)} * \sum Nt_{t.p.} + e_{h.t.(f)} * \sum Nt_{t.f.} \quad (3)$$

where $N_{t.p.}$ and $N_{t.f.}$ are total downtime due to disruption of passenger and freight car traffic, respectively, hours; $e_{h.t.(p)}$ and $e_{h.t.(f)}$ are aggregated norms of costs per train/hour of the corresponding type of traffic, USD.

We will calculate the amount of additional costs per kilometer of train travel and for train travel in the sections with speed limits:

$$D_{t.d.} = e_{ad.e-km} * NL_{ad.r.} \quad (4)$$

where $e_{ad.e-km}$ is additional costs per kilometer of train travel; $NL_{ad.r.}$ is additional train travel in sections with speed limits.

6. CONCLUSION

When conducting this experiment for a month, it can be established that the damage from unscheduled delays alone, as well as from downtime at two stations of the Uzbek railways will amount to about USD 30,000. The introduction of RFID technology in the transportation process will reduce costs while increasing the prestige and safety of rail transport, which will have a positive impact on the competitiveness of rail transport.

The introduction and use of RFID will also optimize transaction costs for shunting operations and reduce train stopping time by eliminating the time spent by station technology center operators on checking the correct formation of railcars in trains.

RFID has long been a known tool in transportation and inventory logistics that speeds up work while solving various issues in different areas of activity. In the implementation of operational processes, these technologies ensure fast execution of operations with a minimum of time.

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