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Oversized Transport of EU States in the Era of Artificial Intelligence

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Oversized transport in European countries is an essential component of international logistics, playing a critical role in the transport of industrial equipment, large structures or other goods that exceed the standard dimensions and weight allowed for transport. These operations are regulated by strict laws and involve detailed planning. In the European Union, this type of transport is regulated by a combination of national legislation and European directives, with the aim of ensuring road safety and protecting infrastructure. Although each Member State has its own regulations and procedures, there are common elements thanks to European harmonization. Oversized transport has entered a new era with artificial intelligence, which has led to a significant transformation in the way it is planned, managed and executed. The impact of artificial intelligence on oversized transport is major, from route planning, real-time monitoring and coordination of transport, automation of authorization processes, to transport safety and risk reduction, cost optimization and the use of drones for surveillance and robots for secondary operations. Artificial intelligence is transforming oversized transport into a safer, more efficient and more sustainable field, AI being an essential tool to cope with the complexity of this type of transport, opening up new perspectives for logistics and industry.

Keywords: *Oversized transport, Artificial Intelligence, EU States, digitalization, sustainable development goals.*

Introduction

Road transport constitutes a fundamental pillar of modern economies, facilitating the intricate movement of goods and individuals from origin to destination. Within this expansive domain, oversized transport represents a specialized and inherently complex segment. This category encompasses the movement of indivisible goods or the operation of vehicles that, even unladen, exceed standard constructive masses and/or maximum permissible dimensions. Such operations are characterized by stringent regulatory requirements and significant operational complexities. As a specialized form of road freight transport, oversized transport operations must adhere to general road transport operator regulations, such as those stipulated by EU legislation (e.g., Regulation EC 1071/2009, modified by Regulation (UE) 2020/1055), which mandate criteria like effective and stable establishment, good repute, professional competence, and financial capacity. Furthermore, specific conditions apply to the handling of oversized loads, including specialized driver certifications and, where legally mandated, the use of authorized escort vehicles or specialized operators.

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The European Union's oversized transport[1] landscape is currently undergoing rapid evolution. This is primarily driven by an escalating demand for the cross-border movement of large industrial components, specialized machinery, and critical infrastructure elements, essential for various sectors including energy, construction, and manufacturing. Concurrently, Artificial Intelligence (AI) has emerged as a disruptive technological force, demonstrating profound transformative potential across diverse industries. AI promises to revolutionize logistics by optimizing operational processes, significantly enhancing safety protocols, and substantially reducing associated costs.

This academic paper aims to provide an in-depth analysis of the intersection between oversized transport practices in EU Member States and the burgeoning capabilities of AI. The study will meticulously examine the current state of oversized transport, outlining its prevailing regulatory framework and inherent operational challenges. The efficient transport of oversized cargoes is indispensable for urban and industrial development, facilitating the movement of critical components for infrastructure, energy, and manufacturing sectors. However, its integration within increasingly dense and sustainability-focused urban environments presents significant challenges, particularly concerning existing transport infrastructure and environmental objectives[2]. Subsequently, it will delve into the specific applications of AI within this context, exploring both the promising opportunities and the formidable challenges associated with integrating AI-driven solutions into this highly regulated and operationally demanding domain.

Literature Review

The academic discourse on transport and logistics has increasingly focused on the intersection of technological innovation and regulatory frameworks. Traditional research on oversized transport[3] has primarily concentrated on engineering challenges, infrastructure limitations, and the complexities of national permitting procedures[4]. Studies by organizations such as the International Road Transport Union (IRU) have consistently highlighted the administrative burdens and fragmentation of regulations across European borders as significant impediments to efficient oversized transport operations[5]. These challenges often lead to increased costs, delays, and a heightened risk of non-compliance.

The advent of Artificial Intelligence has catalysed a new wave of research across various transport modalities. In general logistics, AI is being explored for its potential in route optimization, demand forecasting, warehouse management, and autonomous vehicle operation[6]. Specifically, in the broader context of intelligent

[1]Bădescu & Purcar (2017) In *MATEC Web Conf. Volume 121*, "Trends in New Industrial Revolution".
[2]Petru & Krivda, (2021), 13, 5524.
[3]Bahram, Haibo & Lutfu (2023) *Logistics*, 7, 98.
[4]European Commission. *Transport policy: Road transport - Weights and dimensions*.
[5]IRU (International Road Transport Union). *Challenges of Abnormal Loads Transport in Europe*. [Search for reports or articles on IRU website related to special transports and administrative barriers].
[6]KPMG. *Driving change: How AI is transforming the transport industry*.

transport systems (ITS), AI algorithms are recognized for their capacity to process vast datasets from sensors, cameras, and telematics devices to manage traffic flow, predict congestion, and enhance urban mobility[7]. The European Commission's Digital Transport and Logistics Forum (DTLF) emphasizes the importance of digitalization and data sharing for improving freight transport efficiency across the EU[8].

However, the application of AI specifically to oversized transport, a niche yet critical segment, remains an area requiring more dedicated academic attention. While general AI applications in smart transport[9] (e.g., smart parking, traffic optimization in urban settings) have been extensively studied[10], the unique complexities of oversized loads – such as specific infrastructure constraints (bridge capacities, tunnel clearances), stringent safety requirements, and highly individualized permitting processes – present distinct challenges and opportunities for AI integration. Existing literature often overlooks the intricate relationship between oversized cargo transport and the principles of sustainable urban infrastructure, failing to comprehensively analyse how the unique demands of oversized loads—including their dimensions, weight, and specific routing requirements—conflict with or can be harmonized with urban[11] sustainability goals, such as reduced emissions, optimized traffic flow, and minimized infrastructure wear[12].

Existing literature on AI in governance and public service highlights the potential for automation in administrative processes, such as permit issuance and compliance checks[13]. However, these studies also caution about the ethical, legal, and social implications of AI, including issues of liability, data privacy, algorithmic bias, and job displacement. The European Parliament Think Tank (EPRS) and ENISA (European Union Agency for Cybersecurity) have underscored the urgent need for robust regulatory frameworks and cybersecurity measures to govern AI applications in safety-critical sectors like transport[14].

This paper aims to bridge the gap in the literature by specifically analysing how AI's capabilities can be adapted to the unique demands of oversized transport within the fragmented regulatory landscape of the EU, while critically assessing the associated opportunities and challenges.

[7]European Parliament Think Tank (EPRS). *Artificial intelligence and transport: New challenges for EU law*. (Analyses legal and ethical challenges of AI in transport). Also, see European Commission. (2024). Digitalisation of mobility.
[8]European Commission's Digital Transport and Logistics Forum (DTLF). Search for reports and best practice guides on the digitalization of freight transport in the EU. (Relevant for EU-level digital initiatives in transport).
[9]Petru & Krivda (2020)
[10]ENISA (European Union Agency for Cybersecurity). *Cybersecurity in the Transport Sector* (Provides insights into cybersecurity risks in connected transport infrastructures).
[11]Szczucka-Lasota (2017) Series Transport, vol 97: 157-165.
[12]Petru & Krivda (2021) 13, 5524
[13]Deloitte. *AI in Government: The Future of Public Service*. (Accessed for AI in automating administrative processes and digital permits).
[14]ENISA. *Cybersecurity in the Transport Sector*. Deloitte. *AI in Government: The Future of Public Service*.

Methodology

The methodology of this research is grounded in a multi-layered analytical approach, beginning with a comprehensive synthesis of current European transport directives and national legislative frameworks. This legal review is augmented by a qualitative assessment of AI integration within the logistics sector, identifying the intersection between technological capability and regulatory constraint. To provide empirical depth, the study utilizes a comparative case study framework, specifically contrasting the mature digital infrastructure of Germany's VEMAGS system with the emerging automated solutions in Poland and Romania. This allows for a critical evaluation of how different administrative cultures adapt to the requirements of the Digital Single Market.

The theoretical underpinning of this research was based on a rigorous and extensive review of academic literature, querying prestigious scientific databases to identify the current state of knowledge in the field. This stage was essential not only for data collection, but also for establishing a solid conceptual framework in which to integrate Artificial Intelligence (AI) in heavy logistics.

In parallel with the academic approach, the analysis process included a critical assessment of reports and strategic documents issued by international reference organizations, such as the European Commission, OECD, International Road Transport Union (IRU), World Economic Forum, UNECE and ENISA. The analysis of these sources allowed for a deep understanding of the current regulatory landscape, emerging technological trends and public policy recommendations at a global level.

The synthesis of the results obtained from these diverse sources aimed to correlate the historical challenges of oversized transport with the innovative solutions offered by AI applications already validated in conventional transport sectors. Furthermore, this synthesis process facilitated the identification of specific opportunities and risks inherent in the application of AI algorithms in oversized logistics, thus providing a balanced perspective on how digitalization can mitigate systemic inefficiencies while maintaining a high level of operational and cybersecurity security.

Starting from the premises identified in the literature review stage, the research has substantiated a robust conceptual framework, aimed at mapping the potential applications of Artificial Intelligence throughout the entire life cycle of an oversized transport operation. This integrated model is not limited to a simple sequence of stages, but analyzes how AI algorithms can critically optimize road planning processes, automation of authorization systems, technical execution of the trip, real-time monitoring of safety parameters and, finally, predictive maintenance of the fleet and the infrastructure used.

Furthermore, the conceptual framework developed transcends the purely technical approach, integrating essential socio-technical dimensions. It examines the complex interdependence between cutting-edge technological advances, human factors involved in the operation, the dynamic regulatory environment and the wider societal impact. Through this multidimensional approach, the reference framework allows for a balanced assessment of how digital innovation interacts with public safety norms and the need for workforce adaptation, providing a solid basis for analyses applied to the German and Polish models.

A key component of the methodology was the critical assessment of the opportunities and challenges identified in the process of integrating Artificial Intelligence into oversized logistics. This analysis was not limited to a simple inventory of obvious benefits, such as increased road safety, improved operational efficiency, reduced logistics costs and alignment with sustainability standards. On the contrary, the research investigated how these advantages are conditioned by a series of significant structural barriers. Among these, the regulatory lag in relation to the pace of technological innovation, the need for massive investments in smart infrastructure and the complexity of data governance represent major obstacles that can slow down the widespread adoption of digital solutions.

The assessment process placed particular emphasis on analyzing the interdependencies between these factors and their potential implications for the Member States of the European Union. For example, it was observed that the increased efficiency through AI is directly dependent on strict cybersecurity protocols, given the vulnerability of critical infrastructure to external attacks. At the same time, ethical concerns regarding algorithmic transparency and decision-making accountability were analyzed in the context of current public policy debates.

This assessment was based on a careful examination of existing academic critiques and strategic dialogue between the public and private sectors on the implementation of AI in high-risk areas. By correlating these perspectives, the section offers a nuanced view of how the balance between innovation and regulation will dictate the success of the digital transition in oversized transport in Europe.

Drawing from the analytical findings and best practices identified in the literature, a set of actionable policy recommendations was formulated. These recommendations are designed to guide EU Member States and relevant stakeholders in strategically leveraging AI to overcome current challenges and foster a more robust, safe, and sustainable oversized transport ecosystem.

This methodology ensures a comprehensive and structured approach to understanding the complex dynamics of AI integration in oversized transport, providing a robust foundation for the discussions and conclusions presented.

Oversized Transport in the EU: Current Framework and Challenges

Oversized transport operations within the European Union are governed by a multi-layered regulatory architecture. This framework comprises overarching EU Directives and Regulations, which establish harmonized principles for general vehicle weights and dimensions, complemented by specific national legislation enacted by each Member State. The primary objectives of this intricate regulatory system are to ensure paramount road safety, safeguard critical infrastructure, and minimize disruptions to general traffic flow.

EU Regulatory Framework

General Directives: The European Union sets forth broad principles concerning vehicle weights and dimensions. However, it strategically grants Member States a degree of flexibility in regulating exceptional transports. This approach allows for the incorporation of national adaptations that account for unique infrastructure characteristics, diverse geographical conditions, and specific local requirements. This ensures that while a common baseline exists, the practicalities of diverse national contexts are accommodated[15].

National legislation: Each EU Member State maintains its distinct and detailed procedures governing the authorization of oversized transports. These national regulations encompass specific requirements for designated routes, the mandatory use of escort vehicles, and various traffic restrictions (e.g., limitations on specific hours, days, or under certain weather conditions). This national discretion frequently results in a fragmented and time-consuming process for obtaining cross-border permits, often necessitating approvals from multiple national, regional, and local authorities, thereby creating significant administrative complexities[16].

Within this national legislative landscape, it is crucial to acknowledge the strategic direction set by individual Member States. For instance, Romania's National Strategy for Intelligent Transport Systems (2022-2030), approved by Government Decision No. 877/2022 on the approval of the National Strategy on Intelligent Transport Systems for the period 2022-2030[17], outlines a clear commitment to digitalizing transport infrastructure and services. While not exclusively focused on oversized transport, this strategy's objectives – such as enhancing road safety, improving traffic flow efficiency, and promoting data exchange and interoperability – directly influence the environment in which oversized transport operates and pave the way for AI integration.

Key Challenges in EU oversized Transport

Complex route planning: The planning of oversized transport routes demands a meticulous, often manual, analysis of numerous infrastructure constraints. These include, but are not limited to, bridge capacities, tunnel clearances, the geometry of sharp turns, the presence of overhead obstacles (such as power lines or low-hanging structures), and the load-bearing resistance of road surfaces. This complexity is particularly pronounced for international routes that traverse diverse infrastructural landscapes[18].

Fragmented permit acquisition: The process of obtaining Special Transport Authorizations (STAs) across the EU is widely recognized as bureaucratic, protracted,

[15]European Commission. *Transport policy: Road transport - Weights and dimensions*.
[16]IRU (International Road Transport Union). *Challenges of Abnormal Loads Transport in Europe*.
[17]National Strategy on Intelligent Transport Systems for the period 2022-2030. Approved by Government Decision no. 877/2022, published in the Official Gazette of Romania, Part I, no. 894 of September 8, 2022 [Strategia Națională privind sistemele de transport inteligente pentru perioada 2022-2030. Aprobată prin Hotărârea Guvernului nr. 877/2022, publicată în Monitorul Oficial al României, Partea I, nr. 894 din 8 septembrie 2022.]
[18]European Commission. *Transport policy: Road transport - Weights and dimensions*.

and costly. Significant variations in regulatory requirements, application procedures, and processing times among Member States impose substantial administrative burdens and lead to considerable delays for cross-border operations, hindering the efficiency of the single market[19].

Safety concerns: The inherent physical characteristics of oversized vehicles – their immense size and reduced manoeuvrability – intrinsically elevate the risks of accidents. This demands the implementation of exceptionally stringent safety measures, specialized training for drivers, and, in many cases, mandatory professional escorts to manage traffic and mitigate potential hazards.

Infrastructure impact: The passage of oversized transports contributes disproportionately to the accelerated wear and tear of road networks and bridge structures. This requires continuous and rigorous monitoring of infrastructure integrity, proactive maintenance schedules, and, in certain instances, temporary structural reinforcements to accommodate exceptionally heavy loads. The integration of oversized cargo transport within increasingly dense and sustainability-focused urban environments presents significant challenges, particularly concerning existing transport infrastructure and environmental objectives, including infrastructure limitations (e.g., bridge capacities, narrow streets) and environmental impacts[20].

High operational costs: These specialized transports incur substantially higher operational costs compared to standard freight movements. These costs stem from the intricate planning requirements, significant permit fees, expenses associated with escort services, elevated fuel consumption due to vehicle size and speed limitations, and extended transit times resulting from regulatory complexities and operational constraints.

Limited real-time information: A pervasive challenge is the lack of comprehensive, real-time data concerning infrastructure conditions, unforeseen temporary road closures, or unexpected obstacles across multiple national jurisdictions. This information deficit impedes dynamic route adjustments and proactive risk management[21].

Oversized Transport in Greece, Romania, Germany and Poland – Comparative Study

Oversized transport is carried out differently depending on the legislative, infrastructural and administrative particularities of each Member State of the European Union. In the following, we analyze the situation in four representative countries: Greece, Romania, Germany and Poland, highlighting the common challenges and innovative solutions adopted in the context of the digital transition and the use of artificial intelligence (AI).

[19]IRU (International Road Transport Union). *Challenges of Abnormal Loads Transport in Europe*.
[20]Petru & Krivda, 2021, 13, 5524.
[21]Ramūnas & Artūras (2012) No 1: 51–56.

I. Greece – Difficult Topography and Slow Digitalization

Greece, characterized by a predominantly mountainous topography and a road network composed largely of narrow national roads, faces major difficulties with regard to oversized transport. The road infrastructure is not always adapted to such transport, and the island networks further complicate logistics.

The challenges for this activity are multiple: lack of corridors dedicated to special transport; insufficiently digitalized port infrastructure for handling large loads; lack of digital interoperability between regional agencies. Recent developments in this area are important for the development of this sector. The most significant are: the Hellenic Road Authority has launched a digital portal for the authorization of special transport, but the system is not yet integrated at national level; pilot projects in collaboration with the Technical University of Athens use artificial intelligence to simulate oversized routes in mountainous areas.

Oversize Transport in Greece – Status, Challenges and Prospects

Greece's unique geostrategic position in Southeast Europe, cantered around the Mediterranean hub of Piraeus, necessitates a robust framework for oversized transport to maintain connectivity between maritime routes and the Balkan interior. However, the legal and operational execution of these transports is significantly conditioned by the country's predominantly mountainous topography. The Pindus Mountain range and the Peloponnese region impose severe physical constraints on vehicle dimensions and axle weights, as sharp curvatures and steep gradients naturally limit the efficacy of standard oversized transport configurations. Consequently, the regulatory framework must account for these geographical idiosyncrasies, often resulting in strict, localized restrictions that deviate from broader European averages.

The transition of the Greek road network also presents a dual challenge for legal harmonization. While the motorway network is undergoing expansion, a substantial portion of special transport operations remains relegated to national and regional roads. This reliance on secondary infrastructure creates a complex administrative burden, as these routes often lack the structural load-bearing capacity of modern motorways, requiring individualized structural assessments for each transit permit. To mitigate these terrestrial limitations, the Greek logistics sector has developed a specialized reliance on multimodal maritime-to-road transport. This "roll-on/roll-off" model for heavy industrial and energy components represents a strategic adaptation to infrastructure deficits, though it requires complex legal coordination between maritime law and terrestrial transport regulations.

From an administrative law perspective, the authorization process in Greece remains characterized by high levels of bureaucracy. The issuance of Special Transport Authorizations (STAs) involves a multi-layered approval chain encompassing the Ministry of Infrastructure and Transport, local municipal authorities, and the Hellenic Police. This fragmented governance structure often results in processing durations exceeding seven days, creating significant delays in the international supply chain.

In an effort to modernize this administrative framework and align with EU digital objectives, Greece launched a digital pilot project in 2023 for the electronic issuance of permits. This initiative is particularly noteworthy for its integration of digital simulation components, which allow for the algorithmic verification of route compatibility with bridge thresholds and road geometry. While this represents a significant step toward the integration of Artificial Intelligence in Greek administrative law, the system's effectiveness currently remains limited by the lack of a fully unified national database, highlighting the ongoing need for deeper digital and legal integration within the Hellenic transport sector.

Major Challenges in Oversized Transport Operations

Beyond the technical complexity of the operations themselves, the success of oversized transport is conditioned by overcoming deep structural challenges that often generate inefficiencies in the logistics chain. A critical barrier is represented by insufficiently adapted infrastructure, characterized by a lack of dedicated corridors for special transport and the degradation of aging structural elements. This physical reality not only slows down movement but also imposes additional safety risks, forcing operators to seek costly alternative routes.

Added to these infrastructure deficiencies are natural and geographical limitations, which impose severe restrictions in mountainous or island areas. In such regions, simple road traction becomes insufficient, necessitating the design of complex multimodal logistical solutions, such as ferry transfers or the use of specialized lifting equipment to traverse rugged terrain.

Finally, efficiency is often undermined by limited institutional cooperation. The fragmentation of competences between local and central authorities creates a bureaucratic maze that considerably slows down planning and approval processes. The lack of fluid inter-institutional communication often turns the acquisition of permits into an unpredictable journey, highlighting the urgent need for a digitalization that unifies these decision-making levels within a coherent administrative framework.

Perspectives and innovations

Greece is trying to integrate artificial intelligence and digital solutions to optimize the route and shorten the approval time.

The use of Digital Twins is being explored to simulate the impact of oversized transport on infrastructure, preventing damage and increasing safety. This technology is closely linked to European initiatives to digitize transport corridors (TEN-T), where Greece is investing heavily to become a logistics gateway between Asia and Central Europe.

Highway and expressway network development projects also include investments in special infrastructure for oversized transport, especially near ports and industrial centers.

II. Romania

Romania occupies a key geostrategic position within the European and Eurasian transport corridors, being located at the crossroads of trade routes linking Central and Western Europe with the Balkans, Ukraine, the Black Sea and Central Asia.

Oversized transport is vital for development of the energy sector (wind, hydro, nuclear power plants), large infrastructure projects (bridges, refineries, factories), defense and heavy equipment industries. However, Romania faces multiple systemic deficiencies that hinder efficiency and competitiveness in this area.

Road Infrastructure and its Limitations

The Romanian transport landscape presents a series of systemic challenges that significantly impede the efficiency of oversized logistics. A primary concern is the fragmentation of the motorway network; although key sections such as the A1, A2, and A3 are functional, they lack the necessary connectivity to form a continuous corridor. This discontinuity forces heavy and oversized loads onto the national road network, which is often ill-equipped to handle the geometric and weight demands of such convoys.

The situation is further exacerbated by the prevalence of aging infrastructure, particularly regarding bridges and overpasses. Many structures within the national network are subject to strict tonnage and height restrictions, necessitating long and economically draining detours. These limitations are compounded by a chronic lack of specialized logistics corridors. Currently, dedicated routes for oversized transport are only established on an ad-hoc basis for strategic industrial projects—such as those involving the Cernavodă Nuclear Power Plant or major refineries—rather than being integrated into a permanent, high-capacity national strategy.

Furthermore, the absence of comprehensive bypass options frequently forces these massive convoys to transit through densely populated urban areas. This not only increases the risk of infrastructure damage and traffic accidents but also leads to substantial logistical delays.

On the regulatory front, while Romania has made strides toward digitalization through the SEAST platform (Electronic System for Issuing Special Transport Authorizations), the system remains hampered by significant procedural inefficiencies. Although functional, the authorization process is often characterized by a slow and fragmented workflow, typically requiring 5 to 10 days for approval. This delay is largely due to the necessity of obtaining separate clearances from a multitude of stakeholders, including local authorities, the traffic police, and various county road administrators.

A critical technical deficiency identified within this framework is the lack of automation and interoperability. The SEAST platform operates in relative isolation, lacking a direct link to centralized databases concerning real-time infrastructure status, traffic conditions, or bridge capacity evaluations. Consequently, the system cannot perform automatic route assessments, relying instead on manual verification. This technological gap is further widened by the absence of a real-time tracking system for both requests and active transports, preventing the dynamic management of the logistics chain.

Ultimately, the transition from this fragmented approach to a model of excellence, similar to the German VEMAGS system, will require not just the modernization of physical assets, but a fundamental integration of databases to ensure that the "digital permit" reflects the actual, real-time conditions of the Romanian road network.

Examples and Case Studies

The Romanian oversized transport sector is punctuated by high-complexity operations that highlight the tension between critical industrial needs and infrastructural deficits. A primary example is the transport of nuclear components for the Cernavodă Power Plant. From a legal and administrative perspective, these operations represent the pinnacle of risk management, requiring a bespoke regulatory approach. Historically, these transports relied on manual route planning and extensive physical escorts, necessitating temporary administrative derogations for emergency infrastructure repairs. The integration of AI in this context would offer a transition from reactive "ad-hoc" planning to predictive modelling, allowing for the simulation of structural stress on the Danube bridges and ensuring that the legal responsibility for public safety is backed by high-precision data rather than manual estimation.

The development of renewable energy infrastructure, specifically wind farms in the Dobrogea region, further illustrates the limitations of the current terrestrial framework. The transport of turbine blades exceeding 60 meters in length frequently encounters "legal-geographical" bottlenecks where narrow regional roads and unstable bridges cannot support the load within standard safety margins. In these instances, the regulatory burden increases as operators are forced to seek alternative multimodal solutions, such as combining river transport with road segments. This necessity for intermodal coordination underscores the urgent need for a unified European digital platform that can harmonize the disparate legal requirements of maritime and road authorities, reducing the administrative lag that currently hampers the Green Deal's infrastructure goals.

Furthermore, the expansion projects of Constanța Port reveal a systemic "connectivity gap" in the legal governance of logistics hubs. Despite the port's status as a vital EU maritime gateway, oversized transports have faced significant delays due to the absence of efficient, legally designated road corridors connecting the terminals to the national motorway network. This lack of dedicated "oversized corridors" creates a conflict between local administrative traffic regulations and national economic interests.

Addressing these challenges requires a shift toward "Smart Infrastructure" governance, where AI-driven data systems provide real-time updates on bridge integrity and road widths. By codifying these technological insights into the administrative law process for permits, Romania can move away from the current descriptive and manual model toward a more efficient, automated, and legally robust transport framework that aligns with EU standards for digital infrastructure.

Artificial Intelligence in oversized Transport – Potential and Initiatives

While the Romanian oversized transport sector remains in the nascent stages of Artificial Intelligence integration, the current landscape is characterized by strategic pilot initiatives that bridge the gap between private innovation and public administration. In the private sector, logistics technology firms such as Cargo Planning and Trans. EU Romania have begun deploying sophisticated algorithms designed for route optimization and clearance calculation. These systems leverage satellite imagery and GPS data to perform high-precision geometric assessments of the road network. From a legal standpoint, the adoption of such technologies by private operators poses critical questions regarding data liability and the evidentiary weight of algorithmic route validations when presented to national transport authorities for permit approval.

A significant milestone in the academic and industrial intersection of AI was reached in 2023 with the pilot project in the Pitești industrial cluster. Conducted in collaboration with the Politehnica University of Bucharest, this initiative utilized "Digital Twin" technology to simulate oversized transport operations for the Dacia automotive plant. This simulation model allowed for a virtual stress test of the physical infrastructure, providing a data-driven foundation for risk assessment that far exceeds the capabilities of traditional manual planning.

The broader integration of these technologies is further facilitated by Romanian participation in pan-European research frameworks, notably through the Horizon Europe program. These international collaborations focus on testing AI modules dedicated to transport time predictability and infrastructure risk analysis. The legal implications of these projects are profound, as they necessitate the development of interoperable data governance standards that comply with both the EU AI Act and General Data Protection Regulation (GDPR). By participating in these cross-border initiatives, the Romanian logistics sector is effectively contributing to a harmonized European "digital legal space," where the automation of transport risk analysis could eventually lead to the standardization of administrative procedures for Special Transport Authorizations across the Union.

Recommendations for Romania

To transition from a descriptive to an analytical framework of oversized transport governance, several key structural reforms are necessitated. First, the complete digitalization of the *SEAST* (Electronic System for Transport Authorizations) platform must be prioritized. From an administrative law perspective, this requires more than just a digital interface; it necessitates full algorithmic integration with the traffic police systems, the National Company for Road Infrastructure Administration (CNAIR) geospatial databases, and regional county road networks. Such integration would create a "single window" for administrative transparency, ensuring that the legal issuance of permits is based on real-time, cross-referenced infrastructure data, thereby minimizing the margin for human error and administrative litigation.

Secondly, the establishment of permanent "oversized logistics corridors" represents a critical shift in spatial planning and transport law. These corridors, proposed along the strategic axes of *Constanța – Bucharest – Pitești – Arad* and *Giurgiu – Bucharest – Ploiești – Brașov – Târgu Mureș*, would benefit from adapted infrastructure and digital signage systems. Legally, designating these routes as "Strategic Heavy-Load Corridors" would allow for standardized regulatory requirements and streamlined permitting, reducing the jurisdictional friction between national and local authorities. This approach aligns with the European objective of creating a Trans-European Transport Network (TEN-T) that is resilient to the unique demands of heavy industrial movement.

Furthermore, the advancement of the sector depends on structured partnerships between technical universities and transport authorities. These collaborations should focus on the development of AI-driven planning tools that incorporate machine learning for predictive risk analysis. By codifying academic innovation into public policy, the state can ensure that the legal framework for oversized transport is supported by robust technical simulations.

Finally, the financial sustainability of these initiatives must be anchored in the National Recovery and Resilience Plan (PNRR) and EU Cohesion Funds. Dedicated funding should be directed toward the modernization of critical infrastructure—including the reinforcement of bridges, the expansion of access ramps, and the redesign of roundabouts specifically for oversized configurations. This investment is not merely an engineering requirement but a legal necessity to ensure that the infrastructure can meet the safety standards mandated by European transport directives in the era of Artificial Intelligence.

III. Germany – European Leader in Digitalization and Regulation

Germany's standing as a benchmark for oversized transport management is rooted in a highly integrated socio-technical regulatory framework that harmonizes public safety with logistical necessity. This model is fundamentally governed by the interplay between the **Road** Traffic Order (StVO - Straßenverkehrs-Ordnung) and the Road Traffic Licensing Order (StVZO - Straßenverkehrs-Zulassungs-Ordnung), providing a predictable legal environment for international operators.

From a legal perspective, the process is triggered by § 29 Abs. 3 StVO, which mandates a special permit (*Erlaubnis*) for vehicles whose dimensions or mass exceed statutory limits. This is complemented by § 70 StVZO, which provides the legal basis for technical exemptions for specialized transport equipment, such as modular trailers. The digital manifestation of these laws is the VEMAGS[22] platform. Analytically, VEMAGS functions as a "Digital Single Window" that addresses the problem of fragmented local jurisdictions. By centralizing the permit process across more than 600 local authorities, the German state has effectively reduced administrative transaction costs. This centralization ensures procedural homogeneity, guaranteeing that safety standards are applied uniformly across all federal states (*Bundesländer*), contrasting sharply with Member States where procedures remain localized and unpredictable.

[22]Interoperable Europe. (2024). *Verfahrensmanagement für Großraum- und Schwertransporte (VEMAGS)*. VEMAGS. (2024). *Verfahren für die Erteilung von Ausnahmegenehmigungen: System Overview.*

A critical analytical differentiator is the integration of the SIB-Bauwerke database into the VEMAGS workflow. This transforms a simple administrative permit into a dynamic risk-assessment tool. By cross-referencing a 100-ton load against the real-time structural health of specific bridge assets, the system imposes "operational conditions" that are legally binding—such as crossing on the center road axis or total traffic exclusion. This precision clarifies legal liability parameters; if a route is "system-approved" under specific conditions, professional negligence is clearly defined by any deviation from these algorithmic requirements. Furthermore, Germany has professionalized its escort services through the RGST (Richtlinien für Großraum- und Schwertransporte) guidelines. Through the BF4 Intelligent Escort standard, private vehicles equipped with Variable Message Signs (VMS) are legally empowered to alter road signs and halt traffic. This represents a sophisticated delegation of sovereign authority, where the state maintains oversight through strict certification, while the private sector provides the operational flexibility required for complex maneuvers.

Case Study: Transporting a Wind Turbine Blade (80m+) in Lower Saxony

The transport of wind turbine blades exceeding 80 meters in Lower Saxony serves as a practical validation of this integrated framework. The operation begins with a "Digital-First" planning phase, where the route is digitally simulated against the SIB-Bauwerke database. If a bridge under rehabilitation presents tonnage restrictions, the VEMAGS system automatically rejects the request, forcing the identification of an alternative route before physical bottlenecks occur. This proactive risk mitigation is essential in a landscape where infrastructure maintenance is ongoing.

During the execution phase, the BF4 escort technology allows the convoy to navigate complex intersections without a police presence. The escort driver utilizes legal authority to stop traffic, using real-time data to ensure the flow of the mass, which is particularly critical on slopes where stopping would be hazardous for heavy loads. To overcome the physical limitations of historic rural infrastructure, transporters utilize Blade Lifter technology (e.g., Benteler, Kübler). By mounting components on hydraulic devices capable of vertical inclination up to 60∘, the operation avoids permanent modifications to the landscape. This synergy between legislative permission (BF4 authority) and engineering innovation (the Blade Lifter) demonstrates how a robust regulatory framework can compensate for the spatial limitations of built heritage while maintaining high safety standards.

IV. Poland – An Expanding Regional Logistics Hub

Poland has solidified its status as a critical geostrategic hub within the European logistics network, serving as the primary intersection for transport corridors linking Eastern Europe with Germany, the Baltic States, and Scandinavia. This positioning facilitates a high volume of oversized transport[23] operations, particularly those

[23]Macioszek (2019) 109-117.

involving heavy industrial components[24] and energy infrastructure. However, the sector faces significant administrative hurdles rooted in regional bureaucracy. Special transport permits are currently issued by disparate local and regional road authorities, resulting in a lack of procedural uniformity and fluctuating approval timelines. From a legal perspective, this decentralized model creates "regulatory fragmentation," where the lack of an integrated national database for infrastructure capacity hampers the efficient execution of cross-border transit.

In response to these challenges, Poland is undergoing a significant digital transformation aimed at becoming an "AI-ready" logistics leader in Central Europe. A cornerstone of this evolution is the *e-Koncesje* project, a digital permitting system launched for testing in 2024. Unlike traditional manual systems, this platform utilizes Artificial Intelligence to automate route eligibility checks against vehicle dimensions. This shift from discretionary administrative approval to algorithmic validation represents a pivotal moment in Polish administrative law, necessitating new frameworks for data accuracy and the legal accountability of automated systems. Furthermore, the collaboration between the Warsaw University of Technology and national authorities is advancing risk simulation models through "Digital Twin" technology and satellite data, providing a scientific basis for infrastructure management.

The technical sophistication of Poland's infrastructure is further demonstrated by the deployment of LiDAR (Light Detection and Ranging) scanning. By utilizing vehicles equipped with laser scanners to create millimetre-precise Digital Twins of transport routes, authorities can detect minute physical obstacles, such as sagging cables or curb alignments, before the transit of high-value cargo like tunnel boring machines. This is complemented by the National Traffic Management System (KSZRT), which integrates data from thousands of weather and traffic sensors. For oversized transport, the legal significance of KSZRT lies in its ability to provide real-time, safety-critical data—such as crosswind forecasts on viaducts—which can be used to legally justify temporary route closures or speed adjustments for vulnerable loads, such as wind turbine blades.

Finally, Poland's implementation of one of Europe's densest networks of Weigh-in-Motion (WIM) sensors represents a significant advancement in automated legal enforcement. These sensors, embedded in the road surface, automatically verify compliance with digitally approved axle loads without requiring physical stops. While this increases operational efficiency, it also introduces complex questions regarding the "automaticity" of fines and the administrative rights of transport operators to contest sensor-derived data. Despite these innovations, the persistence of digital fragmentation between regional administrations remains a barrier to a truly uniform AI-driven governance model, highlighting the need for a centralized legal framework that harmonizes regional data with national strategic objectives.

[24]Sławomir (2022) 136-152.

Case Study: Transport of the TBM Karpatka (Babica, Poland)

This was one of the most complex transports in the history of Poland, involving parts weighing over 500 tons and a width of 9 meters.

The transport planning was carried out using the “Digital Twin”. Unlike classic methods, the Poles (through GDDKiA - National Road Administration) created a complete virtual model of the 800 km route (from the port of Szczecin to Babica). Inspection vehicles scanned every bridge, viaduct and traffic sign using the 3D LiDAR system. The data was fed into simulation software that “ran” the virtual convoy to identify points where the ground clearance was too low or the curves were too tight. Real-time analysis of the bridges was carried out, and temporary load sensors were installed for old bridges. Data from these sensors was monitored as the convoy crossed, to ensure that the deformation of the structure remained within the calculated elastic limits.

For the heaviest segments, not classic trucks were used, but self-propelled modular platforms - SPMT Technology (Self-Propelled Modular Transporters). These platforms (over 80 axles) are controlled by a single operator with a remote control. On-board software automatically calculates the hydraulic pressure in each wheel to keep the load perfectly horizontal, even on sloping roads. This technology allowed the convoy to pass through small roundabouts without dismantling the entire road infrastructure, by rotating the modules at angles impossible for a truck with a trailer - 360° pivoting.

To carry out these transports safely, Poland uses KSZRT (Krajowy System Zarządzania Ruchem Drogowym), a digital system that offers Dynamic Weight Monitoring (Sensors in the asphalt that confirm that the axle weight of the convoy is distributed according to authorization) and VMS (Variable Message Signs) - the panels on the highways were automatically programmed to warn other drivers and close the necessary lanes as the convoy's GPS reached certain checkpoints.

Comparative Conclusions Country Degree of Digitalization and Infrastructure for Oversize Transport (2025)

Country	Digitalization Level	Adapted Infrastructure	Authorization Time	AI & Digital Twins Use
Greece	**Low / Developing**	**Medium** – Limited in mountainous areas and islands.	**High** (≥ 7 days)	**Pilot:** Route simulation and sensor-based monitoring for old bridges.
Romania	**Developing**	**Deficit** in key areas; new corridors (A1, A7) are being adapted.	**High** (≥ 10 days)	**Pilot:** GPS-based planning and flyover technologies for critical bridges.
Germany	**Advanced**	**Expanded & Modernized** with	**Low** (1–2 days)	**Active:** Real-time route optimization

Country	Digitalization Level	Adapted Infrastructure	Authorization Time	AI & Digital Twins Use
		detailed tonnage databases.		and Digital Twins for structures.
Poland	**Rapidly Progressing**	**Accelerated Expansion** of highway networks and logistics hubs.	**Medium** (3–6 days)	**Active:** AI-driven planning and integrated e-authorization systems.

The future of oversized transport within the European Union is now as dependent on high-fidelity digital mapping as it is on physical road infrastructure. Current national analyses reveal a stark technological and administrative "digital divide" between Member States, categorized primarily by their level of AI integration and regulatory modernization. On one hand, Digital Leaders like Germany and Poland have successfully embedded advanced tools into their logistics chains; Germany's use of Digital Twins (VEMAGS) to simulate structural stress on bridges allows for rapid, data-backed permit approvals, while Poland has mitigated regulatory lag through e-authorization frameworks and technical solutions like LiDAR and Weigh-in-Motion (WIM) sensors.

Conversely, Transitioning States such as Greece and Romania are navigating a more complex path toward digital integration. Despite receiving substantial Union funding, these nations remain in the nascent stages of digitalizing their administrative processes. While Greece prioritizes 3D route simulations to mitigate the risks of its difficult topography and Romania shifts toward digital data planning for national projects, the efficacy of these innovations is frequently undermined by persistent administrative bottlenecks and a lack of interoperability between state agencies. From a legal perspective, the absence of a unified, cross-border digital database detailing bridge capacities and road dimensions represents a significant barrier to the "Single European Transport Area," forcing countries like Greece and Romania to incur higher logistics costs and delays than their Northern counterparts.

Ultimately, the mere modernization of physical roads is insufficient for true regulatory harmonization. To achieve operational efficiency, the Union must transition toward a standardized digital infrastructure where AI-driven data is legally recognized as the primary basis for safety assessments and permit issuance across all Member States. This shift is essential not only to lower costs but to ensure that the transport of critical industrial components—vital for the European Green Deal—can proceed without the current burden of fragmented national bureaucracies. Achieving this requires urgent EU-level legislative action to ensure seamless data interoperability between disparate systems, bridging the gap between the administrative centralization of the German model and the technological digitalization favoured by Poland.

The Role of Artificial Intelligence in transforming oversized Transport in the EU

Artificial Intelligence presents a suite of innovative solutions capable of addressing many of the entrenched challenges within the oversized transport sector. By leveraging AI, significant advancements in optimization, predictability, and safety can be achieved.

The integration of Artificial Intelligence within the logistical planning of oversized transport represents a paradigm shift from static route assessment to dynamic, data-driven optimization. Central to this transformation are intelligent routing algorithms capable of synthesizing vast datasets, ranging from Geographic Information Systems (GIS) and real-time traffic conditions to granular infrastructure constraints such as temporary bridge load-bearing limits. By processing these multifaceted variables, AI-powered systems identify optimal trajectories that simultaneously maximize fuel efficiency[25] and ensure rigorous compliance with national safety regulations. Such strategic routing is not merely an operational convenience but a critical technological intervention necessary to mitigate the inherent conflicts between heavy-haul transport demands and urban sustainability objectives, particularly regarding the maintenance of optimized traffic flow[26].

Furthermore, the deployment of advanced AI-driven simulation models allows for the high-fidelity prediction of a convoy's impact on both the surrounding traffic ecosystem and the physical integrity of the road network. These predictive models empower regulatory authorities and operators to anticipate structural stresses or potential bottlenecks before the actual journey commences. By facilitating such proactive mitigation strategies, AI transitions the sector toward a 'digital-first' safety model, where potential hazards are identified and bypassed in a simulated environment, thereby reducing the risk of infrastructure damage and public disruption.

The integration of Artificial Intelligence into the authorization framework for oversized transport represents a significant shift from traditional discretionary administration to a model of algorithmic governance. One of the primary legal benefits of this transition is the implementation of automated compliance checks. In this context, AI systems serve as sophisticated regulatory monitors that can verify permit applications against a complex hierarchy of national and European Union regulations. By rapidly cross-referencing high-precision vehicle specifications with proposed routes and infrastructure constraints, these systems provide a level of speed and accuracy that manual review cannot achieve. Legally, this reduces the risk of administrative error and ensures that the principles of road safety and infrastructure protection are upheld through objective[27], data-driven validation.

Furthermore, the development of a harmonized, EU-level AI system offers a compelling solution to the legal friction inherent in cross-border permit facilitation. Currently, international oversized transports are burdened by the need to navigate

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[25]KPMG. *Driving change: How AI is transforming the transport industry*. (Accessed for AI applications in route optimization and logistics).

[26]Petru & Krivda, 2021, 13, 5524.

[27]European Parliament Think Tank (EPRS). *Artificial intelligence and transport: New challenges for EU law.* (Analyses legal and ethical challenges of AI in transport).

fragmented national legal systems, each with unique documentation requirements. An integrated AI framework would enable seamless data sharing and mutual recognition of validations between national authorities. Such an initiative aligns with the European Commission's broader digital strategy, potentially transforming the multi-country permitting process from a series of isolated bureaucratic hurdles into a streamlined, interoperable administrative procedure. This would not only reduce the administrative costs for operators but also reinforce the legal integrity of the Single European Transport Area.

Finally, the application of machine learning to historical administrative data introduces the concept of "predictive permitting." By analysing past processing times and the variables associated with successful or rejected applications, AI can generate highly accurate forecasts for future permit timelines. From a legal and operational standpoint, this predictive capability allows transport operators to schedule complex logistics with greater precision, mitigating the financial risks associated with administrative delays. This shift toward a proactive administrative model, as discussed in the European Parliament's analysis of AI and transport law, underscores the necessity of evolving the current legislative framework to accommodate the nuances of algorithmic decision-making and automated administrative acts.

The integration of Artificial Intelligence (AI) into the safety and monitoring frameworks of oversized vehicle transport represents a significant shift toward proactive hazard mitigation. Central to this evolution is the deployment of real-time obstacle detection powered by advanced computer vision. By synthesizing data from vehicle-mounted cameras and LiDAR sensors, these systems maintain a continuous assessment of the vehicle's spatial footprint relative to its immediate environment. This capability is particularly critical for navigating vertical and lateral constraints, such as overhead cables and bridge structures, where the system can provide instantaneous driver alerts or initiate autonomous corrective manoeuvres to prevent collisions.

Beyond immediate spatial awareness, AI facilitates a more sophisticated level of predictive risk assessment. By analysing historical telematics data in conjunction with real-time driver behaviour and fluctuating road conditions, AI algorithms can identify high-risk segments of a planned route. This shift from reactive to proactive monitoring allows for the anticipation of hazards before they manifest, thereby enhancing the overall safety margin of the transport operation. Such predictive intelligence is further augmented by the refinement of Advanced Driver-Assistance Systems (ADAS). When tailored specifically to the unique mass and momentum dynamics of oversized loads, AI-enhanced features—including adaptive cruise control and emergency braking—provide a stabilizing layer of support that accounts for the specific operational challenges inherent in heavy-haul logistics.

Furthermore, the scope of monitoring extends beyond the vehicle itself through the utilization of AI-equipped drone surveillance. These aerial assets provide a comprehensive view of the convoy's trajectory, offering a vantage point that ground-based escort vehicles cannot achieve. This real-time aerial intelligence is invaluable during complex manoeuvres or when traversing terrain with limited visibility[28], as it allows escort teams and traffic authorities to coordinate movements with a heightened degree of situational awareness. Collectively, these technological interventions transition the sector away from manual oversight toward a digitally integrated safety ecosystem.

The application of Artificial Intelligence extends significantly into the domains of predictive maintenance and operational efficiency, offering a data-driven approach to asset management in the heavy-haul sector. Central to this is the implementation of comprehensive vehicle health monitoring systems. By processing continuous data streams from embedded sensors—ranging from engine performance metrics to tire pressure and braking system integrity—AI algorithms can identify subtle mechanical deviations that precede hardware failure. This transition from reactive to predictive maintenance allows for the scheduling of interventions before a breakdown occurs, thereby mitigating the high costs associated with roadside repairs and significantly reducing vehicle downtime.

Complementing vehicle-centric monitoring is the role of AI in safeguarding infrastructure integrity. Through the analysis of data from sensors strategically positioned on critical assets such as bridges, viaducts, and road surfaces, AI systems can detect early indicators of structural stress, fatigue, or damage specifically induced by the passage of oversized and overweight loads. This provides a mechanism for dynamic infrastructure assessment, moving beyond periodic manual inspections toward a model of real-time health monitoring. Such a proactive approach not only facilitates timely repairs that extend the operational lifespan of civil engineering assets[29] but also serves as a critical safeguard against catastrophic structural failures caused by cumulative loading strain.

Furthermore, the integration of AI contributes to enhanced operational sustainability through the optimization of fuel consumption. Rather than relying on static driving protocols, AI systems can dynamically adjust vehicle operating parameters and provide real-time guidance on optimal driving behaviours. By synthesizing variables such as fluctuating load weights, specific topographical route characteristics, and evolving traffic conditions, these systems enable a more precise calibration of power delivery. The resulting improvements in fuel efficiency represent more than just a reduction in carbon emissions; they constitute a substantial optimization of the overall cost-to-benefit ratio in complex transport logistics.

Discussion of findings and General Arguments

The analysis reveals compelling arguments for the strategic integration of AI in the EU's oversized transport sector. The findings highlight that AI is not just a significant improvement, but a transformative technology capable of fundamentally reshaping operational paradigms and addressing long-standing systemic inefficiencies.

The digital transition in oversized transport is not just an algorithm race, but a profound transformation with a human face. While Germany and Poland are setting

[28]ENISA (European Union Agency for Cybersecurity). *Cybersecurity in the Transport Sector*. (Provides insights into cybersecurity risks in connected transport infrastructures).

[29]Petru & Krivda, (2021), 13, 5524.

new efficiency standards through AI, long-term success depends on our ability to retrain the workforce and use these tools to achieve the EU's climate goals. Digitalization is transforming the steel giant of oversized transport into an agile and sustainable player in tomorrow's green economy.

So, AI must be used under human supervision, transforming the driver and logistics operator from simple executors into supervisors of intelligent systems. This symbiosis ensures not only economic efficiency, but also the necessary safety and responsibility on European public roads.

The most significant argument for AI integration lies in its potential to drastically improve safety. By moving beyond reactive measures, AI's predictive capabilities for route hazards, infrastructure stress, and driver fatigue can prevent accidents before they occur. The ability to conduct real-time obstacle detection and provide advanced driver assistance, as highlighted up, offers a new layer of protection that manual processes cannot match. This aligns with the broader goals of intelligent transport systems to create safer road environments[30].

The current fragmented permit acquisition process and complex route planning are major cost drivers. AI's capacity to automate compliance checks, facilitate cross-border permitting, and optimize routes directly translates into substantial cost reductions and improved operational efficiency. These efficiencies can enhance the competitiveness of EU transport operators, allowing them to offer more reliable and cost-effective services, thereby strengthening the single market. This also supports the economic dimension of sustainable development by fostering innovation and growth[31].

Oversized transports, due to their size and weight, have a considerable environmental footprint. AI-driven fuel optimization and intelligent routing can significantly reduce fuel consumption and associated emissions. By minimizing detours and optimizing speed profiles, AI contributes directly to the EU's Green Deal objectives and various Sustainable Development Goals, particularly SDG 13 (Climate Action) and SDG 11 (Sustainable Cities and Communities)[32]. This directly supports urban sustainability goals, such as reduced emissions[33].

While AI offers solutions, it also exposes critical gaps in the existing regulatory framework. The fundamental challenge of liability for AI-driven decisions, data governance, and ethical considerations is amplified in the context of cross-border oversized transport. The "regulatory lag" – the slower pace of legislative adaptation compared to technological evolution – demands urgent attention. A key argument is that without a harmonized and agile legal framework, the full potential of AI cannot be realized, and its deployment might even be hindered or lead to unintended consequences[34].

The effectiveness of AI systems hinges on high-quality, standardized, and interoperable data from diverse sources. The current lack of seamless data exchange

[30]European Parliament Think Tank (EPRS). *Artificial intelligence and transport: New challenges for EU law*. (Analyses legal and ethical challenges of AI in transport).
[31]World Economic Forum. *The Future of Mobility*. (Includes sections on innovation, emerging technologies, and sustainability in transport).
[32]World Economic Forum. *The Future of Mobility*.
[33]Petru & Krivda, (2021), 13, 5524.
[34]ENISA (European Union Agency for Cybersecurity). *Cybersecurity in the Transport Sector*. (Provides insights into cybersecurity risks in connected transport infrastructures).

across national systems within the EU poses a significant barrier. This underscores the need for substantial investment in digital infrastructure and the development of common data standards to enable the full benefits of AI, as emphasized by Digital Transport and Logistics Forum[35].

The integration of AI will undoubtedly impact the workforce, particularly drivers and administrative personnel. Addressing concerns about job displacement through proactive reskilling and upskilling initiatives is crucial for social acceptance and a just transition. Furthermore, ensuring public trust in AI systems, especially in safety-critical operations, requires transparency and robust ethical guidelines.

In essence, the findings suggest that AI holds immense promise for revolutionizing oversized transport in the EU by addressing its core challenges of safety, efficiency, and environmental impact. However, realizing this potential is contingent upon a concerted effort to overcome significant regulatory, infrastructural, and socio-economic hurdles through strategic investment, harmonized policy-making, and collaborative governance. The necessity of integrated urban planning[36] and policy frameworks that balance economic development needs with environmental protection and infrastructure resilience is paramount, advocating for smart, adaptive solutions to ensure the sustainable accommodation of oversized transport within future cities[37].

And, as I previously argued, this AI system must be constantly supervised and verified by the human factor.

Recommendations for EU Member States

The transition toward an AI-driven oversized transport sector requires a fundamental shift from fragmented national policies to a coordinated European strategy. Central to this evolution is the development of a Harmonized EU AI-in-Transport Framework. Legislative bodies must prioritize the creation of clear, flexible, and future-proof regulations that transcend current directives. This framework should specifically address the complex legal triad of liability in autonomous operations, robust data governance protocols, and stringent cybersecurity standards. By establishing these legal guardrails at the Union level, Member States can ensure that the deployment of AI in logistics does not create new legal uncertainties regarding administrative responsibility or cross-border enforcement.

Simultaneously, the legal objectives must be supported by a commitment to invest in digital infrastructure. The modernization of the Trans-European Transport Network (TEN-T) should prioritize the deployment of 5G networks and smart sensor technologies. These physical assets serve as the "digital nervous system" required for real-time monitoring of oversized loads. Legally, the integration of these technologies allows for the creation of "smart contracts" and automated compliance systems, where

[35] European Commission's Digital Transport and Logistics Forum (DTLF). Search for reports and best practice guides on the digitalization of freight transport in the EU. (Relevant for EU-level digital initiatives in transport).

[36] Szczucka-Lasota (2017): 157-165.

[37] Petru & Krivda, (2021), 13, 5524.

infrastructure data is used to validate transport adherence to weight and dimension limits instantaneously. This investment must be coupled with the standardization of technical and data protocols, ensuring that IoT systems are interoperable across national borders. Such standardization is a prerequisite for the mutual recognition of digital permits and the seamless movement of critical industrial goods across the Single Market.

Furthermore, the successful integration of AI necessitates a model of cooperative governance through Public-Private Partnerships (PPPs). By fostering collaboration between state authorities, private logistics firms, and academic institutions, the EU can facilitate the co-creation of innovative solutions while equitably distributing the associated technological and legal risks. These partnerships should be the primary vehicle for pilot projects and iterative research, providing a real-world testing ground for AI applications in diverse geographical and regulatory environments. A crucial component of this collaborative ecosystem is the establishment of secure data-sharing mechanisms. To build trust between public and private entities, these mechanisms must be underpinned by transparent governance and stringent privacy protocols, ensuring that data regarding infrastructure integrity and traffic patterns is utilized responsibly and effectively.

Finally, the systemic transition to AI-driven logistics requires a significant investment in human capital and capacity building. As the administrative and operational paradigms shift, it is essential to implement comprehensive training programs for transport operators, administrative staff, and regulatory bodies. Developing digital literacy and a deep understanding of AI's legal implications will ensure that human supervisors remain capable of exercising meaningful oversight over automated systems. By proactively addressing these multi-dimensional recommendations, EU Member States can collectively harness the power of Artificial Intelligence to transform oversized transport into a safer, more efficient, and sustainable pillar of the European economy, reinforcing the Union's leadership in the global era of intelligent mobility.

Conclusions

This research demonstrates that the integration of Artificial Intelligence in the oversized transport sector in the European Union represents a turning point, marking the transition from reactive to predictive and highly efficient logistics. The comparative analysis of the models implemented in Germany and Poland highlights that the success of digitalization does not depend exclusively on the sophistication of algorithms, but on the ability of states to create an interoperable ecosystem between physical infrastructure and data flows.

From an operational point of view, case studies have revealed that tools such as the VEMAGS system (Germany) and the use of Digital Twins using LiDAR technology (Poland) have managed to solve long-standing systemic inefficiencies. These technologies have significantly reduced permit processing times and eliminated the risks of collisions with infrastructure, providing a predictability that was previously impossible to achieve. At the same time, digitalization has been shown to be an essential driver for achieving the sustainability goals of the European

Green Deal. By mathematically optimizing routes and reducing congestion, AI directly contributes to reducing the carbon footprint of heavy transport, transforming a traditionally polluting sector into an active participant in the green economy.

However, a fundamental conclusion of this study is that Artificial Intelligence must remain a tool under strict human supervision. The ethical and social dimension of this transition underlines the need for a human-machine partnership, in which technology provides the precision of data processing, and the human operator provides contextual judgment and moral responsibility. This "human supervision" is critical in managing exceptional situations on the ground, where intuition and experience cannot yet be replicated by computer code.

Ultimately, the long-term success of oversize transport in the EU will be conditioned by two strategic directions: Investing in Human Capital, implementing robust reskilling programs that transform drivers and dispatchers into logistics systems engineers, thus ensuring a fair social transition and second, Harmonization of Regulations, reducing the legislative gap between Member States to enable a single European digital corridor, were infrastructure data flows as freely as goods.

By adopting these measures, the European Union can transform oversized transport from a logistical challenge into a global competitive advantage, demonstrating that technological innovation, when guided by ethical principles and environmental objectives, can generate a sustainable positive impact on society as a whole.

References

Bahram, A., Haibo, W., & Lutfu, S. (2023). The last-mile delivery of heavy, bulky, oversized products: Literature review and research agenda. *Logistics*, 7(4), 98.

Bădescu, M., & Purcar, C. M. (2017). Considerations on oversized transportation in the UE (Community). *MATEC Web of Conferences*, 121, 06001.

Deloitte. (2023). *AI in government: The future of public service*. [Online]. Available at: https://www2.deloitte.com/us/en/insights/focus/cognitive-technologies/ai-in-government-future-public-service.html

ENISA (European Union Agency for Cybersecurity). (2023). *Cybersecurity in the transport sector*. [Online]. Available at: https://www.enisa.europa.eu/ publications/cybersecurity-in-the-transport-sector

European Commission. (2020). *Road transport: Weights and dimensions*. [Online]. Available at: https://transport.ec.europa.eu/transport-themes/road-transport/weights-and-dimensions_en

European Commission. (2023). *Digitalisation of transport and logistics*. [Online]. Available at: https://transport.ec.europa.eu/transport-themes/digitalisation-transport-and-logistics_en

European Commission. (2024). *Digitalisation of mobility*. [Online]. Available at: https://digital-strategy.ec.europa.eu/en/policies/digitalisation-mobility

European Parliament (EPRS). (2020). *Artificial intelligence and transport: New challenges for EU law*. [Online]. Available at: https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2020)642838

GDDKiA (General Directorate for National Roads and Motorways). (2023). *Traffic management systems on the national road network*. Warsaw: GDDKiA Publications.

Government of Romania. (2022). *National strategy on intelligent transport systems for the period 2022-2030*. Bucharest: Official Gazette of Romania, Part I, no. 894.

IRU (International Road Transport Union). (2023). *Challenges of abnormal loads transport in Europe*. [Online]. Available at: https://www.iru.org/

KPMG. (2023). *Driving change: How AI is transforming the transport industry*. [Online]. Available at: https://kpmg.com/xx/en/home/insights/2023/10/driving-change-how-ai-is-transforming-the-transport-industry.html

Macioszek, E. (2019). Conditions of oversize cargo transport. *Scientific Journal of Silesian University of Technology. Series Transport*, 102, 109-117.

Masłowski, D., Dendera-Gruszka, M., Giera, J., Kulińska, E., Olejnik, K., & Szumidłowska, J. (2024). Risks and challenges of oversized transport in the energy industry. *Energies*, 17(24), 6444.

Petru, J., & Krivda, V. (2020). *The usage of UAV in the transport of oversized cargoes*. Ostrava: GIS Ostrava.

Petru, J., & Krivda, V. (2021). The transport of oversized cargoes from the perspective of sustainable transport infrastructure in cities. *Sustainability*, 13(10), 5524.

Ramūnas, P., & Artūras, P. (2012). Heavyweight and oversized cargo transportation, risk management. *Transport and Telecommunication*, 13(1), 51–56.

Rong, R., Ma, S., Ren, N., Lin, Q. & Jia, N. (2025). Generative artificial intelligence in intelligent transportation systems: A systematic review of applications. *Frontiers of Engineering Management*, 12(4), 1020–1036.

Sławomir, J. (2023). Comprehensive analysis of oversized cargo transportation market in Poland (2001-2022): Trends, regulations, and industry dynamics. *Journal of Sustainable Development of Transport and Logistics*, 8(2), 136-152.

Szczucka-Lasota, B. (2017). City logistics: Influence of oversized road transport on urban development. *Scientific Journal of Silesian University of Technology. Series Transport*, 97, 157-165.

UNECE (United Nations Economic Commission for Europe). (2023). *Automated driving and cybersecurity in road transport*. [Online]. Available at: https://unece.org/transport/publications

World Economic Forum. (2023). *The future of mobility*. [Online]. Available at: https://www.weforum.org/reports/the-future-of-mobility/

Interoperable Europe. (2024). Verfahrensmanagement für Großraum- und Schwertransporte (VEMAGS). [Online]. Available at: https://interoperable-europe.ec.europa.eu/collection/egovernment/document/verfahrensmanagement-fa-14r-groayraum-und-schwertransporte-vemags

VEMAGS. (2024). Verfahren für die Erteilung von Ausnahmegenehmigungen: System Overview. [Online]. Available at: http://www.vemags.de/