

Krzysztof Rabiej
Independent scholar
e-mail: kr.rabiej@gmail.com

Damian Kociemba  <https://orcid.org/0000-0002-6604-858X>
Independent scholar
e-mail: kociemba.damian.kd@gmail.com

Business process management as a tool for implementing ADR Agreement requirements in the road transport of dangerous goods

Zarządzanie procesami biznesowymi jako narzędzie do wdrażania wymagań umowy ADR w transporcie drogowym towarów niebezpiecznych

<https://doi.org/10.25312/ziwgib.834>

Abstract

This article explores the use of Business Process Management (BPM) as an effective tool for implementing the requirements of the ADR Agreement in the context of road transport of dangerous goods. The theoretical section outlines the essence of BPM, its life cycle, automation capabilities, and role in regulatory compliance. Based on this, the article analyses how BPM can support key ADR-related areas, including documentation management, training, operational compliance, and emergency response. Conclusions are drawn from a review of relevant literature and the author's practical experience as a certified ADR Safety Adviser. The paper demonstrates that integrating BPM with ADR requirements can significantly enhance safety, efficiency, and organizational resilience in the dangerous goods transport sector.

Keywords: ADR Agreement, Business Process Management, Safety Management

Streszczenie

Artykuł przedstawia możliwości zastosowania podejścia Business Process Management (BPM) jako skutecznego narzędzia wdrażania wymagań umowy ADR w kontekście drogowego transportu towarów niebezpiecznych. W części teoretycznej opisano istotę BPM, jego cykl życia, funkcje automatyzujące oraz rolę w zapewnianiu zgodności z regulacjami. Na tej podstawie przeprowadzono analizę potencjalnych zastosowań BPM do kluczowych obszarów ADR, takich jak zarządzanie dokumentacją, szkoleniami, zgodnością operacyjną oraz reagowaniem na sytuacje awaryjne. Wnioski sformułowano na podstawie przeglądu literatury oraz praktyki zawodowej autora w charakterze doradcy ADR. W artykule wskazano, że integracja BPM z wymogami umowy ADR może istotnie zwiększyć bezpieczeństwo, efektywność i odporność organizacyjną podmiotów działających w sektorze transportu towarów niebezpiecznych.

Słowa kluczowe: umowa ADR, Business Process Management, zarządzanie bezpieczeństwem

Introduction

Modern operational safety management in the road transport of dangerous goods requires not only compliance with increasingly complex regulations but also the implementation of contemporary organizational and technological approaches. One of the key legal instruments governing this domain is the Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), which precisely defines the responsibilities of transport participants, technical and procedural requirements, as well as emergency response principles. Due to its complexity, evolving nature, and the severe consequences of potential non-compliance, implementing ADR provisions presents a significant challenge for enterprises.

In this context, Business Process Management (BPM) gains particular relevance as a methodological approach to identifying, modelling, implementing, monitoring, and improving business processes. Although BPM originates from operational management practices, its potential to support regulatory compliance and risk management is increasingly recognized in highly regulated sectors such as ADR logistics.

The aim of this article is to explore the synergy between the BPM methodology and the requirements of the ADR Agreement, and to present the practical application of business process management as a tool supporting the implementation, maintenance, and continuous improvement of compliance with the regulations governing the carriage of dangerous goods. The analysis focuses on process modelling, activity automation, document management, and the integration of BPM with operational safety management systems.

Two primary research methods are employed in this article. The first is a literature review, with particular emphasis on publications concerning BPM, process

automation, and digital transformation. The second is a reflective analysis of the authors' own professional practice, based on experience in implementing and auditing ADR-compliant solutions within transport and manufacturing companies in Poland and the Netherlands. This approach combines a theoretical perspective with practical insights, enabling the identification of real-world opportunities and limitations of BPM in the regulatory context of ADR.

A comprehensive perspective on BPM

Business Process Management (BPM) is a contemporary management concept which posits that organizations achieve greater effectiveness when they deliberately and holistically manage the flow of their processes – from initial input to final outcome (Reijers, 2021). At the core of this idea lies the conviction that business processes – connecting people, systems, data, and physical resources – should be designed and executed coherently, encompassing the entire value chain. BPM not only improves coordination of activities, but also enhances an organization's adaptability, increases operational transparency, and eliminates redundant operations. This supports both the stability of day-to-day operations and flexibility in the face of environmental changes (Gonçalves, 2010: 67). In the literature, BPM is described as an approach that combines strategic and operational dimensions, aimed at systematically analysing, designing, implementing, and improving organizational processes (vom Brocke, Roswemann, 2014: 2). Alternatively, it may be understood as a methodological framework that integrates information technology with process knowledge, oriented toward a deep understanding and sustainable optimization of activities critical to enterprise performance (Gonçalves, 2010: 68).

The evolution of Business Process Management (BPM) reflects a shift from local improvements of individual processes to a holistic, integrated approach encompassing the entire organization. Contemporary BPM is not merely a set of optimization techniques but rather a collection of organizational capabilities, including strategic alignment of processes with company goals, effective governance, application of suitable methods and technologies, employee competencies, and a supportive organizational culture (vom Brocke, Roswemann, 2014: 2).

The origins of BPM lie in industrial engineering and research on organizational structures. However, it was the rise of services and the development of information technologies that highlighted processes as a key strategic resource of modern enterprises. As Hammer (2010) observed, the development of BPM is based on two main currents. The first is the continuous improvement approach – represented by TQM, Lean, and Kaizen – focused on eliminating waste and gradual improvement. The second is the radical approach of process reengineering, proposed by Hammer and Champy in 1993, which involves complete redesign of processes using new technologies to achieve breakthrough performance. Today's BPM combines these

two approaches, simultaneously striving for operational efficiency and strategic effectiveness based on modern technological frameworks (vom Brocke, Roswemann, 2014: 2–3).

At the core of BPM lies the concept of a process, understood as an ordered sequence of interrelated activities that transform specific inputs into expected outputs, creating value for both external and internal customers. This transformational logic applies not only within a single organization, organizing interdepartmental relationships, but also in inter-organizational contexts, such as supply chain management. The process perspective enables the integration of diverse organizational elements – from technology and people to structure and tasks – which forms the foundation for designing modern socio-technical systems (*Ibid.*, p. 4–5).

Contemporary business process management goes far beyond incidental improvements – today, BPM constitutes a permanent element of organizational strategy, essential for maintaining competitiveness and high operational efficiency in the long term. For a BPM system to deliver real benefits, an organization must develop and integrate six key capabilities: the ability to strategically align processes with company goals, efficient process governance, application of appropriate methods and tools, use of information technology, involvement of competent employees, and cultivation of a culture that supports the process-oriented approach (*Ibid.*, p. 5).

Despite the apparent obviousness of this approach, many companies still operate within rigid departmental structures – so-called silos – where each department maintains separate systems and improvement initiatives. Such a fragmented approach often leads to suboptimization of processes and disconnects activities from the actual needs of customers (Reijers, 2021). Meanwhile, studies consistently show that organizations adopting a process-oriented approach – that is, managing processes as a whole – achieve better business outcomes (*Ibid.*). The literature emphasizes that the effective implementation and development of BPM is based on the close cooperation of four pillars: human resources, organizational culture, contextual awareness, and technology, which are discussed in more detail in the following paragraphs.

Initially, employees in BPM were mainly treated as recipients of training, introduced to work according to newly defined procedures. The contemporary approach shifts this perspective, emphasizing their active involvement and the development of competencies that are key to process management. In addition to analytical and design skills, the ability to manage change and to act within BPM centres of excellence is also essential. A comprehensive competency model considers not only individual capabilities but also the organizational context in which they are applied (vom Brocke, Roswemann, 2014: 10).

A BPM-supportive culture is not merely a set of values – it is an environment that fosters the identification and improvement of processes in the spirit of customer orientation, operational excellence, accountability, and cross-departmental collaboration. According to the BPM Culture Model, organizations that consciously develop

such values achieve significantly greater effectiveness in implementing process management (*Ibid.*, p. 11).

Modern BPM must take into account the unpredictability and dynamism of the operating environment. This entails the need for flexibility and the adaptation of tools to the specifics of each situation. Rosemann and co-authors distinguish four types of context that influence the effectiveness of BPM: direct context (concerning the specific process), internal context (organizational conditions), external context (market, regulations), and environmental context (e.g., culture, geography) (*Ibid.*, pp. 11–12).

Technology in BPM supports all stages of the process life cycle – from modeling to monitoring and optimization. Key solutions include PAIS systems¹, workflow, BAM² and predictive data analytics. Contemporary organizations employ technologies such as in-memory computing (data processing in RAM to enhance speed), SaaS (Software as a Service – software delivered as an online service), decision support systems, and component-based architectures (devices built from easily replaceable modules) – not only to improve existing processes but also to radically transform them (*Ibid.*, p. 10).

Importantly, BPM continuously absorbs innovations – previously ERP systems, and today blockchain and Robotic Process Automation – opening new possibilities for automation and reengineering of operations (Reijers, 2021). One principle remains unchanged, however: technology should serve the process and business value – not the other way around. When implementing new solutions, organizations should be guided by real needs and thoroughly analyse the potential costs and benefits. True optimization begins where technology helps create value, not merely reproduce the status quo (Gonçalves, 2010: 70).

Effective business process management relies on the use of specialized tools that support the organization at every stage of the process life cycle – from design to optimization. Business Process Management Systems (BPMS) are one of the key

¹ Process-Aware Information System (PAIS) is an integrated IT system designed to manage and execute operational business processes that have been previously defined in the form of process models. PAIS supports activities involving people, applications, and various information sources, ensuring their coordinated execution in accordance with process logic. Typical examples of PAIS include workflow management systems, case-handling systems, and enterprise information systems (van der Aalst, 2009).

² Business Activity Monitoring (BAM) is an information technology that enables real-time monitoring of business processes executed within computer systems. Its primary objective is to provide operational and senior managers with up-to-date, synthesized information on the progress of key business activities, as well as to facilitate early detection of potential risks and deviations. BAM serves as a critical tool for real-time decision-making and is a significant competitive differentiator for enterprises. Given the increasing volume and complexity of collected data, advanced analytical tools play a crucial role in BAM, including constraint-based analysis and extended forms of first-order logic, which allow for the representation of complex dependencies in analytical processes (Ferro, Hoogendoorn, Jonker, 2008: 1).

technological tools. These are integrated platforms that enable the definition, execution, automation, monitoring, and improvement of processes. Although initially regarded as a breakthrough, many organizations encountered technical and organizational barriers that hindered their full implementation (Reijers, 2021).

As time passed, Business Process Management Systems (BPMS) evolved from tools designed solely for automating routine tasks into advanced platforms that support collaboration, flexibility, and adaptability in dynamic business environments (Bartlett, Kabir, Han, 2023: 116788). Contemporary BPMS must not only enable effective process modelling and execution but also allow for real-time adaptation to changing conditions (*Ibid.*, p. 116786). As the authors highlight, traditional approaches to BPMS design often fall short in today's reality, calling for integration with modern technologies and a new perspective on work design. A key challenge remains reconciling the rigidity of formal models with the dynamic and often unpredictable nature of human practices (*Ibid.*, p.116787).

Modern approaches assume that BPM systems should support not only automation but also tasks that require expertise, contextual awareness, and flexibility. To this end, the authors propose a four-part framework for BPMS design, encompassing process design, work environment design, system adaptability, and context integration – all aimed at better meeting the actual needs of users (*Ibid.*, pp. 116787,116789).

An important trend is the growing role of systems that support mobility and collaboration, enabling seamless task execution regardless of time and location. This requires flexible role and task modelling that goes beyond traditional, linear workflows (*Ibid.*, p. 116790).

At the heart of modern BPMS is the user. System design should take into account not only process efficiency but also the experiences and needs of employees (*Ibid.*, p. 116792). The authors also point to the increasing importance of intelligent BPM systems, which, through monitoring, analytics, and machine learning, can both diagnose and recommend process improvements in real time (*Ibid.*, p. 116795).

Process modelling plays a central role in both the theory and practice of BPM. Initially, it served as a tool for visualising and documenting organisational activities, aimed at improving understanding and identifying potential areas for improvement. Over time, this approach evolved to include advanced modelling techniques such as layered models, process landscapes, and risk-aware approaches (Reijers, 2021).

Process mapping, considered a starting point in an organisation's transformation towards BPM, enables the identification of key processes and their interrelations, as well as the costs associated with their execution. Visualisation – e.g. through flow-chart diagrams – facilitates time consumption analysis, bottleneck detection, and the elimination of non-value-adding activities (Gonçalves, 2010: 70–71).

It is important to distinguish between process modelling and process design. While modelling focuses on depicting the existing or intended flow of activities, design encompasses structural, technological, and organisational decisions such as tool

selection, role assignments, and checkpoint establishment. Design may be supported by heuristics, automation tools for partial design, and modular approaches that allow for flexible and reconfigurable structures (Reijers, 2021).

As modelling techniques advanced, the need for model management emerged. Organisations increasingly produce numerous models, creating the necessity to compare, refactor (i.e. improve structure without altering function), and maintain organised process repositories (*Ibid.*, p. 6). Model management has thus become a distinct field of BPM research and practice. One of the most innovative directions is process mining – the analysis of event logs recorded in IT systems to automatically discover the actual course of processes. This technique enables the validation of processes against reference models, identification of deviations, detection of bottlenecks, and support for optimisation decisions. It is particularly applicable in regulatory compliance and risk management contexts (*Ibid.*, p. 7).

It is important to emphasise that business processes do not exist independently of an organisation's operational principles – business rules and processes are inherently interconnected. Well-defined business rules should be independent of a specific process structure, while clearly delineating its operational boundaries. Four key types of business rules are distinguished: process routing, operational constraints, exception handling, and corporate business strategies. Effective management of these rules forms the foundation of BPM systems' flexibility and adaptability, requiring both alignment with organisational needs and anchoring in a stable technological infrastructure (Gonçalves, 2010: 69).

As organisations mature in their use of process management, BPM assumes a more strategic role, encompassing complex process interdependencies, integration, and optimisation within dynamic and distributed environments. At higher maturity levels, organisations move from managing individual processes to orchestrating them in a coordinated manner – an approach known as orchestration (Reijers, 2021). This ensures that diverse processes operate harmoniously to achieve overarching business goals.

Furthermore, in increasingly complex systemic and inter-organisational environments, interoperability becomes crucial – the ability of various processes and information systems to collaborate effectively and exchange data (*Ibid.*, pp. 5–6). This capability is fundamental to the efficient functioning of global supply chains and multi-system architectures.

Moreover, understanding a process is not limited to describing it as a mechanical sequence of actions. The literature identifies four complementary perspectives (Gonçalves, 2010: 68–69):

- the process as a deterministic machine – perceived as a precisely defined transformation of inputs into outputs;
- the process as a complex dynamic system – capable of adapting to disruptions and changes in the environment;

- the process as a feedback system – where the flow of information and control mechanisms play a central role;
- the process as a social construct – shaped by the values, beliefs, and interpretations of its participants.

To fully grasp the nature of a process, it is also essential to consider its three core aspects: its current state, its potential capabilities, and its design (i.e., how it is structured and organised). Regardless of the adopted perspective, BPM requires a shared language and semantic consistency among participants to ensure that process interpretations are coherent and unambiguous (*Ibid.*, p. 69).

It should be noted that process management can be effectively integrated with outsourcing, whereby external partners carry out specific operational tasks. BPM enables organisations to maintain control over the quality and efficiency of such activities through standardisation, monitoring, and enforcement of requirements. Instead of engaging in costly internal reengineering, companies can strategically “acquire” processes as services – benefiting from the unique capabilities of BPO providers, thus allowing them to focus on their core competencies (*Ibid.*, p. 72).

Implementing Business Process Management (BPM) is a complex undertaking that requires not only appropriate organisational preparation but also consistency and long-term commitment to continuous improvement. The motivations driving companies to embark on such a transformation are rarely purely technological; more often, they stem from economic and market conditions. Ongoing trade liberalisation, growing global competition, and constant pressure for innovation and shorter product life cycles are just a few of the factors pushing organisations toward BPM. Internal departmental needs and the overall maturity level of the organisation – such as prior experience with process mapping or optimisation initiatives – also play a significant role (*Ibid.*, p. 71).

Process management is no longer optional; it becomes a necessity – a tool that ensures competitiveness and long-term development capability. However, effective implementation requires overcoming resistance to change, strategic long-term planning, and consistent efforts to eliminate unnecessary activities, optimise key processes, and manage human resources more efficiently (*Ibid.*, pp. 68).

BPM is based on an iterative lifecycle, beginning with the identification and prioritisation of processes, followed by detailed modelling – both of the current (“as-is”) and future (“to-be”) states – and culminating in the implementation of designed solutions, performance monitoring, and continuous improvement based on data and feedback (*Ibid.*, pp. 72–73). In this context, “what-if” analyses prove extremely useful, allowing for the testing of alternative scenarios and the assessment of their potential consequences without the need for physical implementation, thereby significantly reducing the risks and costs of erroneous decisions. The entire implementation process requires interdisciplinary competences – including both technological and business knowledge – as well as carefully planned communication and training (*Ibid.*, p. 73).

The success of BPM depends on many factors, among which strong and sustained commitment from top management stands out as paramount. Equally important is the organisation's readiness for real change and the availability of modern IT infrastructure that supports process management. Also indispensable are effective change management, clearly defined and measurable performance indicators (KPIs), a strategic approach to organisation-wide process planning, the elimination of departmental silos, and the systematic development of employee competencies (*Ibid.*, p. 74).

BPM, however, does not end with implementation – it rather marks the beginning of a continuous journey towards sustained organisational improvement. Systematic real-time observation and analysis of processes allow for their ongoing adaptation to changing market and internal conditions (*Ibid.*, p. 74–75). Process-based management also helps meet regulatory compliance requirements, enhances operational transparency, and shortens the execution time of key operations. Through BPM, an organisation can evolve – or even undergo a radical transformation – from its current state to an optimised future state, ultimately becoming fully process-oriented (*Ibid.*, p. 2010: 72). In this context, understanding the shifting behaviours and expectations of customers becomes particularly important, as they are increasingly not only recipients of value but also initiators of it. In modern BPM frameworks, customers become both the starting point and final link in the value chain, directly influencing its structure and development directions (*Ibid.*, p. 72).

In conclusion, business process management goes far beyond the mere implementation of IT systems or the structuring of workflows. It is a comprehensive management concept that acts as a value co-creation mechanism, supporting strategic development, innovation, and strengthening organisational competitiveness in a volatile market environment. The strength of BPM lies in its capacity to integrate people, technology, and resources into a coherent structure that effectively and measurably achieves business goals (*Ibid.*, pp. 74–75).

The literature emphasises that modern BPM requires consideration not only of technological factors but also of the social and organisational conditions of work. In an era of constant environmental change, the success of BPM implementation depends on the system's flexibility, its capacity to contextualise actions, and its ability to learn and adapt to new conditions. Only such an integrated, reflective, and proactive approach enables organisations to effectively support employees, make informed operational decisions, and optimise processes in dynamic and often unpredictable environments (Bartlett, Kabir, Han, 2023: 116796).

Regulations on the transport of dangerous goods

The Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) is a fundamental legal instrument governing the road transport of substances and articles which, due to their properties, may pose a threat to people, property, or

the environment (ADR, 1.2.1). It was drawn up in Geneva on 30 September 1957 and has since been regularly updated (on a biennial basis) to align its provisions with technological and scientific advancements as well as evolving safety requirements. Poland ratified the ADR Agreement in 1975. The structure of ADR comprises two annexes, labelled A and B. Annex A contains provisions related to dangerous substances and articles, while Annex B sets out requirements concerning transport means and operations (ADR, pp. iii and vii).

According to ADR, dangerous goods are divided into nine classes based on the type (and dominant nature) of hazard they present. These include, among others: explosives (Class 1), gases (Class 2), flammable liquids (Class 3), flammable solids (Class 4.1), substances liable to spontaneous combustion (Class 4.2), substances which emit flammable gases upon contact with water (Class 4.3), oxidising substances (Class 5.1), organic peroxides (Class 5.2), toxic substances (Class 6.1), infectious substances (Class 6.2), radioactive material (Class 7), corrosive substances (Class 8), and miscellaneous dangerous substances and articles (Class 9) (ADR, respectively: 2.2.1, 2.2.2, 2.2.3, 2.2.41, 2.2.42, 2.2.43, 2.2.51, 2.2.52, 2.2.61, 2.2.7, 2.2.8 and 2.2.9).

The ADR Agreement clearly defines the responsibilities of both primary and additional participants involved in the transport of dangerous goods. Each party plays a key role in ensuring safety at various stages of the transport process. The primary participants include:

1. Consignor, responsible for correctly classifying the dangerous goods, selecting appropriate and certified packaging, preparing the required transport documentation (including the ADR consignment note), and properly marking the packages with warning labels and UN numbers (ADR, 1.4.2.1.1);
2. Carrier, who must ensure that the goods are authorized for transport under ADR, that the vehicle is properly equipped (e.g., with fire extinguishers and personal protective equipment), marked with orange plates and warning labels, and that the vehicle crew holds the required documents (including the ADR driver training certificate) and is adequately trained (ADR, 1.4.2.2.1);
3. Consignee, who is obliged not to delay acceptance of the goods without valid reason. After unloading, the consignee must verify compliance with relevant ADR provisions, including cleaning and decontamination of vehicles or containers when required (ADR, 1.4.2.3).

Additional participants include:

1. Loader, who must hand over dangerous goods to the carrier only if they are authorized for transport under ADR, verify the condition of the packages (including empty uncleaned ones), refrain from forwarding damaged or leaking packages, comply with specific regulations for loading and handling, ensure the container is properly marked after loading, and follow rules regarding segregation and separation from foodstuffs and feed (ADR, 1.4.3.1.1);

2. Packer, responsible for complying with packing requirements, including mixed packing rules, and for correctly marking and labelling packages prepared for transport (ADR, 1.4.3.2);
3. Filler, responsible for checking the technical condition of tanks and their equipment before filling, verifying valid inspection certificates, using only authorized substances, complying with compartment loading rules and maximum filling levels, ensuring tightness of the tank after filling, removing residues from the outer surface, and properly marking tanks, vehicles, and containers (ADR, 1.4.3.3);
4. Tank-container or portable tank operator, responsible for ensuring compliance of the tank with applicable design, testing, and marking requirements, and for maintaining the tank in accordance with ADR standards during regular use. If there is any suspicion of a safety breach - e.g., after repairs, technical modifications, or an accident – the operator must ensure that an exceptional inspection is carried out (ADR, 1.4.3.4);
5. Unloader, responsible for verifying the conformity of the goods with the transport document, checking the technical condition of packages and tanks before and during unloading, following cargo handling rules, and ensuring that after unloading all residues of dangerous materials are removed, valves and openings are closed, required cleaning is performed, and warning labels are removed in the case of full emptying and decontamination (ADR, 1.4.3.7.1–1.4.3.7.2).

Ensuring compliance with ADR regulations involves numerous challenges. One of the main challenges is the complexity of the system and the frequency of regulatory changes. The ADR framework is a comprehensive and detailed set of provisions which, as already mentioned, is updated every two years. This forces companies to continuously monitor amendments, interpret new requirements, and adapt their internal procedures and operational practices accordingly.

Another significant challenge in the transport of dangerous goods concerns documentation. Compliance with the ADR Agreement requires the preparation and ongoing management of numerous strictly defined documents, such as the ADR consignment note, written instructions for drivers, vehicle approval certificates, packaging compliance certificates, driver training certificates, and safety adviser certificates (commonly referred to as ADR advisers). Deficiencies or irregularities in this documentation are one of the most frequently found groups of infringements during roadside checks. As indicated in the report of the Polish Supreme Audit Office, in 2012–2017, as many as 35% of all violations detected by the Road Transport Inspection concerned this formal area (*Realizacja przez organy państwa i samorządu terytorialnego zadań w zakresie przewozu drogowego towarów niebezpiecznych*, 2018: 45).

Training and staff competence are also of critical importance. All employees involved in the dangerous goods transport chain – from warehouse workers and

freight forwarders to drivers – must possess appropriate knowledge and skills, confirmed through relevant training (including basic ADR courses, specialized training for transport in tanks, Class 1 explosives, and Class 7 radioactive materials, as well as on-the-job training) and certifications (ADR, 1.3, 8.2, and 8.5).

Risk management and emergency procedures represent another key area. Companies must identify potential hazards, develop and implement high consequence dangerous goods plans, ensure the availability of appropriate rescue and protective equipment, and regularly train personnel in crisis response protocols³ (ADR, 1.10.3.2).

Human error remains an omnipresent risk at every stage of dangerous goods transportation – from classification and packaging, to labelling, documentation, loading, transit, and unloading. Even a minor mistake can lead to devastating consequences, as tragically illustrated by the disaster in Nigeria's Rivers State in December 2024. A tanker transporting flammable fuel exploded after colliding with another vehicle, sparking an intense fire that killed at least ten people and severely burned over twenty others. The accident occurred in the densely populated Emohua district, along a major hazardous goods transport route from the ports to northern Nigeria. The explosion's force trapped many in vehicles and spread flames to nearby buildings and markets, causing further material damage. The rescue operation was hampered by panic and delayed emergency access (Boyd, 2025). This incident underscored the dire consequences of lacking effective technical and organizational safety mechanisms in hazardous goods transport. Although Nigeria has become a signatory of the ADR Agreement in recent years, UNECE data shows that, as of 2025, no competent authority has been designated to enforce and implement these regulations (Nigeria, 2025), significantly reducing regulatory and preventive effectiveness.

It is also crucial to recognize the costs and consequences of non-compliance. In Poland, ADR violations can incur steep financial penalties – ranging from PLN 300 for failing to equip vehicle crews with written instructions to PLN 10,000 for filling or transporting prohibited dangerous goods (Ustawa z dnia 19 sierpnia 2011 r. o przewozie towarów niebezpiecznych; Dz.U. z 2011 r. nr 227, poz. 1367 ze zm., Annex 1). Monetary fines are not the only possible outcome; in extreme cases, public authorities may initiate procedures that lead to revoking a transport licence under the so-called “good repute” protection mechanism described in Article 7d of the Polish Road Transport Act (Ustawa z dnia 6 września 2001 r. o transporcie drogowym; Dz.U. z 2001 r. nr 125, poz. 1371 ze zm., as amended).

Effective operations management – especially through the implementation of Business Process Management (BPM) principles – can significantly reduce in-

³ The High Consequence Dangerous Goods Security Plan was thoroughly analyzed in the publication titled Plan ochrony towarów niebezpiecznych dużego ryzyka, published in the journal “Zarządzanie Innowacyjne w Gospodarce i Biznesie”, authored by D. Kociemba (issue no. 40/2025).

cidents, lower operational costs (including those from fines, claims, or downtime), and improve service reliability. In the hazardous goods transport sector, both producers and recipients are highly sensitive to safety and reliability. A company that demonstrates advanced process management aligned with ADR, confirmed by low incident rates and positive audit outcomes, is seen as a trustworthy and preferred partner for long-term cooperation. Such a reputation translates directly into a competitive advantage, facilitating new contracts and strengthening existing business relationships. Furthermore, minimizing operational risk through transparent, stable, and well-supervised processes may also result in more favourable liability insurance terms, thus enhancing the company's overall profitability.

Synergy between BPM and ADR in operational safety management

A fundamental step toward ensuring compliance with ADR regulations and enhancing an organization's operational efficiency is not only to recognize and understand existing activities, but also to map them into a structured management system. In this context, Business Process Management (BPM) does not replace the regulatory framework established by the ADR Agreement but serves as a methodological and technological tool supporting its implementation. The ADR Agreement, as a comprehensive legal and technical document, contains precisely defined duties, procedures, and requirements concerning all stages of dangerous goods transport – from classification to emergency response. BPM, in turn, enables their effective representation within the organizational environment through systematic modeling, documentation, implementation, and monitoring of processes.

In practice, BPM supports the institutionalization of ADR-defined processes such as:

- classification of dangerous goods, verification of their physicochemical properties, and assignment of UN numbers;
- selection, inspection, and certification (or verification thereof) of packaging;
- preparation and verification of transport documentation – especially the ADR waybill, written instructions, and vehicle approval certificates;
- procedures for loading, arrangement, securing, and inspection of shipments, including adherence to loading prohibitions;
- periodic technical inspection of vehicles and verification of emergency equipment;
- development of emergency procedures and response plans for accidents, leaks, or fires;
- training management for drivers and other staff, including monitoring the validity of ADR certificates and documenting competencies.

To achieve this, specialized tools and notations such as BPMN (Business Process Model and Notation) can be used, enabling graphical representation of even the most complex workflows. These models can form the basis for the development of company-wide operational standards that reduce the risk of misinterpreting regulations and ensure consistent execution by all process participants – including outsourced partners.

Process modeling with BPM is not solely descriptive – it also serves diagnostic and design purposes. It enables step-by-step process analysis, identification of recurring inefficiencies, unclear accountability, or areas prone to regulatory non-compliance. Through such analysis, it becomes possible to highlight tasks that, due to their repetitive nature and potential for standardization, can be automated, thereby increasing operational efficiency and reducing the risk of human error. In this way, BPM becomes a key component of an organizational safety management system for the transport of dangerous goods – not as a replacement for ADR, but as a tool for its effective implementation and continuous improvement within enterprise structures.

The automation aspect, previously discussed in this article, is particularly enhanced by BPM systems and can cover multiple areas related to ADR compliance, reducing labor-intensiveness and error risks in fields such as:

1. Document Management – Document-centric BPM systems can revolutionize ADR documentation handling. In addition to automating the generation of standard documents (e.g., based on templates), they support electronic workflows for verification and approval, secure archiving, and strict version control (*The Evolving BPM Landscape*, 2022: 1–4). This is critical for transport documents, safety data sheets (SDS), packaging certificates, written driver instructions, or internal control protocols. Moreover, modern tools like PhotoFlow enable automation of photographic documentation collection and assignment, which is particularly valuable when recording cargo conditions, seals, or damage sustained during transport. This automation significantly reduces human error and responsibility ambiguities between stakeholders, while the digital workflows allow for near-synchronous introduction of improvements to prevent future incidents.
2. Workflows – Modern BPM platforms allow detailed definition of workflows that automatically direct tasks, documents, or alerts to the appropriate individuals or departments for verification, approval, or action. For instance, a transport document can be automatically sent to an ADR advisor for final review before printing. If a driver's certification is found to be expired, the system may block assignment of the transport task. Integrated business rule engines (BREs) further support automation by checking whether a given dangerous good may be transported with a specific vehicle type, whether all conditions for applying ADR exemptions are met, or whether the chosen packaging meets the relevant substance requirements.

3. Certification and Training Management – According to ADR, ensuring up-to-date and appropriate qualifications for all personnel involved in transporting dangerous goods is a core element of safety systems. BPM systems can significantly streamline this by automating training scheduling, monitoring individual certification statuses, sending reminders for upcoming renewals (sometimes biennially, depending on regulatory changes), and centrally storing training documentation in digital form. Training requirements differ by role – those responsible for packaging have different needs than drivers, loaders, valve operators, or administrative staff preparing documentation. Automated BPM systems can accommodate these differences systemically, tailoring training schedules and content to job specifications. This not only relieves HR and ADR consultants but also ensures uninterrupted staff competence and reduces the risk of unqualified personnel being unknowingly assigned to critical tasks.

BPM-driven automation in ADR-related activities yields benefits far beyond traditional efficiency improvements or human error reduction. Much of the work required to maintain ADR compliance – such as document verification, training schedule control, regulatory updates tracking, and technical requirement validation – is highly repetitive and based on well-defined rules. BPM enables identification of such areas and the implementation of solutions that facilitate their partial or full automation.

The result is not only an increase in the precision and speed of operations, but also a significant reduction in the time burden on highly qualified personnel – ADR advisors, logistics specialists, or transport managers. Resources thus freed can be effectively used for tasks of higher added value, which require expert competence, systemic thinking, and analytical abilities. These include, among others: comprehensive risk analyses for new categories of goods, designing and testing emergency scenarios, improving operational procedures, or initiating and implementing innovative technological solutions that enhance safety. Process automation within BPM thus not only supports regulatory compliance but also contributes to raising the overall level of safety and operational maturity of the organization.

As mentioned in the BPM section, “BPM is based on an iterative lifecycle that begins with the identification and prioritization of processes, then moves through their detailed modelling – both in the current state (‘as-is’) and the target state (‘to-be’) – and ends with the implementation of the designed solutions, monitoring their effectiveness, and continuous improvement based on data and feedback” (Gonçalves, 2010: 72–73). Continuous improvement, the essence of BPM methodology, is therefore based on the systematic monitoring and analysis of implemented processes – including those that are crucial in the context of ensuring compliance with the ADR Agreement. In practice, this means implementing a range of solutions that enable the identification of inefficiencies, measurement of results, and undertaking corrective actions. The most important of these may include:

1. Use of KPIs to monitor compliance and efficiency – these indicators may involve quantitative assessment of the quality of transport documentation,

the frequency of incidents, the efficiency of shipment preparation, the level of staff training, the timeliness of reporting, and the costs associated with violations. Their effectiveness depends on compliance with the SMART principle, assuming specificity, measurability, achievability, relevance, and a defined time horizon for evaluation (Ayoub, 2017: 2);

2. Continuous improvement of ADR processes supported by BPM – may be based on analysis of data from KPIs, audits, and feedback. This allows for the identification of areas requiring improvement and for decision-making in accordance with the Deming cycle (PDCA: Plan-Do-Check-Act) (*Plan, Do, Check, Act (PDCA)*, n.d.).
3. Generating audit trails and reporting – BPM systems can automatically record all actions, decisions, and changes in processes, creating detailed and undeniable audit trails; this data is invaluable during compliance checks, external audits, and incident analyses.

Integrating BPM with risk management in the transport of dangerous goods completes the picture of this approach as a system not only supporting regulatory compliance, but also actively managing operational safety. Thanks to structured process modelling, the ability to modify them in response to legislative changes, and the functions of monitoring, reporting, and data analysis – BPM enables dynamic and cyclical organizational improvement. Its application is particularly important in identifying and mitigating risks, reducing human error, and ensuring continuous adaptation to evolving ADR requirements. The result is a self-improving system in which process management and risk management complement each other, leading to increased organizational maturity, operational resilience, and a real increase in the level of safety in the transport of dangerous goods.

Conclusion

This article demonstrates that Business Process Management (BPM) is a fundamental methodology supporting the implementation and maintenance of compliance with the requirements of the ADR Agreement (Agreement concerning the International Carriage of Dangerous Goods by Road). The analysis, based on a literature review and practical reflection, confirms that ADR, as a body of standards and procedures, creates a legal and operational framework that can be effectively institutionalized within an enterprise using a process-oriented approach. BPM does not replace regulations but serves as a tool for their systematic implementation, monitoring, and continuous improvement.

The key synergies between BPM and ADR are evident in three main areas:

1. Process Automation: The implementation of BPM systems allows for the automation of routine tasks, such as document management, verification of employee qualifications, and monitoring the lifecycle of certificates. This leads

to a significant reduction in the risk of human error and an increase in operational precision and speed.

2. Modelling and Standardization: The use of notations like BPMN enables the transparent modelling of “as-is” processes and the design of optimized “to-be” processes. This translates into a better understanding of complex regulatory requirements by all participants in the transport chain.
3. Continuous Improvement and Risk Management: The integration of BPM with monitoring systems (e.g., BAM) and key performance indicators (KPIs) creates a mechanism for continuous measurement and evaluation of the effectiveness of operations. As a result, the organization can cyclically adapt its procedures to changing regulations and operational conditions based on data.

Consequently, the application of BPM in the context of ADR not only ensures formal compliance but also contributes to raising the enterprise’s operational maturity and organizational resilience. A company that treats ADR compliance as an integral part of its business processes builds a lasting competitive advantage, strengthens its reputation, and minimizes costs resulting from fines, claims, and incidents. In the long term, such integration is essential for maintaining safety, efficiency, and sustainable development in the dynamically regulated sector of dangerous goods transport.

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About the Authors

Krzysztof Rabiej – M.Sc. Eng., graduate of Wrocław University of Science and Technology in electronics and telecommunications, PhD candidate in the field of management and quality sciences. Since 2008 he has been involved in technological and integration projects, and currently serves as Project Manager and Chief of Staff in the Strategic Sourcing department at ASML. He has over a decade of experience in managing highly complex projects, including in international environments. He specializes in process architecture, team building, and the implementation of sourcing strategies that support organizational transformations.

Damian Kociemba – graduate of engineering studies in transport and master's studies in management. He is the co-author and author of several academic and specialist publications in the fields of logistics, safety, and optimization. He holds a safety advisor certificate for the transport of dangerous goods by road (ADR).

O autorach

Krzysztof Rabiej – magister inżynier, absolwent Politechniki Wrocławskiej na kierunku elektronika i telekomunikacja, doktorant w dyscyplinie nauk o zarządzaniu i jakości. Od 2008 roku związany z projektami technologicznymi i integracyjnymi, obecnie pełni funkcję kierownika projektu oraz szefa zespołu w dziale strategicznego zaopatrzenia w firmie ASML. Ma ponad dziesięcioletnie doświadczenie w prowadzeniu złożonych projektów, także w środowisku międzynarodowym. Specjalizuje się w architekturze procesów, budowaniu zespołów oraz wdrażaniu strategii zakupowych wspierających transformację organizacyjną.

Damian Kociemba – absolwent studiów inżynierskich na kierunku transport oraz magisterskich na kierunku zarządzanie. Współautor i autor kilkunastu publikacji naukowych i specjalistycznych z zakresu logistyki, bezpieczeństwa i optymalizacji. Posiada świadectwo doradcy ds. bezpieczeństwa przewozu towarów niebezpiecznych w transporcie drogowym (ADR).

