METHODS AND TECHNIQUES TO INVOLVE FREIGHT ACTORS IN THE R&D PROCESS TOWARDS DIGITALISED INTERMODAL COOPERATION

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Abstract

Providing efficient, resilient, and sustainable freight networks requires active participation of freight actors in the transition process towards synchro-modal, multi-level distribution, and zero-carbon emission transportation systems. The vision of the Physical Internet (PI) describes the future of logistics like the operation of the internet today, where flow occurs physically based on network resources, neglecting any pre-defined routes or nodes. Active collaboration of freight actors in such an environment is inevitable to be able to manage transport and distribution activities by a governing body. To be competitive in a PI-based logistics market, freight actors need to modify their behavior. They should change the current approach of competing for customers or exclusive partnerships and focus on "operational excellence". In our paper, we are presenting the main drivers of such a transition towards the PI. We aim to analyze and synthesize the results of some selected scientific and R&D activities related to the evolution of freight systems towards the PI. We apply the TRIZ methodology (Theory of Inventive Problem Solving) and explore the connections between the STRIA and ALICE Roadmaps. Although information technologies are present in the form of digital twins, artificial intelligence, and many other forms, trust in the technology and in the PI as an ultimate ideal solution has not been built up yet. There is a fear and a lack of willingness by actors to share their data voluntarily in the freight data communities. Based on the experience of various R&D projects, analysts concluded that proper organizational and governmental factors of freight data communities are essential for survival. Understanding the nature of these common pool resource (CPR) management systems and identifying the factors needed to overcome the freight actor point of view is crucial. Proper freight systems can be planned by forming possible strategies for the inevitable transition.

Keywords: Physical Internet (PI), freight actor involvement, Common Pool Resources (CPR)

1. INTRODUCTION

Freight actors are facing multiple challenges in our modern economies: while the demand for transporting goods is constantly growing, they need to evolve according to -often contradicting- efficiency, resiliency, and sustainability requirements. The European freight sector, as it operates today, over-consumes most of the scarcely available critical resources, namely space (lack of capacity related to the transportation network), assets (logistics infrastructure), time (delays and congestions), workforce (lack of sufficient talented employees) and energy (mainly fossil fuels).

A significant part of the challenges can be attributed to the high share of road transport. As it is in the nature of the sector, there are specific spatial distributions identified in the use of space, time, and logistics infrastructure -as resources- in the first mile (ports and logistics hubs) and last-mile delivery activities (urban environments). The bottleneck embodied by the port infrastructure makes it more and more difficult to ensure the fast and smooth movement of goods. Urban freight is also extremely limited by the available space (for loading-unloading and storage) and transport network resources. Just as the bottleneck embodied by the port infrastructure makes it increasingly difficult to ensure the fast and uninterrupted movement of goods, urban freight is also often extremely limited by the available space (for loading-unloading, warehousing, and storage) and the lack of parallel traffic lanes. In both cases, the contradiction tenses up between the fast movement of goods and the fast movement of transport vehicles: the fast movement of individual shipments requires a large fleet of road transport vehicles (along with properly trained and motivated drivers), but only a limited space and time window is available for loading and transporting the freight. Resolving the contradiction is only possible if, for the sake of sustainability, the developments are not only aimed at the expansion of the fleet or the built infrastructure but also at the efficient utilization of the available resources (Szander *et al.*, 2023).

In order to make efficient use of time as a key resource there is a central question regarding intermediate transshipment actions. Based on the TRIZ methodology (Theory of Inventive Problem Solving) (Gadd, 2011), we can identify C1 and C2 contradictions:

- C1) On the one hand, the condition for the rapid movement of goods is the elimination of idle times, in this case, intermediate loading and storage steps, as they represent a waste of time and associated costs from this aspect. (These factors led to the implementation of door-to-door services solely with trucks and delivery vans on the road, which we intend to moderate or decrease).

- C2) On the other hand, for road transport vehicles to move quickly and thus increase transport performance, we should also consider the driving time limitations (9-11/24h). From this aspect, intermediate cross-docking actions are required to provide a continuous flow of freight.

Solving the contradiction – emphasizing that the ultimate goal is the smooth movement of freight– it is necessary to provide services at some stations or logistics hubs of the distribution network with short loading and storage times, cross-docking solutions, and the transfer of properly organized goods with high vehicle capacity utilization.

The Physical Internet (PI) concept proposes pooling resources and assets in open, connected, and shared networks. The existing idle capacity of assets in all modes of transport and storage could be better utilized in supply chains, and flows could be managed more broadly using and combining transport modes and other logistics assets smartly. Open and interconnected logistics services and networks will maximize capacity utilization, meeting current and future demands. Value creation through efficiency should be used to speed up the transition to greener and cleaner assets instead of price reductions and margin erosion resulting from current assets (Ballot *et al.*, 2020). The development of information technology (IoT Internet of Things, 5G, AI Artificial Intelligence, Digital Twin) and many other innovative concepts and solutions bring these plans closer to reality, but there are obstacles arising simultaneously.

The main reasons why clients do not want to use environmentally friendly and high-capacity rail and waterway transport can be identified as (1) transshipment slows down the speed of the flow of goods and there is a fear that damages can occur in the meantime, (2) the consolidation of smaller shipments is difficult, processes become more complex or vulnerable, and (3) incentives and regulations are still not favoring these solutions on the level of attractiveness clients willing to count with. While rail and inland waterway solutions cannot provide door-to-door (or even near-to-door) services, they can contribute (while still not competing) with road transport in the efficient, resilient, and sustainable freight process by maintaining scheduled, high-capacity link along the supply chain (Qasseer *et al.*, 2023).

To achieve the ambitious goals of the PI, there is a requirement for sufficient freight infrastructure and often other specialized resources. At the same time, Europe is lagging in railway and inland waterway freight infrastructure developments (hubs and inland ports equipped with logistics infrastructure assets, loading bays, and warehouses) (Stopka *et al.*, 2023). Intermodal cooperation is held back by the lack of suitable vehicles. Fleet renewal in rail and waterway transport is far behind that of road vehicles. In addition to technical developments, building trust and willingness among logistics companies is key to putting their needs and resources into properly governed freight data communities (Rodriguez, 2023; Szander *et al*., 2023; Boldizsár *et al*., 2022). The operation of these freight data communities is not limited to enterprises but necessarily consists of B2A (Business to Authority) and B2I (Business to Integrator) communication layers on a certain level. Regarding the shared data, it must be ensured that partners with the appropriate access level can only see them to the extent determined by the participants agreeing to share the data, respecting the integrity of business-sensitive information. The best way to ensure stakeholders (authorities, hauliers and freight enterprises, manufacturers, distributors, and service providers) accept the virtual environment, collaborate, and respect the rules of operation is if they are deeply involved in forming such freight data communities.

In our study, we explore the features and possibilities of this transition. We present what techniques, technological, and organizational solutions can help the creation of the Physical Internet (PI), and we pay special attention to the operation of transport data communities as common pool resource (CPR) systems.

2. ROADMAPS TOWARDS EFFICIENT, RESILIENT, AND SUSTAINABLE LOGISTICS SYSTEMS

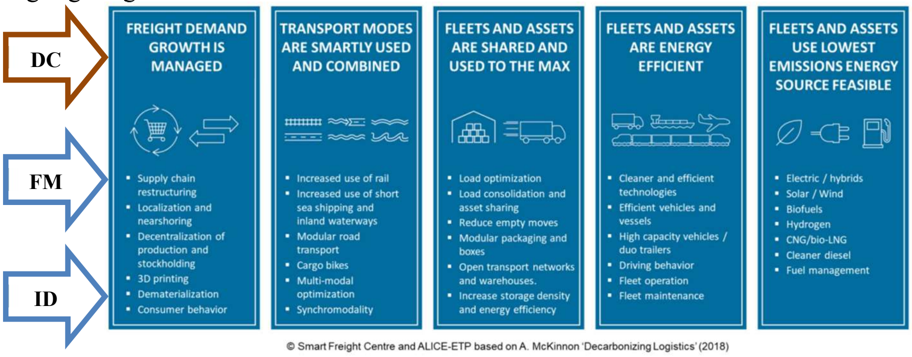
Digitalized intermodal (or synchro-modal) cooperation aims to optimize the efficiency, reliability, and effectiveness of transporting goods across different modes while minimizing delays, costs, and operational complexities and keeping sustainability goals in mind. The critical importance of collaboration has been recognized since the early days of supply chain risk management. By collaborating, companies can gain awareness of potential upstream and downstream risks, try collectively to minimize these risks, and coordinate contingency planning to improve the supply chain's resilience. According to the literature, the success of such a collaboration depends on five things: trust, a willingness to share data, coordinated planning, recognition of mutual interdependence, and a fair distribution of the resulting benefits (McKinnon, 2018).

There are many new, innovative, and green technical solutions available in transportation. However, there is a consensus amongst experts that replacing fossil fuels with electricity or hydrogen will not be sufficient to transform the freight sector to fit all the requirements of the climate goals.

In May 2017, the European Commission (EC) adopted the Strategic Transport Research and Innovation Agenda (STRIA) as part of the 'Europe on the Move' package, which highlights main transport R&I areas and priorities for clean, connected, and competitive mobility (Gkoumas *et al.*, 2021). Seven STRIA Roadmaps have been developed covering various thematic areas, namely: Connected and automated transport (CAT); Transport electrification (ELT); Vehicle design and manufacturing (VDM); Low-emission alternative energy for transport (ALT); Network and traffic management systems (NTM); Smart mobility and services (SMO); and Transport infrastructure (INF).

While the STRIA Roadmaps focus mainly on the innovation of different transportation-related technologies, the ALICE Roadmaps (Alliance for Logistics Innovation through Collaboration in Europe) project pathways towards the Physical Internet (PI) (see Figure 1).

Figure 1 A slightly extended representation of the ALICE PI Roadmap Pillars, highlighting the 3 intervention fields.



Source: Modified version of (McKinnon, 2021)

We concluded that all the efforts to intervene in the five highlighted fields can be expressed as the development of freight data communities (DC: data community), innovative (synchro-modal) management of collaborative fleets (FM: Fleet management), and the renewal of transport and logistics infrastructure (ID Infrastructure development).

The SENSE project developed a Physical Internet roadmap to explain the development of the PI over the next twenty years around five areas of development, including:

1) From Logistics Nodes to PI Nodes, focusing on automation, standardization, and digitalization of physical processes.
2) From Logistics Networks to Physical Internet Networks, in which all processes and services are managed as seamless, flexible, and resilient.
3) Developing the System of Logistics Networks towards the Physical Internet, providing individual logistics networks that are interconnected.
4) Access and Adoption, including different steps and the mind shift required to adopt Physical Internet concepts.
5) Governance (GOV).

There are different approaches to defining Physical Internet (PI) governance:

- BU-GOV is a bottom-up (BU) approach where Logistics Nodes, Networks, and Systems of Logistics Networks develop their governance mechanisms, growing and progressing organically. Companies and consortia develop network governance, creating convergence as the models advance. This could lead to islands or subsets of Physical Internet with their standards and protocols.
- TD-GOV is a top-down (TD) approach where there might be two options:
    - TD-GOV-P Public lead. A central body plans and organizes the Physical Internet under the supervision of governments that consider transport and logistics as a universal and public service/

infrastructure, even if companies provide services in a fully regulated framework. This approach would require strong public-sector action at the European/ global level, supported by massive investments, to enforce standards and ensure that market competition rules are not infringed.

- TD-GOV-I Industry lead. Big corporations integrate and/or build strong logistics network capabilities that afterward open to other stakeholders as a service. These digital logistics platforms can deliver services to all types of companies and users up to end consumers making and organizing use of their network and partners' resources and capabilities.

Good governance ensures cooperative management of the Physical Internet by associated partners, openness for all types of organizations, defined service levels and quality standards, transparent management in routing cargo through the network, and common agreed rules in fair allocation of costs, risks, and responsibilities among the involved providers. Evolution from the current ad-hoc trustee-based models is expected, leading to a replicable set of rules and tools addressing all aspects of asset sharing, from mutual liability to gains redistribution (SENSE, 2020).

3. RESULTS AND RECOMMENDATIONS FROM STUDIES OF COMMON POOL RESOURCE MANAGEMENT

According to the extended research activities on the field of social dilemmas, the issue freight actors should deal with can be identified as a multiple-factor common pool resource problem. CPRs are most importantly time or service speed, coupled with space availability and logistics asset utilization as common pool resources in our case.

The canonical representation of collective action problems shows the structure of an n-person prisoner's dilemma game. Many times –but not always– social science expert groups observed that rational agents were not likely to cooperate in certain settings, even when such cooperation would be to their mutual benefit. The zero-contribution thesis underpins the presumption in policy textbooks (and many contemporary public policies) that individuals cannot overcome collective action problems and must have externally enforced rules to achieve their long-term self-interest. However, the zero-contribution thesis contradicts observations of everyday life. Extensive fieldwork has established that individuals from all walks of life and all parts of the world voluntarily organize themselves to gain trade benefits, provide mutual protection against risk, and create and enforce rules that protect natural resources. Successful self-organized resource regimes can initially draw upon locally evolved norms of reciprocity and trustworthiness and the likely presence of local leaders in most community settings (Ostrom, 2000).

Public sector agencies and industry associations have attempted to sponsor and support the facilitation of horizontal logistics collaboration projects over the past 20 years. However, the literature has yet to reveal that these efforts have largely failed. The worst-case scenario is when outside parties impose rules but achieve only weak control and enforcement. With strong outside control and enforcement, cooperation is enforced without needing internal norms to develop. In a scenario lacking rules or monitoring, norms can evolve to support cooperation. However, in a middle-ground state, a mild level of outside control discourages the formation of social norms while also making it possible for some participants to deceive and defect with a relatively low risk of consequences (Sternberg et al., 2022).

Shipper HLCs fails because shippers are not convinced of the benefits; sponsors and facilitators choose unsuitable shippers (such as shippers that do not have resources to pool); shippers lack self-determination; sponsors choose unsuitable facilitators (who are unable to facilitate pooling as intended); goals conflict; and projects lack control mechanisms. Sometimes, moral hazards are associated (Sternberg et al., 2022).

In order to be able to form sustainable freight communities towards the PI it is worth implementing the results of previous analogue field studies. Resource regimes that have flourished over multiple generations tend to be characterized by the following design principles (Ostrom, 2000):

1) Clear boundary rules enable participants to know who is in and out of a defined set of relationships and, thus, with whom to cooperate.
2) The local rules-in-use restrict the amount, timing, and technology of harvesting the resource, allocate benefits proportional to required inputs, and are crafted to consider local conditions. If some users get all the benefits and pay a few of the costs, others become unwilling to follow rules over time.
3) Individuals affected by a resource regime can participate in making and modifying their rules.
4) Most long-surviving resource regimes select their monitors, who are accountable to the users or users themselves, and who monitor resource conditions and user behavior.
5) Long-life surviving resource regimes use graduated sanctions that depend on the seriousness and context of the offense.
6) Access to rapid, low-cost local arenas is needed for open collaboration to resolve conflict among users or between users and officials by devising simple, local mechanisms to get conflicts aired immediately and resolutions that are generally known in the community, the number of conflicts that reduce trust can be reduced.
7) The capability of local users to develop an ever-more effective regime over time is affected by whether they have minimal recognition of the right to organize by a national or local government. Unanimity as a decision rule for changing rules imposes high transaction costs and prevents a group from searching for better-matched rules at relatively lower costs. Users frequently devise their own rules without creating formal governmental

jurisdictions. As long as external governmental officials give at least minimal recognition of the legitimacy of such rules, the community members may be able to enforce the rules. However, if external governmental officials presume that only they can make authoritative rules, then it is difficult for local users to sustain a self-organized regime.

8) When common pool resources are somewhat larger, governance activities organized in multiple nested enterprise layers are inevitable. Consequently, among long-enduring self-governed regimes, smaller-scale organizations tend to be nested in ever-larger organizations.

4. KEY FACTORS IN INVOLVING FREIGHT ACTORS IN DIGITALISED INTERMODAL COOPERATION

The initiation of forming freight data communities -by exploiting the synergies between supply chain actors and transport operators- will ultimately increase the currently low transport capacity utilization; thus -if not the speed of individual goods- the speed of all goods will significantly increase. The necessity of the transition -like the processes of global economic transformation or the challenges of climate change- has not yet necessarily exceeded the stimulus threshold of all actors in the supply chain. However, it is precisely the untenable situation of the critical actors that forces it (both long-distance road transport and urban goods transport system case) (Szander et al., 2023).

Beyond that, the broad involvement of small and large companies in the collaboration along logistics nodes and networks is essential to achieve common goals, as well as individual efficiency and profit. (To express that in addition to the competition of the actors, their cooperative attitude is also needed -supporting each other to achieve the individual goals- the majority of the authors use the word “coopetition”. In the CPR situations we examined related to PI, “collapetition” is much more recommended since collaboration means joint action to achieve common goals).

Based on previous research in social sciences, we can conclude that governance activities need to be organized in multiple layers of nested enterprises for the success of the PI systems. In order to ensure the success of the governance model, it is worthwhile to address the freight companies in the early stages of development and, in cooperation with them, create the interfaces along which the complex management task can be implemented.

To define the possible layers of collaboration, there is a need to widen the approach of current bottom-up and top-down governance formulation scenarios (formed based on which actor has the power to initiate and exercise influence) and place more emphasis on the nature of the collaborative supply chains related to the contradictions described in the context of CPRs.

A few of the possible partnership layers of freight actors in PI systems are based on:

- the time-sensitivity of the supply chain they are interacting with or the product families they are transporting (BU-GOV-TS where TS is time-sensitivity)
- the frequency of shipments or warehousing activities, with consideration of seasonality issues (BU-GOV-FQ where FQ is the frequency of shipments)
- the specialty of loading-unloading and storage tasks (considering unit sizes, SKU-s, and level of automation) (BU-GOV-LS where LS is loading-unloading and storage)
- the info-communication, material handling, green and other technologies, and innovative solutions they prefer (BU-GOV-TY where TY is technology)
- the spatial distribution of their tasks (complementary, auxiliary, extender) (BU-GOV-SP where SP is spatial distribution)
- the local environment, they have certain –special- tacit knowledge to operate (BU-GOV-LO where LO is locality)
- the utilization of human resources and workforce (BU-GOV-HR where HR is Human resources)
- and many other factors only the actors themselves can explore.

The quadruple helix model (recommended by ALICE, 2020) seems to be feasible for such collaborations, as it invites companies (supply chain partners, manufacturers, producers, distributors, freight, and logistics companies), governmental actors (national and local authorities, official coordinators) research and development bodies (academic research and education) and the civil society.

Certainly, there is a need to strengthen the knowledge transfer related to PI and its governance models between attendees in the frame of webinars, online collaboration platforms, social media communities, pilot projects, personal meetings (conferences, workshops, exhibitions, site visits, and observations) and many other forms of dissemination activities. There is a need for further research on the socio-economic aspects of PI developments in surveys, benchmarks, and network research.

Personal issues and relations are highly important to develop PI tools with user-centric design, real-world relevance, smooth implementation, and long-term sustainability. Shipper HLCs -having shippers pool resources and bundle flows- are typically formed spontaneously through personal relationships between the shippers rather than as an effort orchestrated from the outside (McKinnon, 2018). Effective engagement of freight actors throughout the R&D process fosters a sense of ownership, ensures that their needs are met, and increases the likelihood of successfully adopting the developed digital solutions. Combining a mix of these strategies allows for a well-rounded approach to gathering insights and involving stakeholders in creating solutions that truly address their challenges.

5. CONCLUSION

The transition towards an efficient, resilient, and sustainable freight and logistics system (PI) requires a new approach for all stakeholders, the authorities, state and local government actors, the partners who use the service, and the service providers. The most important element of this is the strengthening of awareness in the choice of the supply chain strategy, in the design and operation of a system that integrates sustainable and resilient multi-stage distribution and environmentally friendly, alternative drive vehicles, as well as in the management and governance of shared information, as common pool resources.

The active contribution of PI partners in broad and voluntary information sharing is an essential part of these systems to operate and survive. Most of all, partners involved must understand and accept that the previously (in the present or past) critical success factor, the exclusive management of the flow of goods and information between the sender and the recipient, has been replaced by the operational excellence (service excellence) factor between distribution stations and steps in the PI systems.

Managing common pool resources in PI systems is challenging due to the opportunistic behavior of individuals and the prerequisite of maintaining visibility and transparency. While existing research in PI focuses mainly on mathematical or simulation models of potential gains rather than on implementing the promising complex PI system, some models and solutions exist in socio-economics studies to solve the contradictions.

There is a need to extend the research of freight data communities with a broad analysis of success stories considering the proposed approaches of this paper (TRIZ methodology, Roadmap analysis, CPR Research, etc.). Future research is also needed to explore the organizational factors influencing the adaptation of the physical internet and propose policy frameworks for encouraging data sharing among freight actors.

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