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Handbook on Automation and Digitalization in Intermodal Freight Transport and Logistics

Submitted by the Chair and the secretariat

I. Introduction

1. Multimodal transport, intermodal transport, and combined transport all refer to the movement of goods using two or more modes of transport. While multimodal transport could be understood as the simplest overarching term for transport of goods using two or more modes of transport, intermodal freight transport refers more specifically to the transport of goods in one and the same loading unit or road vehicle successively in two or more modes of transport, without handling the goods in changing modes.[1] Combined transport is a subset of intermodal transport, where the major part of the European journey is by rail, inland waterways, or sea, and any initial and/or final legs by road are as short as possible.[2]

2. Intermodal transport is recognized as one of the most sustainable and economically sound ways to carrying goods, particularly on distances over 500 km. Despite its benefits in lowering carbon emissions of transport, road transport continues to be the dominant mode of transport in many parts of the world. According to Eurostat, road transport accounted for 77.8 per cent of total inland freight transport in the European Union in 2022, while the share of railway and inland waterways only accounted for 17.1 and 5.1 per cent respectively.[3]

[1] Adapted from definition of intermodal transport according to ECE, Terminology on combined transport, New York and Geneva 2001.
[2] See EU Directive 92/106/EC for the definition of Combined Transport in the European Union.
[3] Eurostat, Modal split of inland freight transport, 15 April 2024.

3. The underutilization of intermodal freight transport could be attributed to several factors, one of which is often the longer delivery time due to handling procedures at intermodal terminals. By nature, intermodal freight transport's effectiveness relies heavily on the seamless coordination amongst various stakeholders and components, demanding efficient information flow throughout the journey. Traditional paper-based exchange of information and documents still prevails in many countries. Although a considerable amount of information and data necessary for intermodal freight transport is being digitized, it often remains localized within individual enterprises or at a national, modal, or regional level. The lack of application of interoperable standards in data poses a significant challenge to the industry, resulting in additional processing time at various intermodal terminals. Without the application of these interoperable standards, the efficiency of intermodal freight transport is substantially restricted and this has a potential of becoming a serious issue in the future.

4. Another bottleneck in intermodal transport, especially for cross-border traffic, is the lack of a harmonized or unified legislative system for rail carriers. Rail companies have long been at a competitive disadvantage due to the absence of a uniform legislative system, unlike their counterparts in road transport (subject to the Convention on the Contract for the International Carriage of Goods by Road), maritime transport (covered by the Hague-Visby Rules), and air transport (covered by the Montreal Convention). While the new Convention on the Contract for International Carriage of Goods by Rail of the Economic Commission for Europe (ECE) may address this shortcoming by enabling, for the first time, rail carriage (and certain intermodal carriage) on long distance and intercontinental routes under one legal system with one contract of carriage stipulated in one consignment note, the competitive advantage would come to rail and intermodal carriage from making the consignment note operational in a digital form.

5. With the rapid pace of technological advancement, opportunities also abound to streamline or automate many manual tasks within intermodal freight transport. Automated machinery has the potential to streamline operations and reducing reliance on manual processes, particularly for tasks that are unappealing due to their repetitive and/or physically demanding nature. For instance, automated coupling and decoupling of rail wagons could significantly reduce human efforts in the process.

A. Purpose of the handbook

6. This handbook seeks to provide a starting point for stakeholders wishing to digitalize and automate intermodal freight transport, including, but not limited to, national governments, transport operators, as well as cargo terminal operators. It covers the potential benefits of digitalization and automation if correctly managed, including enhanced efficiency and safety while reducing hardship and unappealing jobs, alongside with the associated costs of digitalization and strategies for maintaining a human-centric approach when applying these new technologies.

B. Overview of digitalization and automation in freight transport

7. Digitalization refers to the process of converting information or processes into a digital format, with a view to digitalizing and improving business processes. It involves the adoption of digital technologies to transform traditional analogue or manual information and processes into digital ones. It often requires businesses to rethink and reengineer existing business processes to reap the full benefits of digitalization. Automation on the other hand, involves the use of technology to perform tasks or processes with minimal human intervention. It aims to streamline operations, increase efficiency, reduce hardship and human error by replacing manual actions with automated ones.

8. Digitalization often goes hand in hand with automation and is often referred as the enabler and foundation framework for automation. It lays the foundation by transforming traditional paper-based processes into digital workflows, enabling communication and data exchange across diverse modes of transport. Automation relies heavily on the availability of digitalized information to perform various automated process, ranging from simple automated documentation to more advanced functions such as automated scheduling etc.

9. In addition to interoperability, cybersecurity is another main barrier for digitalization in freight transport. In a survey conducted by the International Union of Railways (UIC) in 2022,[4] cybersecurity was ranked with the highest consensus as the most important domain in intermodal transport by intermodal transport operators. Marketers could exploit private, sensitive digital information such as recipient data and order details, or maliciously disrupt train traffic. However, cybersecurity should be considered beyond the narrow confines of preventing cyberattacks. It should also include maintaining system stability and be capable of performing contingency plans to ensure business continuity and basic functionality in the event of a disruption.

C. Overview of the level of digitalization and automation in different countries and economies

10. While there is no readily available information on the level of digitalization and automation for each country in freight transport and logistics, the World Bank's Logistics Performance Index (LPI), or rather its specific components, can provide some insights and serve as a proxy for estimating the level of digitalization/automation. To recall, the LPI, published biennially by the World Bank, is a benchmarking tool designed to help countries identify challenges and opportunities in their trade logistics performance. It consists of six components: customs, infrastructure, international shipment, logistics competence and quality, timeliness, and tracking and tracing scores.

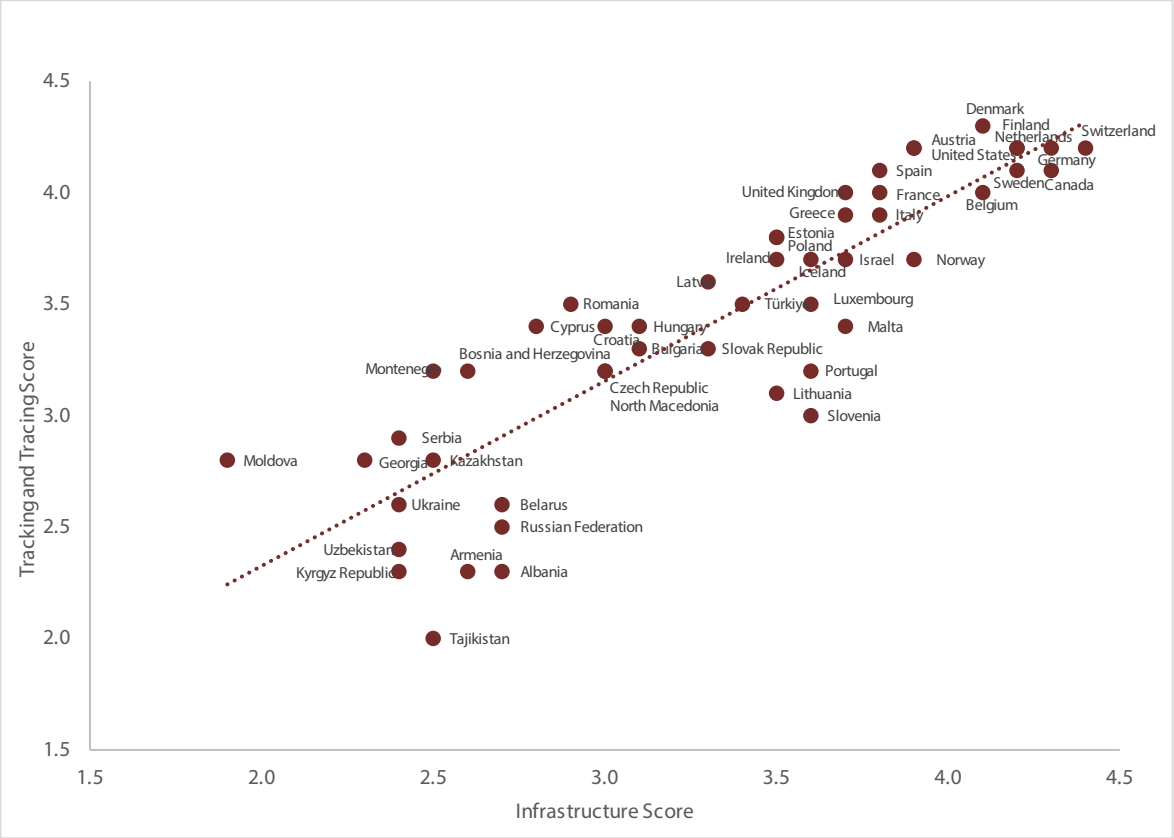
11. While digitalization and automation would affect scoring across all six components, infrastructure, specifically digital infrastructure, and tracking and tracking are of particular relevance. A robust logistics infrastructure often incorporates advanced technologies and automated systems.[5] Additionally, the ability to track and trace shipments in real-time is a direct result of digitalization and automation in logistics. This reflects the integration of Internet-of-Things, GPS and other digital technologies.

12. As shown in the figure below, there is a strong correlation between the infrastructure score and the tracking and tracing score in the LPI in 2023. Notably, countries which top the tracking and tracing score also tend to excel in the infrastructure score. For example, Singapore, which ranked first, and Switzerland, Germany and the Netherlands, which ranked joint third in the tracking and tracing component, were ranked first, second, third and fifth respectively in the infrastructure component.

[4] UIC, 2022 Report on Combined Transport in Europe, January 2023.

[5] The LPI survey does not specifically categorize the types of technologies in infrastructure scoring, but these technologies are indirectly reflected in the dwell times experienced by shippers in various countries. Shippers' expectations for modern infrastructure, including automated cargo handling and recording, could also be reasonably assumed to contribute to the overall assessment of infrastructure quality.

Correlation of LPI tracking & tracing score and infrastructure score in selected ECE member States



II. Marking a Business Case

A. Benefits of digitalization and automation

13. In an ever-evolving landscape of global trade and logistics, the integration of digitalization and automation has the potential to reshape the ways in which goods are transported across various modes of transport. Intermodal freight transport, which combines multiple modes such as rail, road, inland waterway etc., stands to benefit from these advancements. Digitalization and automation in intermodal freight operations, if correctly managed, can offer a multitude of advantages, starting with enhanced multimodal transport reliability, which will in turn lead to improved efficiency and cost-effectiveness. Other benefits involve improved safety and sustainability.

14. This section explores in detail the benefits of digitalization and automation within intermodal freight transport, highlighting their potential to improve operating efficiency, facilitating modal shift, reducing manual efforts, hardship, and unappealing jobs, and thereby improving global competitiveness in general. Details of the various technologies which may be used to achieve these benefits are discussed in section IV.

B. Improving operating efficiency

15. With the adoption of technologies like Internet of Things (IoT), Artificial Intelligence (AI), blockchain, software robots and digital twins, stakeholders in the logistics sector have the potential to streamline traditional practices and realize substantial improvements in time and cost savings. For instance, software robots using automation can significantly reduce manual efforts in processing and preparing information, including the completion of necessary digital documents for freight transport. These digital documents and information would allow the information to be retrieved and exchanged more efficiently. By deploying

IoT-enabled devices and sensors within cargo containers and transportation assets, one could further automate the verification of transport documents, enhance real-time tracking and monitoring capabilities, and enabling operators to more precisely manage routing, minimize idle time at terminals, mitigate potential disruptions, as well as assist advance ruling by regulatory authorities (e.g., customs). Furthermore, AI-driven predictive analytics algorithms could assist in forecasting demand through analysis of big data, optimizing resources allocation, and streamlining scheduling processes. These could all translate into savings in turnaround times and improving asset utilization, making intermodal freight transport more competitive even at shorter distance transport.

16. Additionally, blockchain technology may ensure transparent and secure data sharing, facilitating seamless collaboration among different stakeholders and minimizing administrative overhead. These innovative technologies, if managed correctly, could help intermodal freight operators to achieve efficiency gains, thus enhancing their competitiveness in the global market.

C. Facilitating modal shift

17. Digitalization and automation would also serve as catalysts for facilitating modal shift within the freight transport industry by lowering the costs of transport while improving the delivery time of consignments. By leveraging advanced technologies such as data analytics and optimization algorithms, stakeholders could identify opportunities for transitioning freight to rail, waterways, and other more sustainable transport modes. These technologies could also provide opportunity to implement real-time monitoring of freight movements, allowing for more dynamic routing and scheduling decisions, making intermodal freight transport more competitive. Moreover, digital platforms and standardized data exchange protocols could also improve and harmonize intermodal connectivity across different carriers, streamlining the transhipment process and reducing handling costs and transit times, all of which could encourage shift towards intermodal transport.

18. Another of the key potential benefits of digitalization and automation is the ease of reaching customers through digital platforms and marketplaces. By leveraging digital technologies, logistics providers can establish online platforms where customers can easily access and book intermodal services. These platforms could provide customers with greater visibility into available services, pricing options, and transit times, enabling them to make informed decisions and manage their logistics needs more efficiently.

D. Reducing manual efforts, hardship, and unappealing jobs

19. Digitalization and automation in intermodal freight transport could not only enhance operational efficiency but also reduce manual efforts, hardship, and minimize the reliance on unappealing jobs. Traditionally, freight logistics have been characterized by labour-intensive processes, requiring substantial manual intervention and often exposing workers to challenging and hazardous conditions. However, with the advent of automation technologies such as robotic handling systems and automated documentation processes, many routine and physically demanding tasks can be performed more efficiently and safely. Automation could reduce the need for manual labour in tasks like loading and unloading cargo, which not only minimizes the risk of workplace injuries but also improves overall productivity. Moreover, digitalization may also streamline administrative tasks, reducing the burden of paperwork and manual data entry for workers. By relieving personnel from repetitive and physically demanding tasks, digitalization and automation could enhance job satisfaction, promote safer working environments, and contribute to a more appealing and sustainable workforce in the intermodal freight industry. Furthermore, as mundane tasks are automated, workers may be upskilled to focus on more strategic tasks, fostering a more skilled and engaged workforce capable of driving innovation and growth in the sector.

E. Challenges of digitalization and automation

20. Despite the many benefits bring about by digitalization and automation, there are challenges that hinder their adoption, impacting the industry's efficiency, reliability, and security. Among these challenges are the lack of interoperable standards, the need to re-engineer established business processes, substantial initial setup costs, and growing concerns surrounding cybersecurity. Addressing these issues is crucial for realizing the full potential of technological advancements in intermodal logistics:

F. Interoperability standards

21. The lack of interoperability stands as a significant obstacle in the path toward fully integrating digital technologies across different modes of transport. Without standardized protocols and interfaces for data exchange, using a common semantic reference base, interoperability between various systems and platforms becomes difficult to achieve, leading to inefficiencies, data silos, and fragmented operations. The absence of interoperable standards not only impedes seamless communication and collaboration among stakeholders but also hampers the scalability and flexibility of digital solutions within the intermodal freight ecosystem. The fragmentation of legal regimes and digitalization projects; modal, corporate, national, and regional solutions; as well as syntaxes are a problem in the making.

22. Another related challenge to interoperability standards is establishing trust among the various stakeholders involved. In a highly interconnected supply chain, various actors are often reluctant to share sensitive data due to concerns about how it could be used or misused. To address this issue, a robust, trustworthy, open-source, open standard framework that provides clear guidelines on data ownership, usage, and security is crucial. Such a framework should ensure transparency and security in data exchange, helping to build confidence among stakeholders and facilitate greater collaboration.

Box I
The UN/CEFACT package of standards for multimodal data and document exchange

A UN/CEFACT package of standards for the digitalization of multimodal cargo information exchange offers a comprehensive suite of deliverables for seamless electronic multimodal data and document exchange. It includes a common business requirement specification (BRS) customized for documents accompanying goods carried by different modes of transport, as well as supporting deliverables. These are based on common UN/CEFACT naming rules and definitions, terminologies, and structured data models, crucial for data exchange standards across multimodal supply chains. These ensure seamless communication, interoperability, and efficiency, enhancing digitalization in trade and transport corridors and global trade operations. The package of standards is meant to address the main problem of fragmentation of digitalization efforts and projects, national, regional and modal legal regimes, and various syntaxes.

The digitalization of trade and transport data and document exchange relies on UN/CEFACT robust data standards, critical for initiatives in such areas as trade finance (e.g., electronic Bill of Lading (eBL)), Single Window systems, and European Union's Electronic Freight Transport Information Regulation (eFTI) and other regulations. Future efforts, such as ECE recommendations on smart connectivity, will leverage these standards to further advance global trade networks.

In summary, adopting UN/CEFACT data exchange standards enhances global trade efficiency, fosters international cooperation, and strengthens supply chain resilience and sustainability in an interconnected world.

Pilot projects for the implementation of the UN/CEFACT package of standards, building on the understanding of fragmented digitalization projects and solutions, along increasingly multimodal trade and transport corridors and cross-border supply chains, create a new problem. Experience shows that this problem cannot be addressed through the imposition of a multimodal trade and transport document to accompany goods in transit. Rather, the answer to the problem should focus on data mapping and applying interoperable standards between modes, documents and sectors in the supply chain in a world where information about cargo is increasingly exchanged in the form of datasets (electronic records) rather than traditional documents, be they paper or electronic.

Source: United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT). UN/CEFACT Package of Standards for data exchange along the supply chain, Document ECE/TRADE/C/CEFACT/2024/INF.2, Thirtieth session of the UN/CEFACT Plenary, 11 July 2024. Online: https://unece.org/sites/default/files/2024-07/ECE-TRADE-C-CEFACT-2024-INF-02E.pdf.

G. Initial setup costs

23. The upfront costs associated with implementing digitalization and automation initiatives may pose a substantial barrier for many companies in the freight transport industry. From investing in hardware and software infrastructure to training personnel and adapting workflows, the initial setup costs can be prohibitive, particularly for smaller players and companies operating on tight budgets. Despite the long-term benefits in terms of the potential efficiency gains and cost savings, navigating the financial challenges of digital transformation remains a daunting task. It may also be worth noting that the initial setup costs, particularly on the physical infrastructure which are often costly, may not make commercial sense and such investment should be made with due consideration to the potential return on investment. At the same time, it is worth noting that these costs may be relatively small if compared with investment that would be needed to overcome fragmented digitalization projects in the future.

24. In addition, the distribution of costs and benefits among different stakeholders should be considered. Balancing these factors across different players in the supply chain remains a significant challenge. In principle, costs borne by a market player should be proportionate to its potential gain from the investment. However, achieving this balance is often easier said than done. Due consideration on these should therefore be made from the outset of the project.

H. Cybersecurity

25. In addition to interoperability and setup costs, cybersecurity emerges as a pressing concern in an increasingly digitized and interconnected supply chain environment. As reliance on digital technologies grows, so does the risk of cyber threats such as data breaches, ransomware attacks, and supply chain disruptions. Safeguarding sensitive information, ensuring data integrity, and protecting critical infrastructure from cyber threats become paramount, requiring robust cybersecurity measures, proactive risk management strategies, and continuous vigilance across the intermodal freight ecosystem.

26. Furthermore, the risk of concentration of data should not be undermined. Data concentration under one single or a few entities could give rise to monopolistic practices, raising concerns that may deter efforts towards full interoperability. Addressing these challenges requires concerted efforts from industry stakeholders, policymakers, and technology providers to develop and implement comprehensive solutions and governance that prevent monopolistic practices, foster interoperability, mitigate setup costs, and enhance cybersecurity resilience in intermodal freight transport.

I. Cost-benefits analysis

27. [Placeholder for additional inputs from member States – an overview of the potential gain with digitalization and automation. Details could be supplemented in the case studies.]

III. The Role of Governments

28. Governments play a crucial role in fostering the digitalization and automation of intermodal freight transport, shaping policies and frameworks that drive innovation while addressing potential challenges. As the global economy increasingly relies on efficient logistics and transport networks, creating an environment conducive to technological advancements that enhance the productivity, sustainability, safety, and security of freight operations is crucial. This entails a multifaceted approach encompassing regulatory frameworks, investment incentives, infrastructure development, and collaboration with industry stakeholders to harness the benefits of digitalization and automation while mitigating risks and ensuring equitable outcomes.

29. In facilitating digitalization and automation in freight transport, governments often act as catalysts for innovation by setting standards and regulations that promote interoperability and compatibility across systems. They establish guidelines for data sharing, cybersecurity, and privacy protection to facilitate seamless integration of digital technologies into supply chain operations. Furthermore, governments leverage funding mechanisms and incentives to encourage private sector investment in research and development, pilot projects, and deployment of digital and automated solutions. By fostering collaboration between industry players, academia, and research institutions, governments can accelerate the adoption of emerging technologies and drive transformative changes in freight transport systems for the benefit of society and the economy.

30. In the transition to digitalization and automation, governments also play a pivotal role in ensuring a human-centric approach that prioritizes the well-being and empowerment of individuals amidst technological advancements. Recognizing that technology should serve as a tool to augment human capabilities rather than replace them, governments should ensure that the human element remains at the forefront of this process. This includes implementing policies to facilitate continuous development, equipping workers with the necessary competencies and skills to adapt to the advancement in technologies, with due consideration to the social protection required to those who are inevitably affected.

A. Interoperability standards and cybersecurity

31. Government intervention and regulations are required to ensure safe, secure, and efficient operations in the freight transport and logistics industry. This includes setting institutional/legislative framework for, inter alia, interoperability standards, cybersecurity, and data protection in the industry to ensure seamless communication and coordination between various systems and stakeholders.

32. The arrival of automation and digitalisation introduce new risks, in particular cybersecurity threats. It is important for the government to establishes legislative framework and guidelines on best practices to mitigate these risks, ensuring that the technologies and practices adopted in the industry meet the necessary safety and security standards.

33. [Placeholder for additional inputs from member States on current standards / measures on cybersecurity:

> Commission Implementing Regulation (EU) 2023/1695 of 10 August 2023 on the technical specification for interoperability relating to the control-command and signalling subsystems of the rail system in the European Union and repealing Regulation (EU) 2016/919]

B. Human-centric approach

34. Governments should make every effort to ensure that the benefits of modernization and rationalization are shared fairly among all stakeholders – including the workers – as well as to ensure that any hardships to the workers that could result from such technological modernization and rationalization are mitigated by the adoption of appropriate social security and labour protection policies, accompanied with skilling and training programmes.

35. Owing to the importance of transport and logistics in society and the nature of the problems and challenges facing these services, governments have a major role to play in:

- Promoting the long-term success of automation and restructuring plans, and
- Easing the labour adjustment process resulting from such plans, while
- Fostering healthy labour-management relations, and
- Supporting the training of experts that roll out digitalization projects in the use of United Nations semantic standards, reference data models and legal instruments.

1. Planning for automation and improvement of transport system performance

36. Automation may help achieve sustainable gains in competitiveness while improving performance, quality of service, job security and working conditions. To fulfil these objectives, governments should encourage communication and consultation between intermodal transport and logistics employers, their associations, and workers' organizations on any potential automation and restructuring plans. They should also consider the following aspects in the transition towards digitalization and automation in intermodal freight transport:

- Integrated policies that take into account multi-disciplinary aspects including transport, energy and environment and land use in the promotion of intermodal transport and automation;
- Financing of digitalization and automation technologies;
- Level-playing field between various market players;
- Social costs and benefits of the new improvements (including labour adjustments and their external costs) and their fair distribution amongst the stakeholders;
- Needs for social protection, including monetary support and re-training needs, for those affected by the transition;
- Additional automation-related occupational safety and health standards and other applicable safety standards and means of monitoring compliance;
- Legislation and/or special collective bargaining mechanisms, as appropriate, to cope with labour adjustment problems that may result from digitalization and automation.

2. The role of institutional frameworks to ensure a human-centred approach

37. To promote the effective implementation of labour restructuring plans, governments have a role to play, wherever necessary, in establishing or revising an institutional framework that is adaptive to changing political priorities and include a mechanism for evaluating and revising policies and laws related to the automation and digitalization process. Below are aspects which governments may consider when establishing or revising such a framework to smoothen the labour adjustment process and promote healthy labour-management relations:

- Restructuring plans and their labour adjustment components resulting from a collective bargaining which takes in to account the concerns of both the intermodal transport and logistics employers and workers' organizations;
- Pay structure considerations;
- Criteria and mechanism for worker separation settlements if these are an inevitable part of restructuring plans, so as to ensure fair and equitable treatment of the workers affected;
- Special job-placement and self-employment programmes that can explore, inter alia, opportunities for external redeployment of workers made redundant,
- Planning schemes for early retirement and separation schemes to enable timely payments;
- Applicable international labour standards concerning, in particular, freedom of association and collective bargaining and related nationally agreed standards.

38. The Organisation for Economic Co-operation and Development Principles for Private Sector Participation in Infrastructure (2007) emphasize in Principle 9 that "public authorities should ensure adequate consultation with end-users and other stakeholders including prior to the initiation of an infrastructure project.". Similarly, the International Labour Organization (ILO) advocate in its Conclusions No. 85 that "collective bargaining should be used to adapt working conditions to the structural and technological developments in transport."

Box II
What is social dialogue?

Social dialogue comes in various forms and levels according to national traditions and contexts, including in the form of cross-border social dialogue in an increasingly complex globalized economy. There is no one-size-fits-all approach to organize and strengthen social dialogue. However, the ILO has adopted a Resolution establishing that "collective bargaining remains at the heart of social dialogue. Consultations, exchanges of information and other forms of dialogue between social partners and with governments are also important."*

Social dialogue, based on respect for freedom of association and the effective recognition of the right to collective bargaining, has a crucial role to play in designing policies to promote social justice. It is a means to achieve social and economic progress and is essential for democracy and good governance. Social dialogue comes in various forms and at different levels. The ILO has published a wide range of documents, manuals and guidance on social dialogue practices, including two with a sectoral focus applicable to the transport and maritime sectors:

Social dialogue in the railways sector (2015)

Social dialogue in the process of structural adjustment and private sector participation in ports: A practical guidance manual (2006).

Source: ILO, Resolution concerning the second recurrent discussion on social dialogue and tripartism (2018). Online: www.ilo.org/sites/default/files/wcmsp5/groups/public/@ed_norm/@relconf/documents/meetingdocument/wcms_633143.pdf.

a. Impact on pay structure

39. Workers should share in the benefit which technical progress brings to the undertaking; and measures should be taken to minimize the adverse effects which technical changes might have on their job roles and compensation. Governments should encourage companies to keep its workers informed of the change brought about by the technological advancement. They should also encourage an open dialogue between management and workers concerning technical changes planned as soon as possible. Where necessary, negotiations should be required between the representatives of intermodal transport and logistics employers, their associations, and those of the workers concerning the repercussions of those changes on pay structure.

b. Opportunities and challenges

40. Workers who are at risk of job displacement resulting from automation will face a number of opportunities and challenges in transitioning into the jobs that are expected to be created by the structural changes brought along by automation. Some possible impacts of digitalization and automation on working conditions and labour protection may include earnings, working time, job security, skills development and career progression, safety and health at work, social environment, freedom of association and collective bargaining and equality of opportunity and treatment.

3. Impact on workforce: training, retraining, upskilling

41. If technical progress results in higher job requirements, for instance, increased responsibilities, physical or mental effort, or in the technical skills required of workers holding certain positions, it is important that these roles be appropriately upgraded, taking these new factors into account.

42. A well-trained workforce is essential for efficient freight intermodal transport and logistics operations. The objectives of training should be to provide workers with skills necessary for the safe and efficient performance of their work. Training needs at all levels, particularly in times of change, should be addressed on a consultative basis. Consideration should be given to providing vocational training at no cost to the employees; it should be carried out at ports, railway facilities or other training centres. Governments, in consultation with intermodal transport and logistics employers, their associations and workers' representatives, should facilitate the development and introduction of appropriate training standards and certification of trainers and trainees. Compliance with such standards should be monitored and enforced. Where appropriate, joint training boards responsible for establishing training standards and curricula and for supervising the quality of training should be set up and facilities for worker training should be provided. Workers should be given every opportunity to undertake necessary training.

a. Redundancy and redeployment

43. Technological and organizational changes may lead to a reduction in employment requirements. In such cases it is necessary to give priority to the use of available resources in the enterprise to retrain and redeploy existing employees. The roles of the social partners in minimizing job losses should conform with established agreements, conventions or recommendations, as appropriate.

44. In coping with the problem of redundant employees, governments should encourage intermodal transport and logistics employers implementing automation to – as a first step – make special efforts to redeploy them in consultation with workers and their organizations, and in accordance with applicable international labour standards and national laws or collective agreements, as appropriate. Depending on the circumstances and possibilities, they should endeavour to:

- Transfer workers to other suitable jobs within the same undertaking; or
- Secure, with the collaboration of other undertakings, the governments and, where appropriate, the trade unions concerned, alternative employment outside the undertaking for redundant workers, with a minimum of financial hardship to the workers concerned.

b. Training and retraining programmes

45. Special retraining schemes should be designed to meet the specific needs of redeployment. To the extent possible, the retraining should be based on the profile of each worker affected and the new job requirements; it should also include "assistance to the worker in adapting to the new job". Intermodal transport and logistics employers, their associations, and workers' organizations should promote policy and legislation that facilitate retraining for redeployment.

46. Governments, as well as intermodal transport and logistics employers, their associations, and workers' organizations, have special roles to play in determining and meeting the training needs arising from the restructuring and automation programmes:

- Governments should provide the basic education and technical foundation.
- Intermodal transport and logistics employers and their associations should provide the necessary, job-specific training based on assessments of skills required for new technologies and work methods.
- Workers' organizations should inform intermodal transport and logistics employers or their associations about workers' needs, and possibly participate in the planning, implementation, evaluation and improvement of training programmes.

47. Tripartite training programmes should, to the extent possible and depending on national circumstances, be related to competency standards and the awarding of broad-based qualifications, as these can improve the workers' job prospects, facilitate their redeployment and prevent their redundancy in their current jobs.

48. While training programmes need to be adapted to specific cases, there is a general need to promote technical skills and qualifications that can enhance efficiency and quality of service. Skills in the area of new technologies, digitalization and automation are becoming increasingly important. Furthermore, depending on the redeployment and redundancy measures adopted – such as attrition, hiring freeze and/or early retirement – additional needs for retraining should be made available. At the same time, however, training and retraining programmes should, to some extent, shift their emphasis from the acquisition of traditional management and craft-specific skills, which have become less important, to broader skills. In the context of increasingly digitally based and automated world of work, greater autonomy at work, as well as a growth in virtual communication, requires that workers develop and strengthen certain core skills. These comprise digital skills, critical thinking, self-reflection, problem-solving, advanced interpersonal skills (negotiation, conflict resolution, communication and collaboration), emotional intelligence, creativity and innovative thinking, planning and organizing, career management, and learning to learn. This should also include training on how to implement the UN standards in digitalization projects.

c. Labour adjustments: redundancy and separation

49. The implementation of automation will lead in most cases to restructuring. If redundancy results from restructuring plans and cannot be fully coped with through redeployment efforts, then the intermodal transport and logistics employers, their associations, and workers' organizations, within national law and practice, should work out with governments suitable redundancy schemes that can effectively prevent, or at least minimize, negative effects on workers. Since workers are not necessarily at the root of redundancy, the social cost of the necessary labour adjustments should be shared by society equitably. Government should encourage intermodal transport and logistics employers and their associations to prioritize measures that are least intrusive to the workers and impose minimal strains on the entity's human resource capacity, such as attrition, hiring freeze and early retirement. Separation should be a measure of last resort. If it cannot be avoided, it should involve financial compensation and other suitable forms of assistance that can ease the reintegration of workers in the labour market.

50. Redundancy and separation should be assessed, negotiated, and mitigated in the context of its causes. It should not be a result of unfair labour practices, nor of hasty restructuring programmes that can result from deficiencies in legislation or collective bargaining machinery, or from inadequate planning. To ensure fairness, Government should ensure, through legislations or otherwise, that workers have the right to have their redundancy payments negotiated through clear procedures established, ideally with compensation calculated through mutually agreed formulas.

d. Loss of jobs and budgeting for retraining schemes

51. Loss of jobs will pose major challenges for automation and restructuring, even when acceptable severance payments are negotiated with workers. To cope with these problems, retraining programmes should be organized to help affected workers who lose their jobs to find alternative employment. Particularly for workers who are older, have low and/or non-transferable skills and/or live in remote areas with few employment opportunities, governments should provide special assistance measures to smoothen their adjustment. Small business loans and retraining loans at subsidized rates, as well as job-creation funds should be considered; if feasible, they should be supplemented with technical assistance.

52. In addition to training programmes to assist redeployment efforts and to enhance skills and work-related attitudes, government training programmes should be designed in consultation with intermodal transport and logistics employers, their associations and workers' organizations for workers who lose their jobs. In situations where lay-offs cannot be avoided, the governments should, where necessary, establish labour-market adjustment

schemes whereby affected workers are provided an agreed amount of time off for participation in training courses.

C. Financing, Inclusiveness and Small and Medium Sized Enterprise friendliness

53. Automation and digitalisation may require significant infrastructure investment, which may become prohibitive for small and medium enterprises. This comes in addition to a transport and logistics infrastructure deficit in place in many countries and a need to increase public sector expenditure or promote private sector involvement.

54. Governments plays a key role in regulating and financing freight intermodal transport and logistics infrastructure and services. These can be delivered either through debt financing to leverage limited capital for larger project or under public and private operations, with various degrees of outsourcing and other forms of contracting and subcontracting. Policy responses, including the design of financially balanced and comprehensive contracts to regulate the terms of operations, are needed to promote a level playing field in order to respond to diversity in context and fluctuating demand. Decent work is a central element relevant to these policy responses.

55. Governments can also support intermodal and logistics enterprises and their associations in gaining access to suitable sources of debt or equity finance, by preparing business plans and financing applications, identifying potential lenders or investors, and making necessary introductions. This support can also include working closely with a range of financial institutions, including foreign and local banks, international investment institutions, leasing companies and venture capital funds. It also collaborates with various donor-provided credit lines, e.g., from the World Bank, European Union, etc.

56. Governments play a pivotal role in facilitating this transition into digitalization and automation also through investment in software-based technological solutions. These may include providing open data and assistance in using interoperable standards. By allocating resources in these software solutions, the government could reduce the barriers to entry into automation and digitalisation, and thereby improving competitiveness in the freight transport and logistics sector.

57. It is also important for the governments to ensure automation and digitalisation do not lead to unfair advantages for certain companies or hinder competition. Appropriate policies should be put in place to encourage interoperability and data sharing, enabling different stakeholders to collaborate and compete on a level playing field. Examples of which may include:

- **Regulatory and policy frameworks** – Ensure comprehensive and fair regulations. Developing and enforcing regulations that ensure fair competition and prevent monopolistic practices will provide small and medium-sized enterprises (SMEs) with equal opportunities to participate. Contracts for public projects may include provisions that facilitate SME participation, such as simplified bidding processes and appropriately sized project splitting.
- **Infrastructure and technology access** – Support digital infrastructure. Development and maintaining government-operated digital platforms that provide essential services and tools for automation and digitalization may be beneficial. Making these platforms accessible to SMEs at no or minimal cost may reduce entry barriers. Investment in public digital infrastructure, such as high-speed internet and cloud services, especially in underserved areas, could ensure that SMEs can leverage these technologies. Facilitating development of shared digital resources that SMEs can utilize, such as cybersecurity tools and data analytics platforms, may also be advantageous.
- **Capacity building and technical assistance** – Provide training and advisory services. Government-sponsored training programs could help upskill the SME workforce in digital literacy, automation and advanced logistics management. Collaboration with educational institutions to integrate relevant skills into curricula and provide continuous professional development opportunities might be useful. Establishing

technical support centres that offer advisory services to SMEs on best practices in automation and digitalization could be helpful. Providing consultancy services to assist SMEs in identifying suitable technologies, implementing digital solutions, and optimizing their operations may be beneficial.

- **Innovation and collaboration** – Facilitate knowledge sharing. Creating innovation hubs and clusters where SMEs can collaborate with larger companies, research institutions, and government agencies might be valuable. Public-private partnerships focused on research and development in automation and digital technologies could provide opportunities for SME participation. Organizing conferences, workshops, and networking events that bring together stakeholders from across the sector to share knowledge and best practices may foster innovation. Developing online platforms for continuous information exchange, including case studies, success stories, and technical guidelines, could be beneficial.
- **Inclusiveness and decent work environment** – Support SME associations. Strengthening and supporting SME associations could ensure they're represented in policy dialogue and negotiations. Facilitating the creation of consortiums and networks where SMEs can collaborate, share resources, and advocate for their interests collectively might be useful.

[Placeholder for additional inputs from member States on helping measures to ensure inclusiveness and SME friendliness].

Box III
Navigating Fiscal Responsibility and Debt Sustainability in Developing Economies

In some countries, governments grapple with structural conditionalities that seek to reduce fiscal exposure to fluctuations in revenues, and, in some cases, they further have been compelled to introduce certain fiscal responsibility measures, which include ceilings on expenditure growth, debt ceilings and a ceiling on the structural deficit. For example, debt sustainability has deteriorated in a number of countries. In the past ten years, external debt has risen at an average annual rate of 8.5 per cent for developing countries, and in 2018 totalled US$7.6 trillion. The United Nations Conference on Trade and Development has warned of the fragility of developing economies and provided guidance on how they can mitigate growing debt vulnerabilities. Countries with a higher risk of debt distress may face challenges in finding investments for transport projects, including for its digitalization and automation. Yet, high investments in technology, digitalization and automation may push governments to seek increasing levels of private sector participation to bridge these gaps.

"Principle 1. When assessing overall costs and benefits, all relevant aspects of sustainable development should be taken into account. In particular, infrastructure projects often have important environmental and social repercussions that need to be properly accounted for, including through impact assessments. Independent sustainability impact assessments could be commissioned to assist this process." These can include labour impact assessments.

IV. Example of Digitalization and Automation

58. The various enabling technologies for digitalisation and automation of intermodal freight transport, and how they could improve efficiency or create positive impacts on the reduction of energy consumption, greenhouse gas emissions, etc will be discussed in this section. The following are some of the enablers that are fundamental in realizing the various solutions in digitalizing and automating the freight transport sector:

- Internet-of-Things (IoT) – it refers to the network of physical devices, vehicles, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables them to connect, collect, and exchange data (e.g. data on location, temperature, humidity, and other relevant parameters). IoT technology enables large volume of data to be collected from a wider range of objects that was otherwise costly

to collect before, enabling more parameters to be considered during forecasting and monitoring.

- Reliable communication network – such as 5G or LoRaWAN, is essential for transmitting data from IoT sensors to various management solution platform(s). 5G is the latest generation of cellular network technology that is designed to support high-speed, low latency connectivity. LoRaWAN on the other hand, is a low-power, wide-area networking protocol designed for long-range communication with low data usage. It is optimized for battery-operated devices and sensors that need to transmit small amounts of data over long distances, making it ideal for minoring sensors that requires to be deployed over a wide area and need to communicate wirelessly with a centralised network.
- API and open standards – closed, proprietary-by-design simulation tools are progressively being phased out in favour the availability of open standards and public application programming interfaces (APIs). APIs essentially set out a set of rules, protocols, and tools that allows different software applications to communicate with each other. APIs define the methods and data formats that developers can use to interact with a service, library, or operating system. APIs have dramatically streamlined sharing and data exchanges, making it possible for users to combine data from different sources quickly and reliably for its own analysis and modelling.
- Artificial intelligence and machine learning: they make more complex and sophisticated modelling feasible thanks to continuously improving computing power and availability of big data. Machine learning framework are enabling the development of systems that allow autonomous decisions to be made, taking into account predictions on future operating conditions based on historical and real-time data.

59. These enablers lay the foundation for the various applications of digitalization and automation in intermodal freight transport. In the next section, this section is organized into solutions designed for various stages in the intermodal transport chain. These include business analytics solutions for operators, solutions to enhance safety and efficiency in terminal operations, and solutions tailored for railway carriers. Each subsection will provide an overview of these solutions, complemented by case studies from member States, illustrating their applications, in ECE/TRANS/WP.24/2024/6.

A. Solutions for business analytics

1. Data and information exchange and management platform

60. An effective data and information exchange and management platform should facilitate information and data to flow seamlessly and efficiently amongst all stakeholders involved in the intermodal transport journey. In particular, it should be able to reflect timely the status of the consignment through IoT-enabled devices and sensors. These data would not only allow more efficient tracking but enable more precisive route management that minimizes idle time, as well as predictive analysis with the availability of bid data for better resources allocation and management.

[Placeholder for additional inputs from member States on industry technical standards]

61. While various systems already exist to facilitate such data and information exchanges, they often lack interoperability, restricting their functionality to local or regional contexts. Despite advancements, the integration of diverse systems across different modes of transport remains a significant hurdle. This lack of interoperability inhibits seamless communication and coordination among stakeholders involved in intermodal transport, impeding efficiency and hindering the realization of a truly interconnected global transport network. As the demand for efficient and sustainable transport solutions continues to rise, addressing the issue of interoperability is paramount to unlocking the full potential of data and information exchange in intermodal transport.

2. Digital twins

62. This digital twin serves as an innovative information and analytical platform aimed at facilitating decision-making regarding infrastructure maintenance. It is a virtual representation of an object or system designed to reflect its physical counterpart accurately. It enables the simulation of operational tasks, predictive analytics, and forecasting of infrastructure facility conditions and planned repairs using both real-time and historical data.

63. Below are some examples of the applications of digital twin in optimising intermodal freight transport:

- Maintenance Planning: The digital twin enables a shift towards flexible and targeted planning for infrastructure asset maintenance, maintenance, and repair activities.
- Asset Renewal (Modernization): Utilizing data on the remaining resource, the digital twin facilitates the implementation of infrastructure technical asset renewal and modernization efforts.
- Route planning: digital twins enable real-time monitoring of factors such as cargo load, train performance, and track conditions, allowing operators to optimize routes based on factors like optimal speed, cargo distribution, and scheduling to maximize efficiency and reduce operational costs. Additionally, by simulating various scenarios, digital twins help anticipate and mitigate potential disruptions, enabling proactive decision-making and enhancing overall supply chain resilience in freight railway transport.
- Training Organization with VR Technologies: Virtual Reality (VR) technologies are leveraged to provide immersive training experiences, allowing operating personnel to engage in virtual environments without the risk of physical injury.
- Technical Documentation Maintenance: Automation and data-driven processes are employed for the maintenance, generation, and editing of technical documentation. This is achieved by accumulating data from various systems to inform documentation management.

B. Solutions at terminals

1. Automated system for entry and exit to/from terminals

64. Automated system for entry and exit to/from terminals leverage on various enablers to automate the process of checking in and out of terminals for freight vehicles. Key components and infrastructure required for such systems include:

- Vehicle Identification and Authentication: Automated systems utilize technologies such as RFID (Radio Frequency Identification), license plate recognition, or biometric authentication to identify and authenticate vehicles entering and exiting terminals. This infrastructure includes RFID readers, cameras, and sensors installed at entry and exit points.
- Automated Gate Systems: Automated gate systems replace manual processes with self-service kiosks or electronic gates equipped with scanners and sensors. This could be integrated with weighing stations equipped with weighbridges or scales. As vehicles pass through the weighing station, sensors detect the vehicle’s weight automatically, obliviating the need for manual checking and weighing.
- Integration with Backend Systems: Automated entry and exit systems should also be integrated with backend systems, such as terminal management software or freight management platforms, to streamline data exchange and processing. Data and information captured at check-in should be forwarded to the backend management systems without manual interventions. These include updating inventory records, generating billing invoices, and recording transaction logs etc. This integration ensures real-time visibility of vehicle movements, cargo status, and terminal capacity, enabling proactive decision-making and resource allocation.

- Security and Surveillance Infrastructure: To ensure security and compliance with regulations, automated systems may include surveillance cameras, access control mechanisms, and biometric authentication devices. These measures help prevent unauthorized access, detect security threats, and maintain the integrity of the terminal operations.

2. Automated cranes and vehicles within terminals

65. Automated cranes and vehicles in terminals can significantly reduce reliance on manual labour and mitigating the need for workers to perform unappealing tasks in challenging environments. This automated infrastructure could replace tasks such as container stacking, transport, and truck handling, thus minimising the risk of injuries and occupational hazards associated with manual labour.

[Placeholder for additional inputs from member States on safety features of automated infrastructures.]

3. Automated slot management for trucks and trains

66. Automated slot management systems utilize advanced algorithms and real-time data to allocate time slots for any modes entering and exiting the terminal, ensuring smooth operations and minimizing delays. With AI-enabled algorithms, the systems could potentially optimize the allocation of terminal resources, including loading docks, berths, and rail tracks, based on demand forecasts, vessel schedules, operational constraints, and enable dynamic adjustment based on real-time information brought about by digitalization of information and data exchange.

[Placeholder for additional inputs from member States on technical requirements.]

67. It is important to recognize that AI-enabled algorithms are relatively noble in the context of intermodal transport, and they rely heavily on extensive data, both historical records and real-time, to effectively drive the processes of machine learning and decision-making. They should not be perceived as a panacea that will instantaneously enhance efficiency and productivity. Instead, the possibilities of errors and miscalculation in scheduling should be acknowledged, and contingency plans should be formulated to mitigate such risks. Automated slot management systems for trucks and trains are not intended to completely replace human labour, but rather to complement the existing efforts of scheduling personnel. Schedule makers should be upskilled, making them capable of refining and optimizing the algorithms in slot management. Moreover, they should be prepared to intervene and resolve any issues should the systems fail to respond effectively to address real-world challenges.

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C. Solutions for railway carriers

1. Automated inspections, maintenance of rail infrastructure and risk assessment systems

72. These systems aim to improve the reliability of rail services through more efficient monitoring and maintenance of its infrastructure using sophisticated IoT-enabled sensors. [Placeholder for additional inputs from member States on infrastructure required for these systems]

73. A number of the applications of these solutions are provided below:

- Digital Model and Predictive Analytics for Tracks: Implementing a digital model and predictive analytics system to forecast the technical condition of tracks. This will automate the planning of repairs and maintenance based on forecasted data.

- Predictive Analytics for Signalling Devices: Utilizing predictive analytics to forecast the technical condition of signalling devices based on diagnostic data.
- Maintenance and Repair Programs: Formulating maintenance and repair programs based on the forecasted technical condition of railway equipment. This includes automation and telemechanic systems.
- Life Cycle Management System: Introducing an information system for the life cycle management of track machines and mechanisms.
- Automated Documentation Maintenance: Implementing a system for automated maintenance and updating of technical documentation.
- Predictive Analysis for Freight Cars: Introducing tools for diagnosing rolling stock while trains are in operation to conduct predictive analysis of freight car technical condition.
- "Virtual coupling": Enabling the synchronized movement of two freight trains with minimal distance between them, facilitated by coordination of locomotive driving modes through a secure digital radio channel. An intelligent system monitors location, speed, speed changes, and distance to the leading train. It can increase capacity of railway sections without compromising on safety, simplify work for locomotive crews and increased its operational speed.

2. Automated coupling and decoupling

74. Automated coupling and decoupling systems utilize robotic arms, hydraulic mechanisms, or electromechanical devices to perform the coupling and decoupling process autonomously. These systems can accurately position railcars, engage couplers, and secure connections with minimal manual intervention. These systems are equipped with sensors and control systems on both the terminal and the railcar, capable of monitoring the position, alignment, and status of railcars during the coupling and decoupling process. These sensors ensure precise alignment and engagement of couplers, preventing misalignment, overshooting, or unsafe conditions. This technology will be an important enabler and prerequisite for automated and autonomous locomotives.

75. These systems could reduce risk of human error and minimizing the potential for accidents or injuries during coupling and decoupling operations.

3. Automated locomotives

76. Automated locomotives are trains that operate without direct human intervention for controlling their movement. Instead, they rely on a combination of advanced technologies such as artificial intelligence, sensors, cameras, GPS, and communication systems to navigate, monitor their surroundings, and make decisions.

77. Automated locomotives could have the potential to optimize train movements for improved efficiency, reducing energy consumption and minimizing delays. However, safety continues to be of a paramount concern in automated train systems. Many of the automated locomotives at present are operated in local, isolated networks, given the challenges in ensuring interoperability with existing infrastructure, addressing cybersecurity concerns, and navigating regulatory frameworks governing autonomous transport in railway