INTERNATIONAL MULTI DISCIPLINARY JOURNAL FOR RESEARCH & DEVELOPMENT
eISSN 2394-6334 Impact factor: 8.854 Volume 13, issue 02 (2026)

UDC 629.4.027.5

DIGITIZATION OF CAR WHEELS AS A MEANS FOR RELIABLE ACCOUNTING OF CAR PARTS IN «UTY» JSC

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Abstract

The need for digital marking of wheelsets is to improve the quality of reporting documentation and the reliability of accounting throughout the entire life cycle of the wheelset. The result can be achieved by using part identification systems (wheel sets) operating in automatic mode.

Keywords

wheelset marking, wheelset accounting, screencoding, wheelset life cycle.

Today, when organizing a scientific and production complex, digitalization and marking of parts, as well as components, is one of the most relevant technical and technological operations, which indirectly affects the quality indicators of manufactured products. Without a special label, it is very difficult to control product performance. The application of any barcodes to the owner provides an additional opportunity to confirm the guaranteed trouble-free operation of the product under specified conditions.

There are many methods for digitizing and applying informative labels (Data Matrix method, RFID tags, etc.), but all of them are aimed at improving the system of interaction between technical and technological processes, detecting counterfeit or defective products in railway transport, and improving activities to ensure production safety. and operation of rolling stock.

Expanded Overview and Related Work

Digital identification of railway wheelsets is a key enabler for reliable asset accounting and life-cycle traceability in maintenance-intensive rolling stock systems. In practice, traceability gaps most often arise at the interface between heterogeneous data sources: electronic certificates and automated accounting systems on one side, and paper-based repair and inventory documentation on the other.

Two major families of automatic identification technologies are typically considered for heavy industrial railway environments: (i) direct part marking with 2D codes (e.g., Data Matrix or QR) and (ii) RFID-based identification. Data Matrix is a standardized 2D symbology defined in ISO/IEC 16022 [11]. For interoperable supply chains, GS1 DataMatrix provides an application framework based on ISO/IEC 16022 and supports structured encoding of identifiers and attributes [12].

RFID solutions provide the advantage of non-line-of-sight reading and higher throughput in controlled read zones (e.g., portals, gates, or trackside points), which is attractive for large fleets and fast inventory operations. Railway-oriented studies and guidelines discuss practical

constraints such as harsh environments, metal surroundings, tag placement, and standardized data exchange [13-15].

In this context, a pragmatic implementation strategy for wheelset traceability is to: (1) assign a unique wheelset identifier at repair or manufacturing stage; (2) apply direct part marking (QR/Data Matrix) via laser on a controlled zone of the wheelset; (3) register key geometric and ownership attributes at the moment of marking; and (4) enforce scanning events at critical transitions: storage entry/exit and installation onto the wagon.

Table 1. Comparison of identification options for wheelsets

Criterion	**2D code (Data Matrix / QR) with laser direct part marking**	**RFID tag-based identification**
Readability / range	Line-of-sight; typically short range; tolerant to partial damage (error correction).	Non-line-of-sight; short-to-medium range depending on frequency, antenna, and mounting; metal environment requires careful tag placement.
Infrastructure	Low: marker + handheld or fixed scanner; minimal integration effort.	Higher: readers, antennas, portals/trackside points, middleware; planned read zones are recommended.
Data strategy	Encode unique ID and minimal attributes; full history stored in the database linked to the ID.	Encode unique ID (EPC/GIAI or similar) in the tag; full history stored in the database linked to the tag ID.
Anti-counterfeit	Laser marking is hard to remove without traces; supports audits and visual checks.	Tag cloning risk exists; mitigated via secure encoding, tamper-evident tags, and system-level validation.
Best-fit scenarios	Workshops, repair depots, and storage yards where operators can scan at close distance.	High-throughput yards, border crossings, and corridors where vehicles pass fixed readers.

There is an information system in which you can request data on the configuration of the wagons according to numbered parts. For certain query commands, it is possible to display information about the construction and repairs (scheduled, unscheduled) in any time interval of the life cycle of a particular car. Taken together, these data represent all the parameters that characterize the wagon as a whole, its components and parts by geometric and other criteria. The issue of developing a single database is faced with the problem of combining electronic certificates and reporting and accounting forms filled out on paper. The relevance of data integration lies in the efficiency and correctness of decision-making when detecting cases of traffic safety violations or counterfeit products.

Let us analyze the issue related to the provision of storage and rolling of already repaired wheelsets at various production sites. Analyzing the production sites of the TOP, as structural units, the fact of storage of wheel sets was revealed without indicating geometric indicators on

them and ownership of the property. This is due to the existing limitations of production areas and continuous production process [3-5]. Subsequently, this method of storage leads to an increase in the time of identification of the wheelset and a violation of reliable accounting when wheel sets are rolled directly onto the car. To solve the created inefficient working conditions, it is proposed to use the method for determining the classification of the wheelset, accompanied by its marking by applying a QR code (Fig. 1) [6-8].

Figure 1. Using a laser mark to mark the wheelset of a wagon

Information about malfunctions is also submitted using the VU-53M journal, only in electronic form, while information about the ownership of the wheelset must be included in the electronic certificate 2731 “Information on the units and parts of the car” [8].

Today, the issue of the emergence of rolling stock, the details of which have double numbers, is particularly acute, including these facts that are manifested in automated systems for accounting for cars. Parts and assemblies that meet these requirements are counterfeit.

In order to effectively resist the emergence of counterfeit units and parts of wagons, it is necessary to carry out strict control over the supply of new rolling stock parts. For this, it is proposed to additionally mark the most critical parts for their accurate identification [9].

Let's highlight the advantages of the laser marking method: minimal mechanical impact on the marked area; high accuracy, optimal performance of information application; admissibility of marking in difficult areas of parts.

Conclusions

All this information together gives a complete picture of all the parameters of both the car as a whole and its individual parts and assemblies. But at the same time, there is a difficulty in combining data that is already in the information base (electronic certificates) and those that exist only on paper (reporting and accounting forms). In most cases, the most complete information on the components of the car is needed when investigating any cases of violation of traffic safety or detection of counterfeit products. Under such circumstances, in order to make the right decision and competently analyze the current situation, the efficiency, reliability, and completeness of the data provided for a particular unit or the car as a whole (as a unit of rolling

stock) play an important role. The marking system (Data Matrix, RFID tags, etc.) makes it possible to save a complete picture of the life cycle of any part on which these technologies can be applied. Barcodes can contain any information that becomes available in the process of manufacturing, repair and maintenance of cars and their components.

Appendix A. Suggested additions to strengthen the manuscript (to be removed before submission)

- Add a concise data model for the wheelset 'digital passport' (unique ID, owner, geometry, repair events, storage status) and specify which events update the record.
- Provide a simple system architecture diagram (scanner/reader -> identification module -> database -> reporting/VU-53M -> analytics) and describe integration with electronic certificates.
- Include a pilot plan with measurable metrics: identification time before/after, accounting error rate, share of non-identifiable wheelsets in storage, and number of detected duplicate IDs.
- Add a short discussion of environmental robustness (corrosion, dirt, shocks) and operational constraints for both 2D codes and RFID, supported by standards and rail guidelines.

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