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Digitalization and standardization on railways of the Organization for Railway Cooperation (OSJD) on selected examples

Abstract: In recent years, the transport industry has recognized the need to develop and implement digital technologies. To a large extent, this applies to rail transport, as it is due to the necessity and its importance in ensuring both sustainable mobility of the population and uninterrupted transport of goods in the Eurasian space, especially during periods of large-scale restrictions, e.g., during a pandemic. As practice shows, the future of rail transport lies in digital technologies. In order to accelerate the digitization of railways in the OSJD member countries and thus ensure the successful development of both the railways themselves and international rail transport in communication between Europe and Asia, deliberate and continuous work is needed to introduce innovative digital technologies in all areas of transport activity. In his article, the author presents the introduction of digital technologies into the practice of rail transport on selected examples in the railways of OSJD member states.

Keywords: Digitalization; OSJD; Electronics waybill, One Windows System; EDI; Standardization

Introduction

The future of rail transport lies in development based on digital technologies. In the OSJD member countries (Organization for Cooperation between Railways headquartered in Warsaw, with 30 member countries from Asia and Europe), despite the significant development of the Eurasian railway network and measures taken to digitize rail transport, the scope of tasks to be solved in this area is expanding along with scientific and technological progress. This creates the groundwork for the successful development of railways, increasing their efficiency and competitiveness, and improving the quality of both passenger and freight transport services. Among the key trends in the digitization of the railway sector, we can identify, for example: driverless train management, real-time control of rolling stock and infrastructure, registration of transport documents in domestic and international traffic, planning and accounting for freight traffic, improving the accuracy of passenger information, and the development of reservation and ticket sales systems, predictive maintenance planning, and most importantly, integration with other modes of transport. Existing forecasts for the development of rail transport, for example by the International Transport Forum, predict that by 2050, passenger mobility will increase by 200–300%, and freight transport by 150–250%.[1] Taking on such challenges requires seeking intelligent solutions to ensure adequate capacity for growing volumes of cargo and passengers. Therefore, the OSJD organization is undertaking targeted actions to achieve these tasks. The purpose of this article is to present selected activities in the field of digitization based on the analysis of secondary sources and analytical documents on the topic of digitization in rail transport.

The Faces of Digitization within the OSJD Organization

In recent years, the OSJD has devoted considerable attention to digitization issues and the introduction of modern digital technologies. One important example of this work is the digitization of transport along OSJD railway transport corridors, where digital technologies and business

processes of railways and other railway enterprises involved in transport processes along the corridors are integrated. The basic elements of the railway digital transformation process are [2]:

- Digital Data
- Connectivity
- Automation of Processes
- Digital Customer Access

Full utilization of these components of digitization enables the implementation of tasks in the field of rail transport, namely [3]:

- creation of a railway network offer that uses reliable communication, ensuring safety, efficiency, and the attractiveness of railway services;
- increasing customer satisfaction;
- increasing railway capacity, reliability, and efficiency through the automation of transport processes;
- increasing the competitiveness of railways by optimally using data within, for example, big data analytics.

The use of modern digital technologies among OSJD member countries is constantly being expanded. This, among other things, applies to shortening time during border and customs procedures, gradually reducing the number of documents and eliminating paper document circulation, increasing transport speed, and providing additional services. In order to achieve this goal, the following activities are carried out [4]:

- unified approaches to coding and IT are being developed, and joint OSJD documents are prepared with other international organizations (in the field of facilitating border crossing procedures, coding objects and enterprises of rail transport services, etc.);
- message libraries are being created and updated, operating within and according to SMGS principles (these notes are the basis for concluding bilateral agreements on electronic data interchange – EDI), and technical specifications for the IFTMIN electronic message for the CIM/SMGS consignment note are being developed and updated;
- work is underway on organizing financial settlements based on electronic documents, electronic messages in the UN/EDIFACT standard;
- in the area of passenger transport, work is being done to develop electronic information, reservation, and ticket sales systems for rail passengers, which enables optimizing the technology of all parts of the infrastructure for passenger services and traffic, expanding the scope of reference and information services, and ensuring the interaction of various reservation systems in the organization of international passenger traffic.

Digitization in Examples [5]

Among the directions of digitization, particular attention is paid to the international cooperation of the OSJD organization in the field of paperless document circulation related to the transport process and the simplification of border-crossing procedures, as well as the use of modern technologies related to the management and organization of rail transport. The basic examples include:

Electronic Consignment Note (CIM / SMGS) [6]

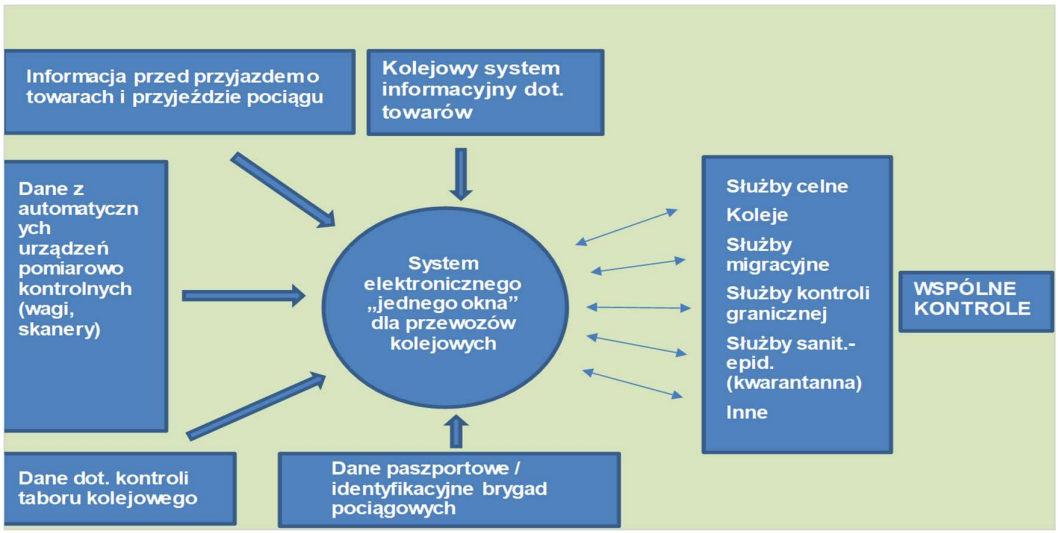
The necessity of integrating solutions between individual railway systems on an international scale (common digital platforms) and institutions at border stations (simplification of procedures and their standardization, unification of transport law). The CIM/SMGS electronic consignment note is a uniform consignment note used for the transport of goods in countries applying different international transport regulations (SMGS and CIM). The consignment note is issued for the entire route without re-registration at the point where the transport law changes. The CIM/SMGS consignment note is confirmation of the conclusion of CIM and SMGS transport contracts in traffic between states applying CI and SMGS. It is recognized as a customs document and simplifies

border-crossing procedures for goods transported by rail. The implementation of this consignment note in international transport practice has brought positive effects for rail transport, including:

- significant reduction of train downtime at border stations;
- improved service quality and reduced transport costs;
- time savings previously allocated to re-registering documents at borders;
- reduction of costs related to reissuing documents concerning the continuation of transport on railways where different transport law applies;
- elimination of many inaccuracies and errors made as a result of re-registering transport documents for shipments; ensuring a high level of compliance with legal standards during transport for its participants;
- shorter cargo delivery times due to the reduced cargo dwell time at points of re-consignment.

Single Window System [7]

To harmonize information and customs procedures in international rail transport, actions are being taken within OSJD-UN relations to create single-window systems for rail transport, i.e., an electronic one-stop service point at border crossings using modern technologies. Railways and public authorities largely need the same documents, certificates, and information to carry out appropriate customs clearance procedures. Among other things, for example, information on the name of the cargo and loading/unloading points is usually required by railways, customs authorities, sanitary-epidemiological control authorities, etc. Figure **1** illustrates the concept of the single-window system, i.e., the electronic one-stop service point at border crossings. Data from several sources, in particular from electronic railway systems, customs authorities, migration services, automated control systems, and systems for scanning transported objects, may be stored on neutral platforms or in a single-window system for rail transport. These data and information can then be made available to control authorities at border crossings to carry out inspections required by the relevant regulations in each country. Establishing links between railway information systems, state authorities' information systems with a single point of contact, and carriers' information systems will ensure effective information exchange and significantly reduce the need to resubmit the same information.



1. Electronic window for railway transport and border control authorities
Source: OSJD and United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) materials, Warsaw/Bangkok 2022, p. 22

Data from several sources—particularly from electronic railway systems, customs authorities, migration services, automated control systems, and systems for scanning transported objects—can be stored on neutral platforms or in a single-window system for railway transport. These data and information can then be made available to control authorities at border crossings to carry out inspections required by the relevant regulations in individual countries. Establishing links among the information systems of railways, state authorities (with a single point of contact), and carriers' information systems will ensure effective information exchange and greatly reduce the need to resubmit the same information.

Digital Automatic Coupling (DAC) and Freight Transport Automation

Introducing Digital Automatic Coupling (DAC) as part of the European project is a key direction in improving train operation processes and automating freight transport. The efficiency of operations and reduction of time needed to assemble/disassemble trains depend on this innovation. The issue of replacing screw couplers with automatic couplers has been considered multiple times in Europe over the years. The goal of this project is to shorten the time needed to form trains, eliminate physically demanding and hazardous manual coupling work during shunting, increase train load capacity by enhancing tensile strength, and, as a result, allow for longer train lengths. For the complete replacement and introduction of the new coupling type, in addition to a substantial financial component, a whole range of actions is necessary: certification, creation of regulatory documentation, implementation of changes in railway algorithms and railway staff procedures, etc. The implementation of this task is particularly relevant in the context of achieving "carbon neutrality" by 2050, under the adopted "European Green Deal."

In 2022, several European railways began months-long tests on a freight train equipped with DAC system digital couplers. Mass implementation in Europe is planned after 2025. These couplers ensure automatic connection of brake lines and power/data transmission lines, thus expediting technological operations carried out in freight transport and creating conditions to transition to more advanced train control technologies using moving block sections. Leading European freight carriers and leasing companies are designing freight wagons equipped with on-board telematics devices and sensors to track the location and condition of both wagons and the goods being transported. An example is the Austrian operator Rail Cargo Group, which has already equipped 11,000 wagons (out of a planned 12,000) with telematics devices.

Inductive Sensor Technology

One of the manufacturing companies collaborating with the Organization for Cooperation between Railways on infrastructure solutions offers a product for use on the international railway automation and telemechanics market. These technologies facilitate access to information needed for the operation, control, and protection of railway infrastructure—for instance, defining open turnouts, protecting railway switches, etc. The systems for wheel detection, axle counting, and monitoring can be used as standalone or integrated solutions.

This solution operates on the basis of inductive sensors and the method of distributed acoustic sensing. Wheel sensors and axle counters rely on inductive sensor technology, resulting in highly reliable products regardless of location, rail segment, or conditions. The components and technologies adopted in the solution are extremely durable and require minimal maintenance. Specific project requirements are taken into account through the possibility of creating customized solutions in terms of system architecture and flexible interfaces.

Digital Railway Project

The Digital Railway Project is a digital environment in which information is a resource defining processes, a management model, and available services. The project's aim is to increase the competitiveness of railways in the global transport and logistics services market. The tools for

implementing this project include digital platforms and a set of interconnected technological solutions for the interaction of transport market participants; the Internet of Things (IoT); large databases; wireless communication technologies; virtual and augmented reality; and smart systems. Examples include the "Freight Transport" electronic trading platform—which serves as a foundation for creating a multifunctional platform solution—or technologies for monitoring the location of rolling stock. These contribute to adapting and integrating railways into new business models such as "mobility as a service," "door-to-door" transport, and multimodality.

Locomotives and Trains with Automatic Guidance Systems (Unmanned Trains)

Robotization of rolling stock is a revolutionary change in rail transport, comparable to the transition from steam to electric traction. It contributes to improving the efficiency, safety, and competitiveness of rail transport. Rolling stock with automatic guidance systems (locomotives for heavy freight trains of mining companies, suburban electric trains and metro trains, trams) is already in operation in OSJD member countries and others, for example in Australia, Bulgaria, Great Britain, Hungary, Germany, China, the Republic of Korea, Russia, and France. The introduction of automatic train control systems, as well as upgrading security center facilities, reduces the number of technical errors, optimizes information flow, and increases the attractiveness of rail transport for passengers.

For example, under the Digitale Schiene Deutschland (DSD) initiative in 2022, several microprocessor-based interlocking (MCC) systems were introduced in different parts of Germany. These projects enable the development of technology and procedures for the rapid implementation of MCC and the European Train Control System (ETCS), combined with advanced dispatch control across the network in the coming years and in the medium term. It is expected to increase the capacity of the German railway network by up to 35% without building new lines. As part of the DSD initiative, efforts are being made to create digital twins and photorealistic railway models. These models will be used for training neural networks employed in unmanned operations and for using artificial intelligence in dispatch control of train traffic.

In Germany, regular operation of trains with an automatic guidance system based on ETCS began in 2022. Many unmanned train projects are underway in various European countries and, for example, in the Republic of Korea. One of the latest achievements in this field is the Cognitive Pilot unmanned driving system. Locomotives are equipped with the Cognitive Rail Pilot system featuring a vision system capable of detecting objects on the railway (other trains, points, tracks, people, traffic lights, etc.). Artificial intelligence assesses the environment and alerts the driver to potential hazards. If the driver does not respond to these signals, AI makes its own decisions in such situations. Innovative driver assistance systems (ADAS), as well as automatic driving technologies for light rail systems and shunting operations (FSD), are being developed. Artificial intelligence, deep learning technology, computer vision, and sensors are used to develop the OTIV Light Rail Vehicle System (OTIV), which adapts locomotives to urban working conditions. Since ADAS and FSD systems are equipped with obstacle detection and collision avoidance technologies, their implementation will allow for an increased level of efficiency in the transportation system as a whole.

Innovative Intelligent Transport Process Control System

In the context of growing demands for high-quality transport services, railways need integrated transport management systems and operational control centers for transport corridors, which can increase the efficiency of their operations and thus strengthen their position in the freight and passenger transport market. To address this issue, it is necessary to gather all available information about the operational situation in a controlled test area in a single control center, where it will be used to achieve the main goal—ensuring continuity and safety of the transport process.

A Transport Control Center (MCC) is a technological complex designed to provide operational management of the transportation process and the operation of railway infrastructure. The main tasks of the MCC include organizing and controlling the transport process, ensuring routing for passenger and freight trains, maintaining railway infrastructure and carrying out scheduled repair work, managing fleets of rolling stock, interacting with similar control centers (or structures performing their functions) of other railways, and with crisis response services and other state authorities. Depending on the transport management structure of a given country's railway, distinctions can be made, for example, between a network (national) control center and a line (route) control center.

Normalization and Standardization of Digitization Processes [8]

Digitization brings profound changes to human activities, from the production of goods and services to their consumption. It also changes the functioning of international trade; it transforms supply chains worldwide and in the UNECE region.

In particular, digitization alters how goods and the associated information move across borders. It creates the potential to integrate data and document exchange among different modes of transport and links in the supply chain, thereby boosting efficiency. However, current digitization efforts are fragmented and often focus on specific modes of transport or particular parts of the supply chain. This fragmentation creates significant challenges for interoperability and ultimately hinders the expected efficiency gains.

To avoid such fragmentation, it is important to consider the benefits of UN standards and supporting tools that can help ensure interoperability of information flows within supply chains, including multimodal transport chains. Examples of such UN standards are UN/CEFACT standards and reference data models developed as international public goods through an established UN procedure, as well as the new UNECE package of standards for multimodal data and document exchange. The UN/CEFACT standards, especially the new package of standards, offer, among other things:

- A universal basis for interoperability across industries and modes of transport, while retaining existing sector-specific standards and solutions.
- Adaptation of trade and transport data methodology through a common, overarching reference data model for the supply chain (the so-called BUY-SHIP-PAY model) as a foundation for interoperability.
- Standardized data exchange structures based on a shared core data exchange structure, independent data exchange syntax, and a common basis for implementing the chosen data exchange syntax.

According to the UN, implementing the new package of UN/CEFACT standards brings a number of benefits. It can, among other things:

- Support information exchange, e.g., in data pipelines, through timely capture of high-quality data from original (business) sources for secure, authorized use of specific data sets, ensuring visibility of data exchange in the supply chain.
- Reduce administrative burdens by effectively reusing data shared throughout the international supply chain.
- Increase collaboration among public and private stakeholders.

Given the importance of a holistic approach to digitizing data flows along supply chains, the UN/CEFACT standard is relevant for key stakeholders. UN/CEFACT standards do not replace existing international regulatory standards for transport contracts, such as the standard electronic airway bill or electronic railway consignment note. Instead, UN/CEFACT standards provide a basis for functional interoperability of cargo data across different modes of transport and sectors using a common semantic foundation. The package of standards is not a standalone product but part of

broader UN/CEFACT standard-setting efforts for digitizing information exchange throughout the supply chain.

The new package of standards consists of several components. It includes technical specifications, business requirements specifications, and supporting tools for key documents accompanying goods transported in one or more of the five major modes of transport, as presented in Table **1**. Using UNECE UN/CEFACT standards as a common foundation can enable smooth data exchange among different data sets, which are relevant for European Union initiatives. This is especially important given that EU Regulation 2020/1056 on electronic freight transport information (eFTI) requires that the exchange of transport information in EU Member States be conducted electronically and in a multimodal manner. Moreover, UN/CEFACT standards and recommendations on single windows contribute to the successful implementation of EU Regulation 2022/2399, which establishes the European Union Single Window Environment for Customs.

Tab.1. The UNECE Package for the Standard on Digitizing Information Flows along Supply Chains

1. Standards designed for digitalization Information flows in different parts of the supply chain before 2020:	**3.** Standardized data exchanges to support crossmodal cargo transfers – package of standards for digitalization of multimodal data exchange
1. e-CMR 2. Inter-industry invoice 3. Inter-industry delivery 4. Inter-industry catalog 5. Inter-industry quote 6. Inter-industry money transfer consulting 7. Inter-industry planning 8. Cross-industry ordering process 9. Material Safety Data Sheet (MSDS) details 10. Financial contract execution management 11. Market research information 12. Verified Gross Mass Documents (VERMAS) 13. International forwarding and transfer documents 14. Information on smart containers 15. Numerous agricultural certificates, accounting and other documents	1. Inland Waterway Transport Contract Document (IWT "Bill of Lading"; CMNI waybill; etc.) 2. Sea Waybill 3. CIM/SMGS and SMGS Waybills 4. CIM/SMGS Wagon List (+Trade Act etc.) 5. eCERT Certificates and Basics (Sanitary-Phytosanitary) 6. For other certificates: aligned to Buy-Ship-Pay • Reference Data Model
2. Standards for Logistics Exchange Data and Documents published in October 2020 at www.unttc.org and https://unece.org/trade/uncefact/mainstandards	**4.** Documents for air cargo and dangerous goods:
1. Temporary booking 2. Company booking 3. Confirmation 4. Shipping instructions 5. Waybill 6. Status report	1. Air Waybill 2. Dangerous Goods Declaration 3. Shipment Security Declaration **Electronic version of FIATA multimodal bill**

7. Status request 8. Packing list 9. RASFF (Rapid Alert for Food and Feed Safety)	**Lading launched in 2022; work on three other FIATA documents in progress**

Source: Developed based on materials from the United Nations Economic Commission for Europe, Geneva 2023, p. 4

It is worth emphasizing that the creation and consultation of standards take place as part of a long-standing UN collaboration with other international organizations, such as the European Commission, the Eurasian Economic Commission (EEC), the Organization for Cooperation between Railways (OSJD), the World Customs Organization, the Eurasian Economic Commission, the Permanent Secretariat of the Transport Corridor Europe-Caucasus-Asia (TRACECA), and many others.

Summary

The widespread use of information and automated systems as active elements of the transport process and economic activity as a whole is becoming a reality of our time. Digital technologies are completely transforming both the external and internal image of the railway sector. Practice and research have shown that digitization will bring a number of significant benefits for railways, for example:

- Additional capacity – increased demand for rail transport has led many systems to reach their capacity limits. Digitization can increase the capacity of many lines by more than 20% without building additional tracks.
- Cheaper but more efficient services – railway infrastructure operators will benefit from improved operational and maintenance efficiency as well as lower equipment costs. Lower costs can lead to reduced access charges, and with the introduction of digital train control and digital traffic management, the availability, reliability, and punctuality of the entire railway system will increase.
- Strengthening of technological leadership – automation and the harmonization of standards necessary for digitization give equipment manufacturers and the entire railway industry opportunities for innovation and the chance to conquer new markets.
- Improved environmental sustainability – digitization improves operations, which will be a key factor in achieving overall CO_2 emissions reduction goals in transport over both the short and long term.

Railways in OSJD member countries should adopt innovative technologies. Digitization plays a fundamental role in making rail transport an economically viable and environmentally friendly mode of transportation. The efficient functioning of rail transport in the OSJD region is crucial for creating conditions for modernization, transitioning to an innovative development path, and promoting sustainable economic growth across all member states of the Organization. Digitization is actively transforming and streamlining the work of transport and logistics systems both at the control and management level and in the day-to-day operations of individual companies.

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