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DIGITISATION OF RAIL TRANSPORT: THE APPLICATION THAT DELIVERS FASTER AND MORE EFFICIENT SERVICES

Abstract. The article analyses the use of modern technologies in rail freight transport with a specific focus on the process of transferring information from transport documents through automatic identification technology. The main transport document in this context is the consignment note, where automatic identification is required. The automatic identification technologies investigated are RFID/NFC and QR code, with the analysis suggesting that QR code is more accessible and convenient in the current railway environment. However, in practice, limitations have emerged regarding the capacity of the stored information and the readability of the QR code data. It concludes that the use of modern technologies in rail freight transport brings new opportunities and increases the efficiency of information transfer associated with transport documents. Despite the advantages of QR code technology, limitations have been identified, in particular in terms of capacity and readability. The results also show that users with access to modern technologies, such as internet-enabled mobile phones or computers with internet access, are able to handle this technology efficiently, suggesting potential process improvements in rail freight transport. Overall, the paper highlights the importance of integrated technology solutions within this sectoral area and suggests that technological advances are opening up new opportunities for more efficient management and monitoring of rail transport processes.
Keywords: consignment note, QR code, transportation

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Introduction

The article provides a basic conceptual picture of the use of modern technologies in rail freight transport with a focus on the process of transferring information from transport documents using automatic identification technology. The main transport documents that "move" with the consignment include the transport order (loading request), the consignment note (national CN, CIM, CIM/SMGS) with wagon list, vehicle list, other documents e.g. for RID, exceptional consignments, etc. The main transport document for which automatic identification is required in the freight transport process is the consignment note (also referred to as CN
RFID/NFC and QR code were selected as the investigated automatic identification technologies for the transfer of information between entities. Both technologies are currently characterised by their advantages and disadvantages in their use. Listing all the advantages and disadvantages was not part of the original intention. The analysis below showed that QR code technology is more accessible and advantageous in the current railway environment.

The analysis described in the following chapters did not describe the first practical experiments with this technology revealed the limitations of the chosen information carrier in terms of the capacity of the stored information and the subsequent readability of the data. The analysis also revealed the assumption that the CN document is handled by a user who has access to modern technologies such as a mobile phone with an Internet connection or, again, a computer with an Internet connection.

1. Analysis of the process of circulation of transport documents from the point of view of information content

The analysis aims at describing the transport and transportation process with a focus on the circulation of train and transport documentation, in particular consignment notes, freight train manifest and international train braking reports. Several actors are involved in these processes, acting in multiple roles. For example, these roles are: consignor, ordering party, carrier, consignee, freight forwarder and railway undertaking (Gašparík et al., 2010) . The connections between some of them are illustrated in the following figure 1.

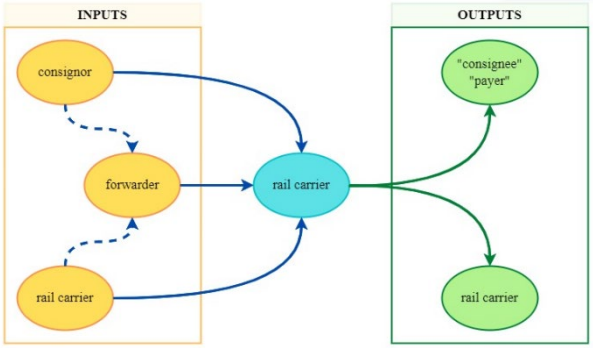


Fig. 1. A simplified graphic representation of the main flow of information between transport participants (Source: authors)

The documentation shall be kept when transport operations are carried out. From the point of view of the carrier, the following documents are used for standard continuous transport and constitute the transport documentation:

- consignment note (CN),
- wagon list,
- RID reports,
- documents for oversize consignments.

In terms of train documentation these are:

- vehicle list for freight trains,
- international train braking report.

As regards documentation relating to the operation of the carrier's system, these are

- order,
- loading request,
- handover note,
- return note.

The prerequisite for an uncomplicated process is that the user (transport orderer, consignor, carrier, consignee and payer) is equipped with computer technology (PC - desktop computer, laptop; touch-tone mobile phone) to carry out the administrative tasks related to the consignment note. It is a prerequisite that a person with access to desktop applications, the Internet and a printer currently performs the tasks for the transport customer.

Communication and completion of bills of lading and other documents can take place:

- physically:
  - by hand,
  - printed from the printer,
- electronically:
  - email x exchange media x data files;
  - e-mail x data file for electronic data exchange.

In principle, the following variants of communication or transmission of the information contained in the consignment notes shown in Table 1 can be encountered in normal operation.

Table 1. Variants of the process flow at the consignor, carrier and consignee

Variants	CN - to be filled in	„EDI“
A	1	1
B	1	0
C	0	1
D	0	0

Legend:
Note CN - fills in - includes work at the carrier/carrier at first contact (i.e. initial filling in) or subsequently on the way, when the partner does not hand over the CN filled in
"EDI" - partners have an electronic exchange of data between them concerning the consignment notes (also thought of as a simple email message)

Variant A - the carrier/transporter works with CN - the data to CN is accessed via "EDI".
The carrier/carrier has an IS for filling in the CN.
Carrier/carrier does not have an IS for filling in the CN.
Variant B - carrier/carrier works with CN - does not have data electronically.
Carrier/shipper has an IS for filling in CN .
Carrier/carrier does not have an IS for filling in CN.
Variant C - does not need to work with CN and has electronic data for other needs.
Variant D - carrier/carrier does not work with CN but does not have data - laboriously scans CN or transcribes/records information from CN into their systems (paper, ICT).

2. Technological processes of railway transport and transportation

This subchapter describes the process flow in rail freight transport. Several milestones separate the different phases of a consignment's transport journey, at which the basic operations with transport documents and means of transport are carried out. In general, these are the following transport phases (Matejov, Šestáková, 2021):

- transport order,
- completing/delivering information to CN,
- analysis and confirmation of the transport order (based on receipt of the loading order and subsequent loading request),
- arranging and placing the wagons for loading,
- arrival and handover of the wagon for loading,
- acceptance of the loaded wagon - inspection and confirmation of the CN, the consignor receives a second copy of the CN,
- creation of train documentation - wagon list for freight train, braking report,
- handover of the transport and train documentation to the partner carrier at the transfer/'handover' station,
- arrival of the consignment at destination,

- handover/confirmation of the transport documentation (CN) to the consignee (handover of the original CN),
- invoicing the payer or the railway carrier.

The processes are carried out with small variations depending on the specific actors involved.

In the following sections of the analysis, the processes are described in the following breakdown:

- loading at the consignor,
- handover between carriers,
- unloading at the consignee.

At present, communication between carriers and shippers is relatively satisfactory and the carrier obtains the necessary information because it has a stronger bargaining position, since the customer is the one who requires the carrier to perform the service. From a systemic point of view, this is not a fundamentally problematic solution, although communication takes place in a number of ways which vary from customer to customer. However, the main problems arise in the transfer of information and documents between carriers on the transport route. Processes at train or marshalling yards, which are carried out by a carrier without handing over wagons or trains to another carrier, are not included in this analysis.

2.1. Shipper's freight

This chapter describes the different steps of the process related to loading at the consignor and the start of transport. It also outlines the different participants in the process, including the necessary documents. The completion and submission of documents, in particular the bill of lading and possibly other transport documents between the carrier and the customer, is crucial (Čamaj et al., 2019).

The carrier prepares the transport on the basis of an order, which leads to the conclusion of a transport contract. Once the contract has been concluded, the carrier waits for a request to issue the loading documents as agreed. The customer (carrier) hands over the order to a designated employee of the carrier who organises the transport - usually an employee in the role of wagon dispatcher. He informs the customer of the receipt of the loading request. Delivery may be made via the carrier's web form, by e-mail containing a completed loading request or by a carrier's employee at the railway station. The loading request is the first important document that contains a lot of information which is then included in the transport documentation - the consignment notes. On the basis of this document, the carrier prepares the wagons for loading. In the case of smaller carriers, a form of e-mail order is used to secure the wagons for loading.

A designated employee of the carrier ('wagon dispatcher', 'dispatcher') monitors the availability of suitable wagons for loading and wagons for unloading. On the basis of information from consignors, consignees and other parties, he allocates the available vehicle capacity to the relevant operations. He prepares documentation and instructions to train staff for specific operations. After locating the wagons and agreeing the conditions of carriage, registers the business case, arranges for the required wagons to be conducted to the loading point and organises the handover/informs the consignor/customer of the arrival of the wagons at the loading point.

The loading of the goods must take into account the activities related to the arrival of an empty wagon or several wagons for loading at the customer's location, as well as the removal of the loaded wagon within the transport. When empty wagons are handed over, a document referred to as a handover note is essential. This is a document containing the wagon numbers that have been made available to the customer for loading. The wagons should also be in perfect technical and clean condition. The condition of the wagons shall be checked by a designated employee of the carrier and documented in the handover note.

Once the wagons have been handed over, the wagon shall be at the full disposal of the consignor for loading for an agreed period. Once this has been completed, a necessary step is the completion of the heavily framed section of the consignment note, which contains details of the consignment, consignor, consignee, route, etc. This section is completed by the consignor and then handed over to the carrier's staff to complete themselves. In parallel with loading, the thickly framed section of the national or international consignment note may already be filled in and other documents necessary for the carriage of goods or materials, such as customs procedures, the provision of RID documentation, documents for the carriage of an exceptional consignment, etc., prepared. These documents are then sent/delivered to the designated carrier's employee and, after checking the details in the CN with the cargo and wagons prior to carriage, the CN is validated and the wagon(s) are accepted for carriage. The consignor receives a second copy of the CN from the carrier, e.g. for future claims, etc.

The consignment note accompanies the consignment throughout the transport and one of its parts (one sheet) is left with the consignor. There are several ways of filling in and processing the consignment note:

- The first way is to fill it out electronically in the carrier's web environment.
- The second way is, for some carriers, to fill it out in the shipper's system and transmit it to the carrier via electronic data interchange (EDI).
- The third way is to complete the consignment note in the consignor's system and then print out all parts of the consignment note.
- The fourth way is to fill in the consignment note in one of the editors - this may be an excel file and then print all parts of it.
- The fifth way is to fill in (e.g. print from an excel file) the pre-printed consignment note form.

Figure 2 shows the consignment note circulation process.

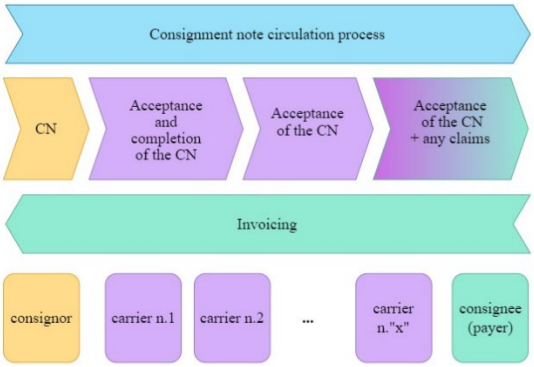


Fig. 2. Flowchart of the consignment note circulation process (Source: authors)

2.2. Takeover between carriers

This subchapter describes the technological operations that take place during the handover between carriers from the perspective of the carrier that takes over the train or wagons from the partner carrier.

At present, this part of the transport is very problematic, especially when it concerns the handover from a foreign smaller carrier. On the basis of local investigations at border crossing points, it has been found that in some extreme cases the taking over carrier becomes aware that he should take over a train from a third party, for example an employee of the infrastructure manager, such as a train dispatcher.

In many cases the train documentation is not available (the handing over carrier does not pass it on or with a long delay). In such cases, the train is taken over either by the accepting carrier requesting the documents from the transferring carrier, which is a time-consuming task, or by producing the train documentation itself on the basis of the technical inspection and the wagon inventory. Also, the international braking report is produced by the accepting carrier on the basis of a full brake test and the data on the wagons. This is a very time and capacity consuming job.

In most cases, the receiving carrier has no possibility to intervene in the choice of the carrier in the previous leg of the transport. In the case of transport under the RID Agreement, the documents necessary for the creation of the RID Declaration are usually available.

2.3. Handover between carriers

This subchapter describes the technological operations that take place during the handover between carriers from the perspective of the carrier who hands over the train or wagons to the partner carrier.

At present, this part of the transport is seamless from the point of view of a large carrier equipped with information systems with appropriate interfaces when cooperating with another similar carrier. In the case of the transfer of trains to smaller carriers not equipped with information systems, the process is more complex but can still be assessed as satisfactory. Data needs to be exported from the IS systems and forwarded to these carriers, for example by e-mail. In the case of information transfer between smaller carriers, e-mail communication is always used. Unfortunately, data continuity is not ensured by this method of communication, as data is transcribed by the carriers' employees from one of the e-mail communications to the necessary forms. This leads to errors, but especially to unnecessary time delays. In some cases, the accepting carrier creates the train documentation itself on the basis of the technical inspection and the wagon inventory. Also, the international braking report is created by the carrier itself on the basis of a full brake test and the data on the wagons. In the case of carriage under the RID agreement, the documents necessary for the creation of the RID report are usually available.

2.4. Unloading at the consignee

The subchapter describes the process steps involved in unloading at the consignee and completing the shipment. The individual process participants are listed, including the necessary documents. The transfer of documents, in particular the last part of the consignment note and, if applicable, other transport documents (wagon and vehicle list for the freight train - if it is a direct train) between the carrier and the transporter and vice versa is crucial. In the case of unloading of goods, both the part relating to the delivery of the wagon consignment for unloading and the part relating to the removal of the empty wagon are taken into account for the sake of completeness of the description of the process. When the consignment is delivered, the basic document is the consignment note, which subsequently confirms receipt of the consignment and completion of the transport by the consignee and the carrier's employee. An invoice is created on the basis of the CN bill of lading and sent to the payer of the shipment named on the CN. In the event of damage or loss of the shipment, a document called a commercial entry is completed. In case of other defects and discrepancies, a document called general entry is filled in. These two documents are drawn up before handing over and confirming the consignment note. Another document associated with the addition of loaded wagons is the Bill of Lading. Similar to the loading document, this document contains the numbers of the wagons that have been made available to the customer, in this case for unloading.

3. Use of automatic identification elements in freight transport

Automatic identification is used to identify given objects without the use of the human factor when data is automatically collected and converted into a computer or database where the data is stored in binary form. The

method of recording the data varies technologically from element to element. With today's capabilities, different technologies/methods can be used to transfer information between entities: - OCR, biometrics, magnetic tag, smart card, RFID, barcode and QR code. QR code technology was chosen in view of the transport of goods and the need to handle the paper form of the bill of lading, which is standardised throughout the international trade environment (Gerhátová et al., 2021).

In terms of implementation and processing capability, it is uniquely designed to identify and transmit QR code technology. In June 2000 it became part of the ISO 18004 standard. Currently, 40 size versions can be used and store data in it. Anyone can create their own QR code and publish it. A research project has created an app that can create a QR code and the user can then easily read the data using a QR reader, which is available as a mobile app for any smartphone with a camera, which means that if the QR code is printed on the bill of lading in a given format and at a given location, it can contain either a reference to the relevant shipping event or the public part of the shipping data, thus gradually speeding up the clearance of the shipment at all shipping points. In fact, the QR code can be automatically generated and printed (Petrova et al., 2021).

Below is an analytical section that presents the specifics of each possible use of automatic identifiers in freight transportation.

3.1. OCR-optical character recognition

OCR, or optical character recognition, involves the automatic or mechanical conversion of images of typed, handwritten or printed text into machine-encoded text, whether from a scanned document, a photograph of a document, an image of a scene (such as text on signs and billboards or photographs of a scene) or caption text superimposed on an image (such as text from a television broadcast). Biometric technology is currently used primarily as a method of automatic authentication based on the biological characteristics of the subject and therefore does not appear to be suitable for the transmission of information placed on rail freight documents. Currently, optical character recognition from a scanned document, a photograph of a document, an image of a scene (e.g. text on signs and billboards or photographs of a scene) or caption text overlaid on an image (e.g. from a television broadcast) can be used to distinguish a text message, which is then processed by a machine and stored in binary form. This will allow it to be fully digitised and the subsequent automation of data processing. Depending on the quality of the image, the text can then be subjected to, for example, proofreading by a computer program. However, this technology always requires a suitable template, which seems inappropriate in the transport sector, given that the bill of lading passes between many pages during transport (partial or total deterioration of the written form may occur). It is also necessary to take into account the increased time and other costs that could be incurred in the proofreading process. For example, there is a risk that the owner or sender of the parcel may not be recognisable, which may require the document to be checked by a member of staff. This appears undesirable and unnecessary (Holanda et al., 2018).

3.2. Biometrics

Biometrics is an automatic method of authenticating quantitative traits of living organisms or biological characteristics and behaviors of humans. However, there is a consideration that the principle of biometrics could be used in the acquisition of consignment note data, which would need to be tagged with some deterministic unique identifier based on the data it carries (achieving uniqueness) and, for example, a combination of location, time and method of acquisition (given worker, etc.) (Dargan, Kumar, 2020).

A biometric system consists of creating a sample image of subject A (e.g. a fingerprint or a print of a bill of lading bearing a unique character) and storing it in a database. This database is also accessed by Entity B, which, when prompted, verifies the proclaimed data of Entity A (e.g., a gatekeeper or a machine into which a given CN or other document would be inserted/scanned) (Crockett et al., 2017).

The now widely used field of biometrics appears to be another possible, but also not entirely appropriate, method for the purpose of transmitting data placed on a bill of lading. Functionally, the method is intended as authentication of a subject based on his biological characteristics. These are lacking in a bill of lading (but could probably be simulated). As can be seen, in rail freight we do not intend to recognise biometric features of humans or animals, but text. Simulating possible biometrics would be very expensive and time consuming to research. Also, given the zero experience in the industry to date on this issue, biometrics does not seem to be suitable for transmitting information placed on rail freight documents (Yin et al., 2022).

3.3 Magnetic tag

Another technology that is used today for automatic identification is the so-called magnetic label. This is widely used, for example, as a medium on payment cards or access and other cards on which a magnetic layer is applied to form a stripe. The application and the medium that carries the magnetic stripe shall conform to ISO specifications (size, mechanical resistance, location and data format characteristics). From the point of view of handling costs, magnetic labels in their present form do not appear to be suitable for placement on a bill of lading. The bill of lading is a paper document and the placement of a magnetic label is by its nature impossible (it travels

across the logistics chain and it is almost impossible to guarantee abrasion resistance according to the relevant ISO specification). In addition, the cost of procuring magnetic labels is disproportionately high from the carrier's perspective, given the amount of data required (López-Vicente et al., 2023).

3.4. RFID

Data transmission technology AIDCTechnically, an RFID tag can be described as an RFID chip, an antenna and their encapsulation. In practice, we encounter inlay tagging, where the chip and antenna are placed in a transparent film, which is further encapsulated, depending mainly on the application. The antenna can take on different dimensions depending on the application. Due to the existence of thermal transfer printers that are used in industry, a label can be printed and information encoded in one step. Tag housings are made from a variety of materials, from paper envelopes to rigid thermoplastic to highly durable ceramic molds. The encapsulation protects the chip from external influences. Special enclosures are then used especially in industries where interference occurs, or its placement on a metal surface - particularly in the railway environment where placement on chassis or car bodies, wheelsets, etc (Casserly et al., 2021).

RFID enables automatic identification of an object by means of electromagnetic pulses that are transmitted to the surroundings and can therefore be read remotely. In practice, two technical elements are needed, a reader and an RFID tag (also popularly referred to as an antenna). RFID tags can be of different sizes and encased in different materials to ensure longer lifetime, especially in railway environments where there is prolonged outdoor exposure and the tags must be resistant to mechanical and thermal influences (Martínez-Sala et al., 2009).

Among RFID technology, NFC technology, which has been known for many years and is already standardized, was chosen as an alternative for this concept. The technology allows reading and writing to the chips. Its use is intended for transport documentation. Although for cars its use is much broader (Tarjan et al., 2014).

3.5. Code QR

A quick response (QR) code is one of the two-dimensional barcodes that is now commonly used in many industries and environments. It is similar to a barcode in that it also contains machine-readable data about the object to which it is associated. In a QR code, the information is encoded two-dimensionally, which allows storing more data compared to a barcode (Okumura et al., 2019). It was invented by Denso in 1994 and started to be used for its high capacity, high safety and low error rate. In 2000, QR was considered an ISO 18004 standard for the first time, making it official in the tech world. In 2011, the international standardization body GS1 approved it for use in mobile phones. The code can have 40 sizes and consists of several layers using different algorithms (Baier et al., 2017).

In the context of rail freight transport, which focuses on the process of transferring information from transport documents using automatic identification technology, the QR code appears to be a suitable means. Especially because it can make it easier to find information needed in daily operations. However, here it is appropriate to consider this means together with the use of mobile phones with constant access to the Internet network (Jonak et al., 2020). Only then does the use of this technology seem appropriate (e.g. in the form of a mobile application, the code can be read and the data can be displayed or sent where they are needed).

Using a mobile reader or app, the data is decoded step by step. It happens in two stages. The first stage is to extract the QR code from the original image and the second stage is to decode the information (Peltokorpi et al., 2021). The first phase takes the most time, which affects real-time efficiency. As a result, several decoding variants were investigated in order to achieve the shortest possible time (Kjeldsen et al., 2023).

Nowadays, the quality of the image obtained from the camera, the technology of which has improved significantly, has clearly improved. QR code processing is therefore performed on high-resolution images. In addition, it is worth noting that real-time applications are becoming the norm these days.

Use of QR code

The first option is the possibility to store in the QR the maximum minimum amount of necessary information from CN, the remaining part, which will not be stored in the QR code, will be made available in the data storage on the "internet" via a hyperlink. This option is graphically represented in Figure 3.

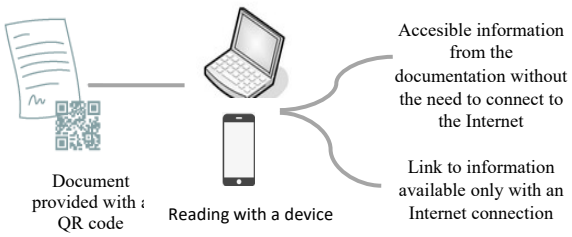


Fig. 3. Scheme of variant No. 1 (Source: authors)

The second option is to create a QR code that contains only a generic x-ID number and a link to the data repository.

In the case of the second option, there is an increased risk of replacing the QR code with any other sign, e.g. with a numeric code that will allow access to the data store to retrieve information without the need for an additional update/installation of the software that will generate the QR code. The CN creation software

application still needs to be updated so that the information can be sent to the data warehouse.

For this option, it is recommended to check with the user who creates the CN, the possibility of printing a QR code or pasting a QR and related matters.

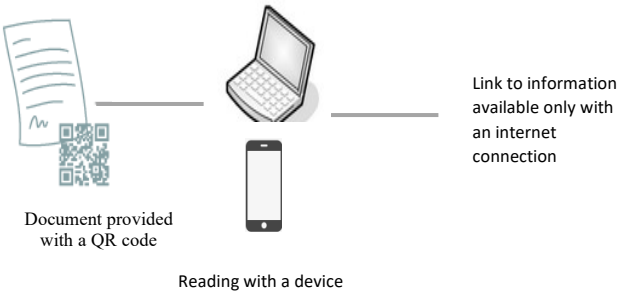


Fig. 4. Scheme of variant no.2 (Source: authors)

In this Chapter 3, the use of automatic identification features in freight transport was examined in detail. Automatic identification is used in this field to identify objects without human intervention, automatically collecting data and converting them into digital form in a computer or database. There are currently multiple technologies/methods for transferring information between entities, including OCR, biometrics, magnetic tags, smart cards, RFID, barcodes and QR codes. Among these options, the QR code was chosen, mainly because of its wide availability, advantages and ability to process information in the current railway environment.

The chapter describes in detail the features of the QR code technology, which has become part of the ISO 18004 standard and enables the storage of various information in 40 size versions. The research project is connected to the created application, capable of generating and reading QR codes, providing users with an efficient way of handling transport documents.

In the context of rail freight transport, the QR code is seen as a suitable tool that can simplify the search for information needed in daily operational activities. The use of this technology in combination with mobile phones and access to the Internet can ensure the efficient transfer of information and speed up the handling of shipments at various points of transportation.

At the same time, the chapter emphasizes that the image quality and processing of QR codes have now become the standard, which enables their effective use in real time. Finally, the possibilities of using QR codes in freight transport are listed, either in the form of storing a minimum amount of information with a link to a repository on the internet or creating a code with a general ID and a link to a data repository. For the second option, it is necessary to emphasize the need to update the software application to create the CN and verify the possibility of printing or pasting the QR code.

Conclusion

The use of modern technologies in railway freight transport brings new possibilities and improves the efficiency of the transmission of information connected with transport documents. We focused primarily on automatic identification technology, exploring RFID/NFC and QR code technologies.

The analysis shows that QR code technology is not only more accessible in the current railway environment, but also more advantageous compared to other options. Nevertheless, within the framework of our research, we have identified the limitations of this information carrier, especially regarding the capacity of stored information and readability of data.

At the same time, it was found that users working with the bill of lading and using modern technologies such as mobile phones with internet connection or computers with internet access have the ability to manipulate this technology effectively. This shows us that the implementation of modern approaches to information transfer can significantly improve processes in the field of rail freight transport.

Overall, we explored the dynamics of information transfer in this industry area and highlighted the importance of integrated technological solutions. As technological progress continues to develop, new opportunities are opening up for more efficient management and monitoring of rail logistics processes.

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