DOI: 10.7251/JTTTP2502079S
UDC: 622.648.2:656:519.8

ORIGINAL SCIENTIFIC PAPER

RMSRM Software - Identification, Creation and Defining adr Routes and Dangerous Goods Transportation Management in Local Communities

Milorad Stefanovic
Master of Science in Traffic Engineering, CEO, Click & Find doo Beograd- Novi Beograd, Belgrade, Republic of Serbia, miccstc@gmail.com

Pavle Gladovic
PhD in Traffic Engineering, Engineering Academy of Serbian, Belgrade, Republic of Serbia, anaipavle@gmail.com

Radovan Viskovic
PhD Sc, Associate Professor, Doctor of Technical Sciences, University of East Sarajevo, Faculty of Technology, Zvornik, Republic of Srpska, Bosnia and Herzegovina, radovanviskovic1964@gmail.com

Zeljko Djuric
PhD Sc, Associate Professor, Doctor of Technical Sciences, University of East Sarajevo, Faculty of Transport and Traffic Engineering, Doboj, Republic of Srpska, Bosnia and Herzegovina, zeljko.djuric@fpm.ues.rs.ba

Received: November 24, 2025
Accepted: December 12, 2025

Abstract: This paper introduces a remote system designed for comprehensive management of dangerous goods (especially oil and gas liquid fuels) shipments and haulage. The system integrates various functions to streamline the planning and scheduling of trips, duties, and task allocation for dangerous goods transport. It considers available resources, appropriate routes, suitable timeslots, and adequate infrastructure to ensure the safest and lowest-risk passage of dangerous goods shipments and haulages within the local community.
The paper details the system's concept, algorithms, functionalities, features, and architecture. It also outlines the system prototype and the experimental results prepared for a pilot program intended for a larger urban areas

Key words: risk management, planning, scheduling, allocation, monitoring, evaluation.

INTRODUCTION

Creating a safer and more secure environment necessitates the development of ongoing mechanisms that guide and positively influence the awareness and actions of individuals, companies (whose activity is the dangerous goods transportation), and institutions. This can be achieved by applying algorithms grounded in the principles, procedures, rules, and methodologies of developed appropriate risk assessment standards within a company's safety and resilience framework, with a specific focus on the impact and interaction related to the transportation of dangerous goods as outlined by ADR regulations [1] [2].

The increasing demand for the transportation of energy and hazardous materials, driven by the growth of mobility in modern society, unfortunately presents challenges to consistently ensuring compliance with regulations and rules for every trip and every entity. Despite the presence of numerous competent and inspection bodies, a significant portion of responsibility ultimately rests with individuals.

Day-to-day operations highlight the need for a tool that can significantly enhance the control, coordination, management, and forecasting of future requirements in the design and establishment of new ADR routes. This tool should be capable of distributing and collects data, information and results from its and others databases, providing synchronous alerts, and, when necessary, delivering files. System should also assist in identifying appropriate entities for business partnerships related to the transportation and distribution of dangerous goods. This includes all the stakeholders involved in designing, planning, supervision, legal compliance, education, and operations.

Table 1. provides an overview of the types of data collected from dangerous goods transportation vehicles, examples of specific data points, and the technologies employed for their collection.

Table 1. Vehicle Data Collection

Type	Data Example	Technologies
Vehicle status	Truck data: - Engine status - Fuel consumption - Brakes status - Tire pressure - Axles load - Speed	Truck CAN bus[5] Additional sensors
	Semitrailer/Trailer data: - Brakes status - Tire pressure - Axles load	*Semitrailer/*Trailer CAN bus[6] Additional sensors
Driver status[7]	Driver data: - Driver Card Data - Driving and Rest Times - Driver Activity - Events and Error Messages Driver-related data: - Vehicle Speed - Distance Travelled - Country of operation - Vehicle identification	Tachogarph[8]
Cargo status[9]	- Towed Vehicle status and data - Temperature - Pressure - Open/Close valves - Open/Close doors - Quantities	Cargo sensors
Vehicle and Cargo documents[10]	- Transport documents - Driving license - Dangerous good transport card	Stored on the On-Board System

[5] Modern trucks commonly utilize standard fieldbus network technologies, such as the CAN bus, for managing vehicle diagnostic data. The Controller Area Network (CAN) system facilitates communication between various electrical components within the vehicle using a single or dual-wire setup. For further information on the specifics of the available data, please refer to [3].

[6] Semitrailer/Trailer electronics is evolving to the use of standard fieldbus technologies with the aim of integrating all on board electronic equipment. VISIONS project invested on trailer electronic data management as the semitrailer/trailer is responsible for most of the vehicle weight and is at the origin of most accidents. For further information on the specifics of the available data, please refer to [4].

[7] By EU regulations it is mandatory to install a tachograph in new vehicles having a mass of more than 3,5 tones when they are intended for the transport of goods... For further information on the specifics of the available data, please refer to [5].

[8] The tachograph is the device that records driving time, breaks and rest periods as well as periods of other work and availability of drivers engaged in the carriage of goods or passengers by road. The purpose of the tachograph is to enable controls of compliance with the set of EU rules aimed to prevent driver fatigue and to contribute to good working conditions of drivers, road safety and fair competition. For further information on the specifics of the available data, please refer to [5].

[9] VISIONS project invested specially on dangerous goods data collection, as the monitoring of such goods strongly impacts on safety.

[10] This type of data includes all information typically contained in law-enforced documents generally available in paper form. The electronic management of such documents makes inspection more efficient.

RESULTS

The Risk Management System for Routing and Monitoring (RMSRM) main function are:

- Collecting vehicle and driver, in an on-board information hub and infrastructure data in an information hub.
- Make data available to external information systems as interactive services.

Table 2. Vehicle Data Delivering

Task	Function	Adopted Technologies
Management of wireless communications	- Wireless networking in local area and wide area - Log on / Log off detection - Dynamic allocation of IP/ Hostname to hosts - Names resolution	WI-FI[11] GPRS[12] *Logoff Service*[13] DHCP [6] DNS
Support of a domain-specific open interface between ground applications and on-board applications	- Messaging - Service Interface Definition (SID) - Security - Map editing	XML [7] SOAP [8] WSDL [9] WSS [10] G3 [11] QGIS [12]
Management of temporary available network services	- High dynamics service discovery - Location awareness	UDDI [13] *Trigger Engine*[14] *Location Registry*[15]

[11] In the proximity of a local road infrastructure, information passes through a wireless LAN connection. WI-FI network support higher data rates than the GPRS network and for this reason it is used in the proximity of VISIONS enable infrastructures, where a high amount of information must be transferred, for example performing a large amount of cargo data.

[12] When the vehicle needs to transmit or receive data to or from a remote system, the mobile GPRS network is used. The GPRS network is characterized by a lower data rate, but its coverage is potentially unlimited, see [4].

[13, 14,15] See chapter 2, 2.1 and 2.2 and 2.3.

For the RMSRM system is selected a Service-Oriented Architecture (SOA) due to its inherent interoperability. This allows us to effectively integrate and work with diverse applications across different organizations, which is particularly beneficial for the complex software systems often found in large enterprises.

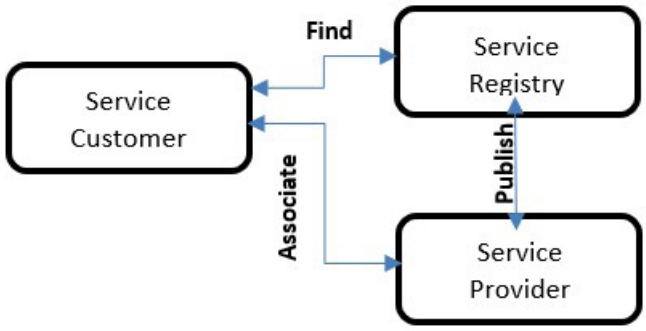

Figure 1. Presents basic interaction of Service Oriented Architecture. SOA defines three main actors: the Service Consumer, the Service Provider and the Service Registry. Providers publish the services they offer to a Service Registry. Consumers interrogate the Registry to discover the services they need and to obtain all the information needed to access such services.

SOA approach will leverage web services that adhere to standard internet protocols. These web services will primarily be implemented using:

- SOAP for messaging.
- WSDL for service interface description.
- UDDI as a service registry.

In this setup, the UDDI will serve as a directory, storing the addresses of service providers for specific services and links to their respective Service Interface Definitions (SID). The Information System architecture is created from the following modules:

Mobile Services

The Risk Management System for Routing and Monitoring (RMSRM) architecture builds upon the advancements of existing systems like VISIONS. These systems have successfully adapted Web Services technologies for wireless mobile environments, partly using Free and Open-Source Software (FOSS) and available software in the possession of regulatory bodies and countries. This approach facilitates access to crucial information and databases necessary for effective real-time risk management. The following paragraphs describe the architectural components added for this purpose.

Location Registry Module

Currently, the SOA Service Registry does not include support for location services, which are crucial for tracking the whereabouts of vehicles. To address this, RMSRM Location Registry stores location information as an additional attribute for the services already within the Service Registry. This enhancement allows applications to query the system more effectively by filtering requests based on specific location criteria.

Consequently, the Location Registry enables various users and applications to access different services based on service location and specific conditions. For instance, a consigner's administration or an ADR Competent authority or vehicle inspection body might only need to track trucks approaching or leaving a loading point or an authorized technical inspection station, particularly if the vehicle has a prior modification or remanufacturing or reconditioning record [14] [15] [16]. In contrast, the police might be interested in monitoring all vehicles within a defined geographical area, such as an ADR parking zone.

RMSRM architecture is designed to process four types of location information: geographic coordinates, rules, constraints, and points of interest. A point of interest refers to a specific location within the infrastructure, such as a road, intersection, gate, or parking space. The system can associate both a set of geographic coordinates and a relevant point of interest, along with any applicable rules and restrictions for them.

Trigger Engine Module

Trigger Engine component provides a valuable signalling mechanism to applications whenever a specific change occurs within the Service Registry or the Location Registry. Trigger Engine functionality allows applications to stay informed about relevant events without the need for constant polling of the registries.

For example, triggers can be activated by events such as:

- A vehicle joining the Service Registry.
- A vehicle leaving the Service Registry.
- A vehicle arriving at a specific point of interest.
- A vehicle departing from a specific point of interest.
- A newly registered vehicle offering a particular service.
- A vehicle entering a designated geographic area.
- A driver joining the Service Registry.
- A driver obtains new attribute (e.g., extension of possessed license, police notice)

Consequently, the Trigger Engine ensures that applications have up-to-date information regarding the available services at any given time. This is particularly beneficial in dynamic environments with frequent changes, such as mobile networks where vehicles routinely connect to and disconnect from the infrastructure, leading to rapid shifts in service availability.

Logoff Service Module

Functionality of the Logoff Service, which plays a crucial role in managing vehicle service registrations

within an infrastructure. When a vehicle connects, it must register its availability at Service Registry. However, disconnections are often abrupt due to the nature of wireless coverage.

The Logoff Service Module addresses this by continuously monitoring the network to detect when a vehicle leaves the infrastructure's coverage area. Upon detection, it automatically removes the vehicle's entry from the Service Registry. This process necessitates interaction between the Logoff Service and the network infrastructure to ensure accurate and timely deregistration.

Trip Tracking Module

The Trip Tracking Module is designed to comprehensively monitor compliance with legal requirements, established rules, criteria, and performance indicators across all facets of individual driver work tasks. It offers real-time comparison of efficiency, quality, and quantity of individual task performance against existing database information based on predefined rules and objectives. The data is then recorded in the appropriate RMSRM registers.

Tachograph Module

The Tachograph is an approved, user-friendly measuring device installed in every vehicle for dangerous goods transportation. It is designed for the secure collection, processing, storage, and transmission of accurate and reliable data related to the driver, driver activity, and the vehicle itself. The Tachograph Module acts as middleware, enabling RMSRM to collects several key pieces of data relating to vehicle and driver activity, stored both in the Tachograph 's mass memory and on the driver's card, monitor driver behaviour by continuously sending queries and collecting data.

This allows for the identification of drivers and their behaviour during work tasks, particularly along predefined itineraries, and points of interest. It also provides real-time information and time intervals of events, ensuring adherence to prescribed rules and procedures.

Vehicle Module

The Vehicle Module focuses on collecting relevant and robust data from all available vehicle sources. These sources include the CAN (Figure 2.), tachograph, and other integrated vehicle sensors and devices, such as the onboard vehicle's computer, camera, driver fatigue detection system, and following vehicle distance detection system. This data is crucial for determining the vehicle's status and condition [17].

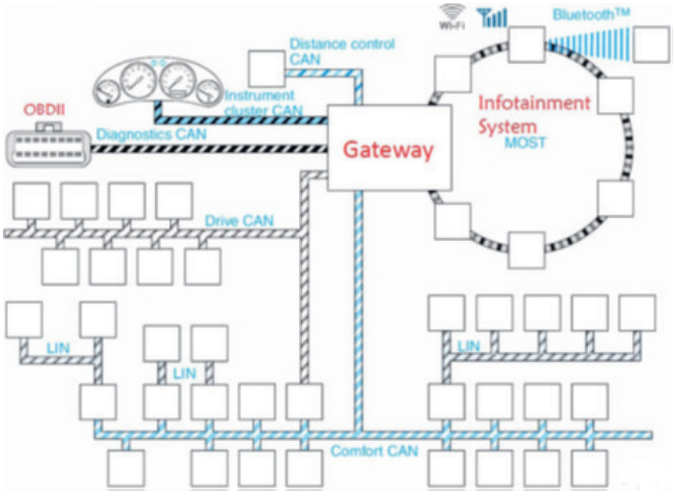

Figure 2. Presents Area Network (CAN). CAN is the most established automotive communication system protocol for the internal vehicle network. It allows safety-critical ECUs that attached to it to sufficiently broadcast information in the form of CAN packets between them and other connected busses (e.g., FlexRay, MOST, LIN) through several gateways [18]

The data collected from the vehicle, along with information from GPS devices and other available devices like upgraded video surveillance systems and alco-testers, are processed, stored, and distributed within the RMSRM database.

Inspection Authorities Module

The core function of inspection authorities is to act preventatively. This is achieved by monitoring the implementation of legislation and regulations through document control, field inspections, and supervision during incidents, with conclusions drawn from factual findings.

The Inspection Authorities Module aims to significantly enhance these processes and procedures, both quantitatively and qualitatively, by streamlining operations and substantially increasing the sample size of inspections, whether automatic or ad hoc.

The collected data, information, and documents would then be processed by the RMSRM. Based on predefined criteria, rules, and forms, it would synthesize the results of multi-criteria monitoring into comprehensive reports and interactive reviews.

These reports are categorized by monitored entities (such as companies, organizational units, managers, individuals, fleets, and vehicles) and controlled elements (including adherence to prescribed periods and scope of vehicle and driver controls, use of ADR parking lots and ADR transportation predefined routes, and details of transported documents, goods, and transported quantities).

Figure 3 and Figure 4 demonstrates a sample report, and the user interface clearly displays the selected perpetrator's behavior rating, including a list of violations, their locations, and times of occurrence.

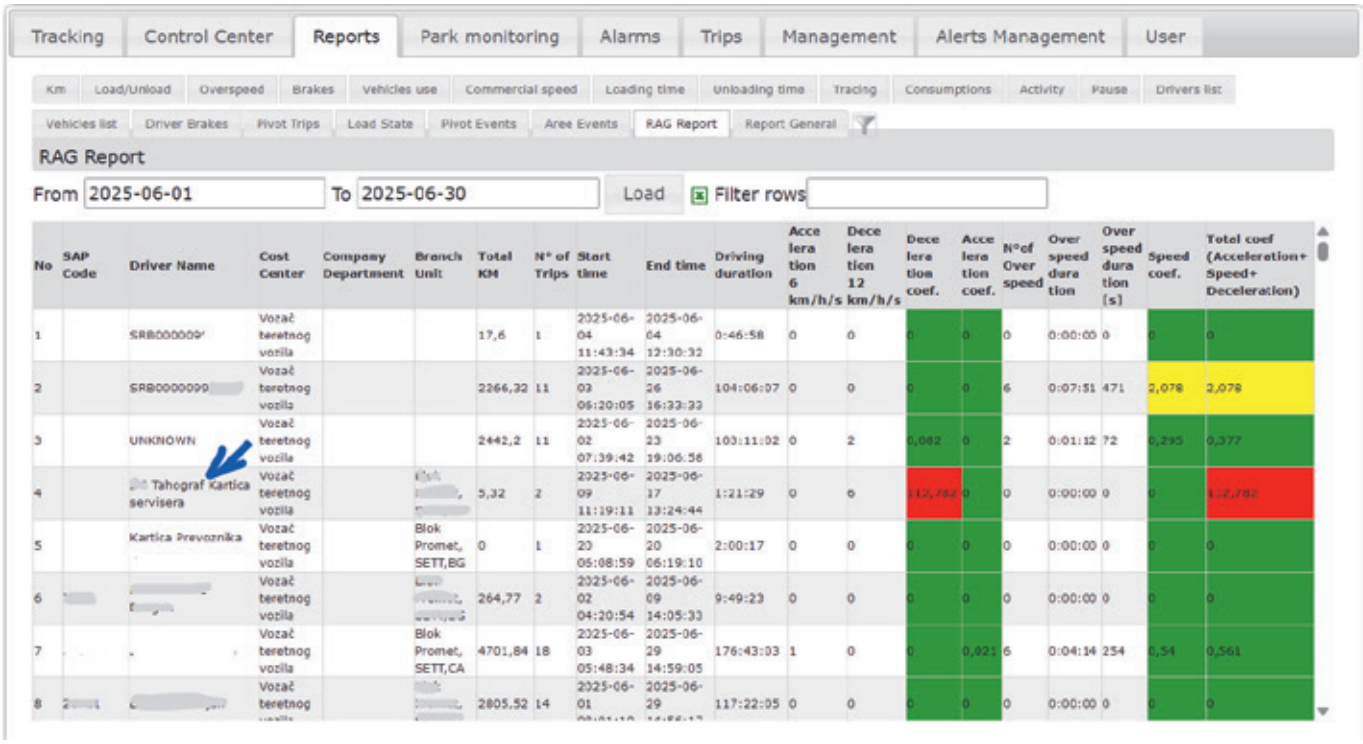

Figure 3. Presents RAG (Red, Amber, Green) Report

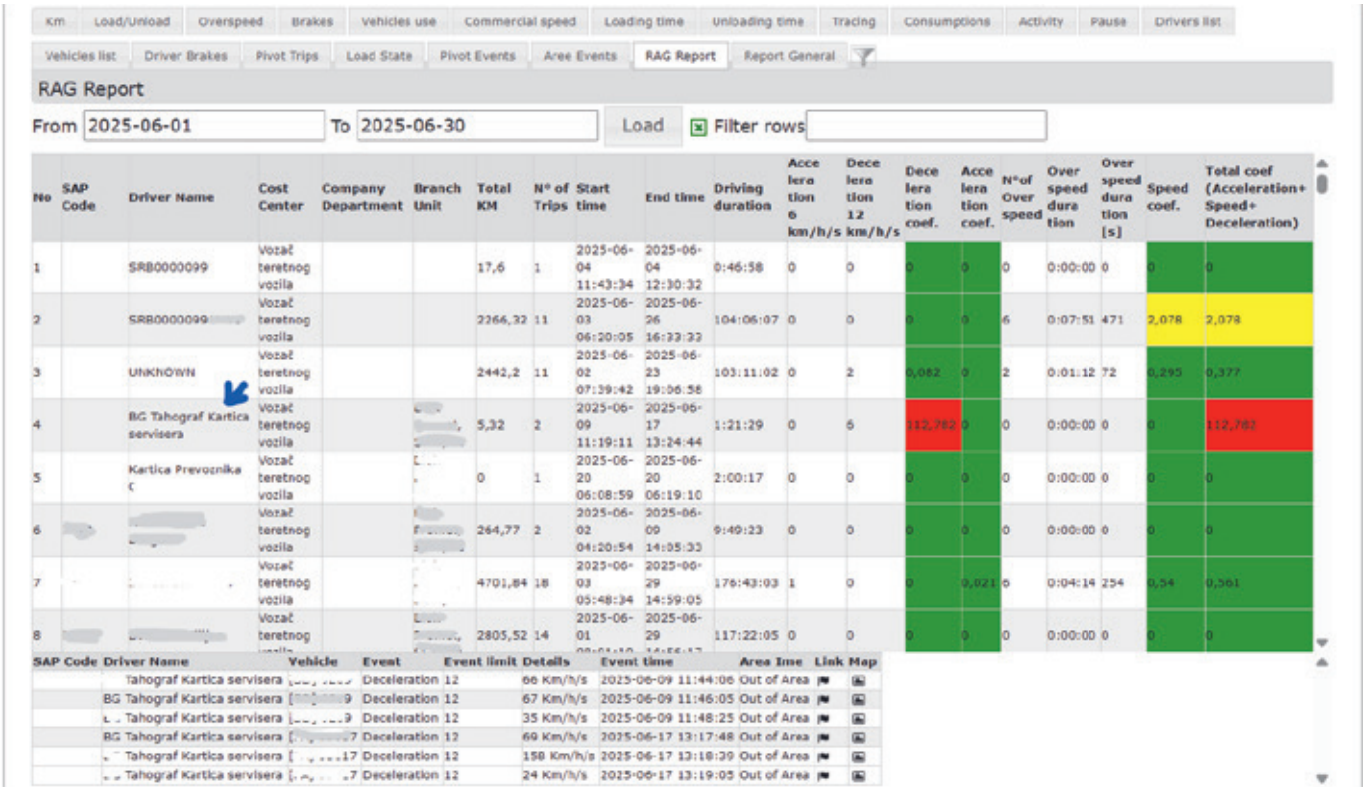

Figure 4. Presents result of the digging-in detected red fielded entity in RAG (Red, Amber, Green) Report and its content (violated rule/ restriction, locations of the violations, violation durations, vehicle's fleet number and driver's ID)

Inspection Authorities Module

The Supervisory Authority Module is designed to centralize and manage publicly available data from diverse institutions, including the police[1], courts[2], and medical facilities over standard application programming interfaces (APIs). This consolidation encompasses critical information such as driving license validity[5], violation records[3], driver and vehicle details, fine payments[6], initiated legal proceedings, judgments, and psychophysical assessments for various license holders. Additionally, the module integrates data from ministries and bodies overseeing transportation, economy, energy, infrastructure4, and construction[5].

Currently, accessing this information is challenging, often involving lengthy bureaucratic requests or fragmented searches across multiple websites. This difficulty in data exchange impedes coordination among relevant parties within economic and state entities. The RMSRM system's architecture addresses this by enabling seamless digital service exchange and direct transmission of crucial data among various bodies, institutions, companies, organizational units, and responsible personnel.

This system significantly enhances the efficiency and reliability of rule implementation, promoting transparency and effectively minimizing the risk of unauthorized or sanctioned entities participating in any process.

DISCUSSION

A key aspect of this system is its multi-layered, real-time monitoring capabilities. It delivers timely alerts and reports to all pertinent stakeholders regarding events, regulatory compliance, and the adherence to rules by everyone involved in the complete dangerous goods transportation process. The system facilitates the exchange, requests, collection and processing of data in real time between all parties directly and indirectly involved in the transportation of dangerous goods. This is done efficiently, within established deadlines and according to pre-defined rules, using comprehensive RMSRM databases.

The system's architecture allows for smooth and seemless digital service exchange between vehicles and road infrastructure components, such as roads, key traffic intersections, schools, hospitals, authorities data bases, tunnels, highways, O&G operators depots and its monitoring system (bottlenecking, throughputs, accumulations and expected state at the expected time of arrival) etc [19] [20]. This enables the direct transmission of important data from vehicles (including informations related to driver, engine status, cargo specifics, vehicle cargo space status, and cargo documentation, and all this in relation to the regulations) to the various information systems mentioned above (e.g. information systems of infrastructure, supervisory, emergency, supervisory authorities, etc.).

In the RMSRM is implemented a easy customizable subsystem where events and behaviors categorized as high importance or high risk automatically trigger notifications and alarms on designated equipment. This ensures timely action by the institution and/or end-user. In addition, all data is securely stored in the system databases and is accessible through user-friendly reports.

CONCLUSION

The paper provides a detailed description of the system's concept, algorithms, functionalities, features, and architecture. It also covers the system prototype and experimental results, which were prepared for a pilot program targeting larger local communities.

Built with a service-oriented architecture, the system incorporates specialized extensions designed to address the unique requirements of the field, such as managing highly dynamic events and adapting to short service lifetimes within the network.

The application of this system is expected to improve traffic safety in urban areas by reducing the risks of potential accident situations.

BIBLIOGRAPHY

[1] Security and resilience of society — Risk assessment SRPS A.L2.003:2017 (sr), August 2017.

[2] ADR 2025 - Agreement concerning the International Carriage of Dangerous Goods by Road, United Nations, 2024.

[3] Lokman et al. "Intrusion detection system for automotive Controller Area Network (CAN) bus system: a review", EURASIP Journal on Wireless Communications and Networking, (2019), 2019:184.

[4] M. Fornasa; N. Zingirian; M. Maresca; P. Baglietto "VISIONS: A Service Oriented Architecture for Remote Vehicle Inspection", Conference Paper IEEE, Toronto, October 2006.

[5] EU Commission "Official Journal of the European Union - Document 32014R0165", February 2014 https://eurlex.europa.eu/legal- content/EN/TXT/?uri=CELEX%3A32014R0165

[6] R. Droms, RFC 2131 - Dynamic Host Configuration Protocol, 1997.

[7] T. Bray et al., Extensible Markup Language (XML) 1.0 (Third Edition), W3C Recommendation, 2004.

[8] N. Mitra, SOAP Version 1.2, W3C Recommendation, 2003.

[1] Driving license status check in Croatia. Link: https://mup.gov.hr/ostalo-48/kutak-za-vozace/283633

[2] Register of unpaid fines and other monetary amounts in Serbia. Link: https://rnk.sipres.sud.rs/

[3] Notifications on traffic violations per driving license number in Croatia. Link: https://eprekrsaji.mup.hr

[4] Publicly available information of the Ministry of Construction, Transport and Infrastructure (Serbia) about carriers, licenses, vehicles, licenses issued to carriers, violations updated in real time and available via the link:
https://mgsi.gov.rs/lat/prevoz-putnika-i-tereta-u-drumskom-saobracaju and

Roads network in Serbia https://www.putevi-srbije.rs/index.php/en/referentni-sistem-eng or https://cloud.gdi.net/smartPortal/SRBRefSistem

[5] Publicly available information of the Ministry of Construction, Transport and Infrastructure (Serbia) https://ceop.apr.gov.rs/ceopweb/sr-cyrl/home

[9] E. Christensen, F. Curbera, G. Meredith, S. Weerawarana,, Web Services Description Language (WSDL) 1.1, W3C Note, 2001.

[10] Web Services Security: SOAP Message Security 1.1 (WS-Security 2004), OASIS Standard Specification, 2006.

[11] P. Gladovic, V. Popovic: "Savremene informacione tehnologije u drumskom transportu", izdavac Fakultet tehnickih nauka u Novom Sadu, 2010. (pomoćni udzbenik),UDK: 656.1.025.4:004(075.8), ISBN: 078-86-7892-301-2, strane:276

[12] Passy, P.; Théry, S. The use of SAGA GIS modules in QGIS. QGIS Gen. Tools 2018, 1.

[13] Universal Description, Discovery and Integration (UDDI) version 3.0.2, OASIS Standard Specification, 2005.

[14] ADR 2025 – Agreement concerning the International Carriage of Dangerous Goods by Road, Chapter 1.2.1, United Nations, 2024.

[15] https://webgate.ec.europa.eu/single-market-compliance-space/home

[16] ADR 2025 – Agreement concerning the International Carriage of Dangerous Goods by Road Chapters 9.1.2.3, 6.11.5.3.2, 4.1.1.12, United Nations, 2024.

[17] Lokman et al. "Intrusion detection system for automotive Controller Area Network (CAN) bus system: a review", EURASIP Journal on Wireless Communications and Networking, 2019, 2019:184.

[18] T. Nohet, H. Hanssont, L.L. Bello, in IEEE Symposium on Emerging Technologies and Factory Automation. Automotive Communications-past, Current and Future, Catania, 2005.

[19] M. Stefanovic et al. " SIMULATION ANALYSIS OF LOADING AND UNLOADING OPERATIONS IN TRANSPORT OF DANGEROUS GOODS IN THE PEAK MONTHS", SYM-OP-IS 2018, Zlatibor, September 2018.

[20] M. Pejica et al. "SIMULATION ANALYSIS OF LOADING OPERATIONS IN TRANSPORT OF DANGEROUS GOODS ON VARIOUS LOADING BASE", SYM-OP-IS 2019, Kladovo, September 2019.