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EC-FUNDED PROJECTS' LESSONS LEARNED IN EARTH FRIENDLY FREIGHT TRANSPORTATION

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The paper is based on the research project ePIcenter (www.ePIcenterproject.eu) supported by the EU HORIZON 2020 Programme. ePIcenter connects thirty-six partners: port authorities, logistic service providers, manufacturers, academic institutions, and technology partners. The main goal is to develop and test AI driven logistic software solutions, apply new technologies and methodologies to increase the efficiency of global supply chains and reduce their environmental impact. One of the significant aspect the project focusses on is optimisation, using AI, digitalisation, automation and innovations in freight transport and handling technologies. Finally, modelling powerful solutions to enable resilient, efficient and environment friendly supply chains.

Knowledge sharing is one of powerful tool for researchers, policymakers, service providers and other stakeholders to develop a holistic and comprehensive common knowledge base. First, a theoretical framework had been developed through identification and review knowledge available from previous projects funded through the European Commission as well as other international funding projects. Second, lessons learned and success stories from previous EC-funded projects and other international research programmes were reviewed and provided in the first year of project implementation.

Keywords: projects, transportation, supply chain, innovation, AI, IoT, big data

1. Introduction

The European Parliament approved the proposal of the "Regulation establishing the mechanism of recovery and resilience" (ESPO, 2021) on February 9, 2021. Accordingly, the transport sector received support due to the negative impact on industry due to pandemic events, including the digitalization of transport and logistics. One of aims set be achieved until 2050 in European Union is to create the system which would allow track movement of the cargo in real time and introduction of a single electronic transport document. This will, among other things, create conditions that will allow to advance the development of multimodal transportation in the field of planning, information, online systems, and their use. These points were included in the technology plan which is provided in White Paper (EEA, 2011). Digitalisation and further automation of components will continue to receive investments because of the importance on international trade chain (ESPO, 2019).

The European Commission (COM, 2016a) defines digital transformation as the process of combining advanced technologies with the integration of physical and digital systems. It is characterised by a fusion of advanced technologies and the integration of physical and digital systems, the predominance of innovative business models and new processes, and the creation of smart products and services (COM, 2016a). The process is dominated by innovative business models and new processes, as well as the creation of intelligent products and services, and supply chains are crucial for all businesses today.

Five significant (Pfohl *et al.*, 2017) relevant characteristics from Industry 4.0 to be considered in the expansion to the supply chain: (1) the digitalisation of products and processes, (2) the automation of processes and decision, (3) the transparency of organization and customers, (4) collaboration ability and (5) real time information availability. However, as mentioned in (Frazzon *et al.*, 2019), the biggest challenges are the practical applications of the techniques from Industry 4.0 such as Artificial Intelligence (AI), Big Data, Data Mining, the Internet of things (IoT), Internet of Service (IoS) and others for supply chain management (SCM) and end-to-end integration is the core of SCM 4.0. The use of IoT, IoS, and other technical elements allows a network that is integrated, synchronized, dynamic, and flexible.

Application of the Industry 4.0 concept (Frazzon *et al*., 2019) may strongly benefit SCM (including increased performance and customer satisfaction), but this process requires investments in technologies, and the diffusion of such concepts must consider a lot of factors.

The project ePIcenter (https://epicenterproject.eu/) should accelerate progress towards an Enhanced Physical Internet enabled Global-European Network ("ePIGEN"), i.e. efficient integration of the infrastructure or "hard" TEN-T network with global networks, and seamless integration in the "soft" layer, secure international information flows and digitalisation, combined with ethical algorithms for environmentally-friendly logistics and seamless freight movements. The focus of the ePIcenter project is to develop AI-based solutions, logistics technologies and supporting methodologies, that enables the end-to-end optimisation of logistics processes to increase the efficiency of supply chains and reduce their environmental impact.

There is a significant amount of research and innovation initiatives around the areas to be addressed by ePIcenter, and the project will build on them to advance quickly on the analysis of current initiatives, the identification of new trends, and the definition and development of real innovations. The proposed innovations, methods, and tools should be built on previous efforts and developments in other initiatives. This paper focuses on the possibility of in-depth research on other ongoing or already completed funding projects.

Section 2 describes the research methodology; Sections 3 and 4 are devoted to results and findings, and Section 5 presents the conclusion.

2. Research Methodology

The main purpose of the ePIcenter project's first stage is to identify, summarize and structure the most up-to-date results gained during previous projects. This is aimed at ensuring progress in the development of innovative projects and pilot applications within the ePIcenter project since all stakeholders involved will have:

a) a holistic and comprehensive base of general knowledge;
b) the possibility of in-depth research and networking with other ongoing or already completed funding projects becomes possible and accessible.

The ePIcenter project unites 36 partners (port authorities, logistic service providers, manufacturers, academic institutions, technology partners, industry leaders, etc.) throughout Europe and beyond (see Figure 1) to develop and test AI-driven logistic software solutions, new transport technologies, and supporting methodologies to increase the efficiency of global supply chains and reduce their environmental impact.

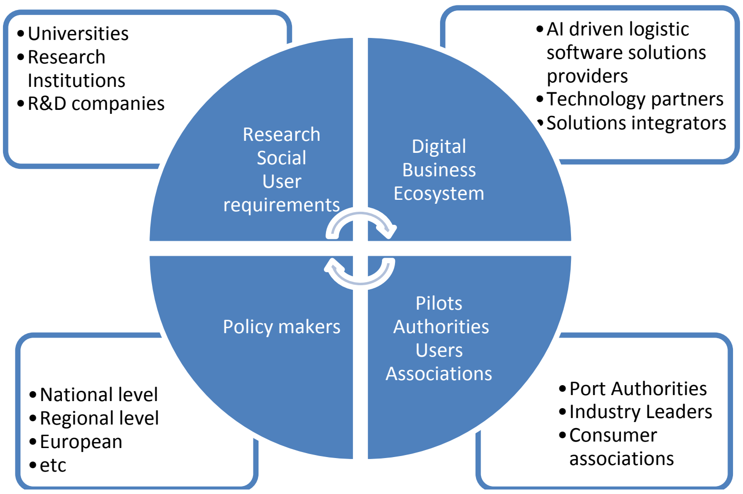

Figure 1. Groups of partners in the frame of ePIcenter

For identification and summarization of the state-of-the-art results and knowledge available through previous projects, a structured approach has been applied. Research of relevant projects has been elaborated through multi-channel research including European research and projects databases (CORDIS, Interreg databases), interviews with ePIcenter project partners and stakeholders, as well as working with regional databases and network sources (see Figure 2). The research focuses on relevant project data and their relationship to ePIcenter-relevant topics and technology fields, their areas of application, their innovation capacities as well as their potentials for exploitation and transfer of knowledge towards ePIcenter.

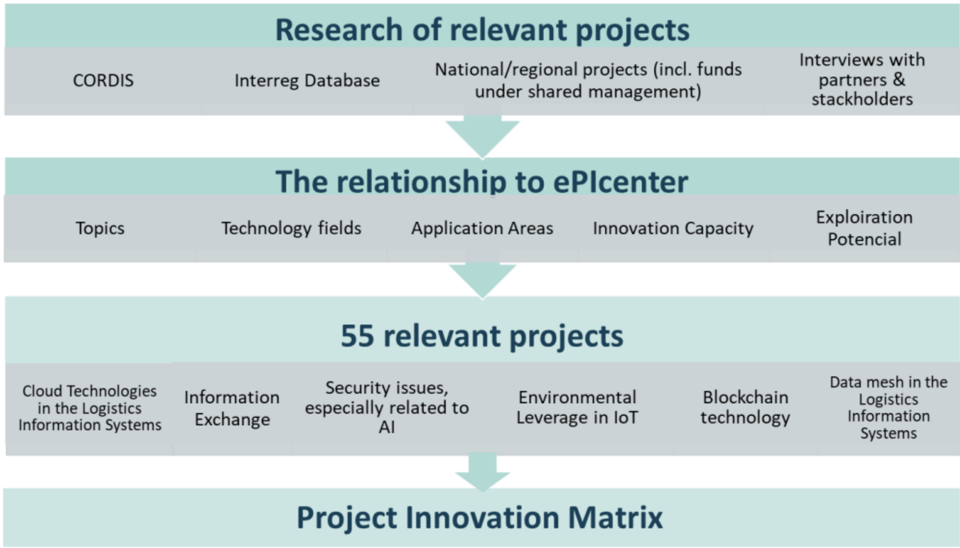

Figure 2. Research Methodology

Then the evaluation of the identified projects includes a structured, standardized project profile. This focuses the presentation on relevant project data and their relationship to ePIcenter-relevant topics and technology fields, their areas of application, their innovation capacities as well as their potential for exploitation and transfer of knowledge towards ePIcenter. It also makes it possible to compare project descriptions directly with one another. The structured approach described above has been applied based on a better knowledge of the needs and specifics of the ePIcenter research and pilot development.

Relevant projects, with synergies towards ePIcenter, have been analysed and clustered in terms of the most relevant topics with relevance for ePIcenter research: (1) Cloud Technologies; (2) Information Exchange; (3) Security Issues; (4) Environmental Leverage in IoT and (5) Blockchain Technology.

As finalizing element of the methodology, lessons learned as well as recommendations have been formulated with a focus on ePIcenter research and application partners to address specific projects identified for the sake of activating synergy potentials and assuring an efficient transfer of knowledge in joint fields of research and application between those projects and ePIcenter pilots being developed.

3. Results: Main Characteristics of Identified Projects

In total, 55 relevant projects, with synergies toward ePIcenter, have been identified. They have been analysed and clustered in terms of the most relevant topics with relevance for ePIcenter research. The result with a list of projects categorised into 4 groups:

a) 32 FP7 and Horizon programmes funded projects;
b) 14 Interreg programme funded projects;
c) 4 National/regional projects;
d) 5 other projects.

Different attributes of these projects were analysed. First, note that 49 from them have a global impact, and only 6 are local. Moreover, the potential for Exploitation and Knowledge Transfer is wide and includes developed Living Labs, Knowledge Hubs, etc. 28 projects are included it in the list of results (see Figure 3). The projects have several beneficiaries (see Figure 4).

Figure 5 is presented the main issues of investigated projects' Innovation capacity matrix. The matrix content is based on a study of relevant outputs and the tasks of reviewing projects and initiatives. The matrix includes digitization, technology used, innovation capacity, exploitation/transferability. Separately, after the matrix, the main technologies that are essential for the relevant developments and innovations in the frame of the ePIcenter project are analysed and considered (see Figure 6).

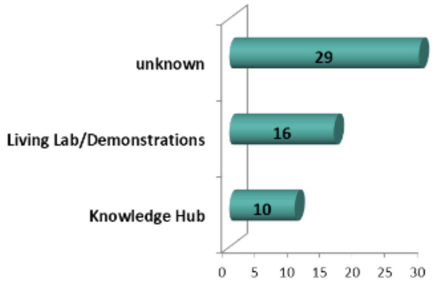

Figure 3. Projects' Ability to Exploitation and Transfer Knowledge

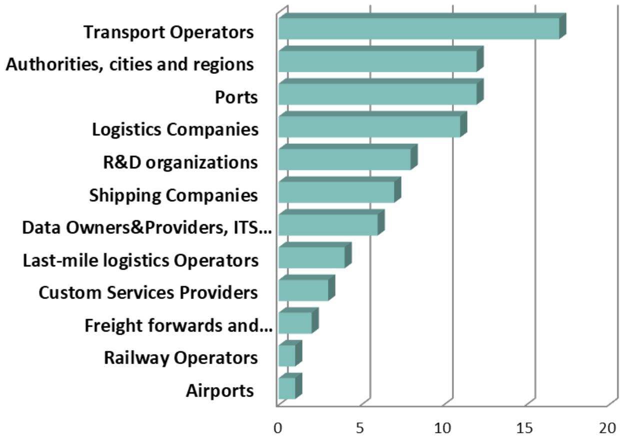

Figure 4. Main Project Beneficiaries

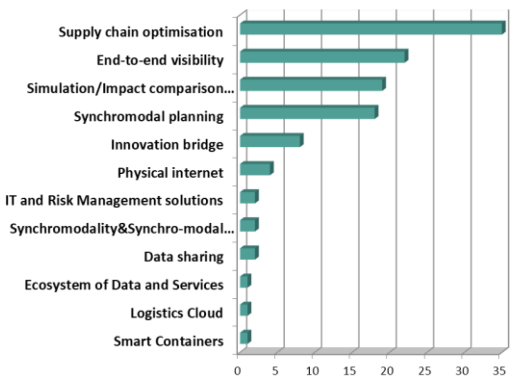

Figure 5. Innovation Capacity Matrix

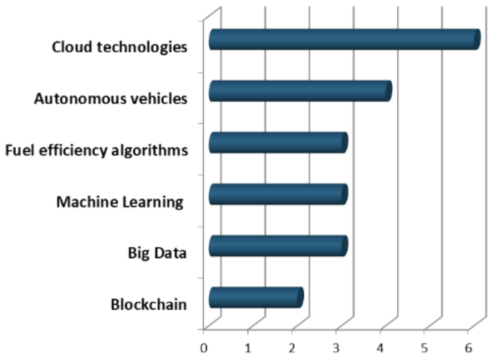

Figure 6. Digitalization: Used Technologies

4. Results: Lessons Learned from Previous EC-funded & International Projects

Based on the analysis of the project results and different solutions it is highlighted the 5 technological domains: information exchange, cloud technologies in the logistics information systems, security, environmental leverage in IoT, and blockchain technology.

4.1. Information Exchange

Related projects: NIMBLE (NIMBLE, 2022), AEOLIX (AEOLIX, 2022), ASAP (ASAP, 2022), AUTOBarge (AutoBarge, 2022), COMCIS (COMCIS, 2022), CONTAIN (CONTAIN, 2022), B2B

LOCO (LOCO, 2022), BOOSTLOG (BOOSTLOG, 2022), CORE (CORE, 2022), COREALIS (COREALIS, 2022), ICONET (ICONET, 2022), SAFEPOST (SAFEPOST, 2022).

Below are presented the main exploitable findings and outcomes.

There is a growing information demand generated by hinterland stakeholder to the port / terminal operator to improve the planning process of hinterland transportation as well as resource optimisation in both directions – import and export. A solution could be the integration of hinterland systems.

Another example of insufficient information exchange is the notification of vessel calls to the port. By exchanging more detailed information regarding Automatic Information System (AIS), estimated time of arrival process could be improved. More detailed information means also more productive performance of vessel waiting time at berth as well as better steering of embarkation and disembarkation operations as well as a more efficient ship supply/disposal of waste regarding e.g., water, bunker-services, or waste which is partly suboptimal.

But not only the improvement of data exchange and system integration are the focus of the activities but also the process optimisation e.g., the optimisation of customs clearance processes. In this case, the objective is to implement a higher level of security and more electronic data exchange instead of paper-based documents.

To conclude it should be mentioned that there are many different systems available along the supply chain and especially in the direct or indirect port environment which is a heterogeneous Information and Communication Technology (ICT) environment, but they are partly not well efficiently connected, and standards are missing in some sections. Although the National Single Windows are already implemented in most European countries (COM, 2022a), different reporting formalities are used regarding the following aspects where – on which way and when the message must be delivered.

Project "Architecture for EurOpean Logistics Information eXchange" (AEOLIX, 2022) provides a cloud-based collaborative logistics ecosystem for configuring and managing (logistics-related) information pipelines. AEOLIX ensures visibility across the supply chain, enabling more sustainable and efficient transport of goods across Europe. Existing collaboration in the ePIcenter supply chain can be improved using simulation from AEOLIX – more exchanging information on cloud system adoption contribute to ePIcenter innovation capacity.

Another aspect of information exchange is an open-access knowledge base with interactive elements embedded in a network of European cities and regions, currently being implemented by Awaken Sleeping Assets Project (ASAP, 2022).

The development of best practices should be addressed in best practice implementation actions stimulating modal shifts on the company or regional level, cooperation among stakeholders, or the introduction of best practices into administrative procedures.

4.2. Cloud Technologies in the Logistics Information Systems

Related projects: AEOLIX (AEOLIS, 2022), BOOSTLOG (BOOSTLOG, 2022), COMCIS (COMCIS, 2022), NIMBLE (NIMBLE, 2022), EMP 4.0 (EMP, 2022), HANSEBLOC (HANSEBLOC, 2022), ROboB (ROboB, 2022), Analytics and Big Data techniques for the development of intelligent and sustainable transportation systems (Sabana, 2022), Optimisation models and methods for inventory routing problem in humanitarian operations (Espejo-Diaz, 2020), Big-data-driven management system for trans-Arctic maritime transportation (Zhang *et al.*, 2019).

In the analysis of these projects, the following presented aspects were identified.

Research demonstrates increasing growth of demand for cloud technologies in building logistics information pipelines. Several advantages of using the cloud for logistics information system solutions identified.

(1) Data availability. Cloud systems positively affect various European projects and becomes an emerging trend. Using cloud technologies, logistics information systems can access resources from anywhere in the world and from any source. Cloud technologies support increased cooperation between various departments inside and external communication and make resources and infrastructure more available. Thanks to cloud innovation, cooperation between employees and departments increases: one can create joint discussions and track the progress of tasks.

(2) Security. The advantage of distributed denial-of-service (DDoS) protection in cloud solutions lies in the thorough analysis of traffic. Through analytics, normal traffic patterns are determined, which are then used as references when detecting threats. Most commercial solutions provide threshold-based alert mechanisms that are triggered based on the collection of information from logs. Another method of protection against DDoS attacks is multi-level filtering. Its advantage lies in the timely detection and mitigation of attacks at the network

and application levels. European logistics projects demonstrate the increasing demand for complex security solutions while maintaining comparable budget rates.

Storing user data according to EU data privacy regulations increases demand for complex solutions in the cloud. Logistic information systems consume sensitive user data that must be protected and anonymised. Data leaks and stolen data lead to extremely high reputational losses for European logistics projects exceeding financial losses. How data can be stolen from an on-premises information system? The system can be hacked due to user mistakes. Similarly, it is possible to steal data from the cloud, but in practice, it is much more difficult with more resources involved from the attacker's side.

Cloud storage is protected with modern software, data is encrypted, and access is granted after two-factor authorization. In addition, you can set the rights for each user, restricting access to a certain part of the information in the vault.

(3) Reduced cost on Internet traffic: all work on the collection and analysis of traffic takes place on the side of the provider. Successful mitigation depends on the ability to monitor and analyse traffic patterns in real-time.

(4) Infrastructure that means positive effect on project budget: no need to buy servers, maintain them, or hire system administrators – services-as-a-services can be used remotely for a small fee. Reduced investment in hardware and infrastructure (CAPEX), as well as the reduced costs of managing and maintaining typical hardware solutions (OPEX) make cloud technologies an inevitable support solution.

(5) Disaster recovery. Disaster recovery is an important benefit of cloud computing. Backups are stored on a secure server, and at the right time, the restoration of the latest version is started. Unlike a physical backup, the cloud backup frequency can be fine-tuned. In order not to waste time on a long recovery, you can run a backup of only part of the data, files, or system.

(6) Automatic software update. Often it is not enough to buy licensed software for an effective project lifecycle, software must be updated on time. Some updates are free, while others require payment. The advantage of using cloud technologies is timely software and OS updates at no additional cost.

(7) Environmental friendliness. Eco-friendly solutions are especially important for large logistics businesses, where any environmental pollution provokes a rating drop. Storing data in the cloud is more environmentally friendly than on-premises datacentre.

(8) The scalability of the cloud solution opens perfect opportunities for logistics information systems, where the amount of streaming data from various sources changes so often. It is possible to set up pay-as-go or pay-as-demand options best suitable for the project. Resources can be not only increased but also reduced. For example, a consumer service logistic network needs more capacity before the holidays and much less off-peak capacity. In a cloud computing environment, scaling happens in one click or even automatically.

If certain project does not want to waste time testing and selecting the optimal capacities empirically, it's possible to order additional audits – the cloud representatives will assess the scale of the project and recommend a suitable configuration, however, most of the leading cloud vendors provide advanced tools for budget allocation.

(9) Ecology. Advantages of cloud technologies in the context of ecology:
   a) less energy resources;
   b) electricity is spent wisely;
   c) paper consumption is reduced;
   d) reduced passenger traffic.

Along with undeniable advantages, cloud technologies have several disadvantages:
   a) cloud versions of some programs are not as convenient as on-premises;
   b) project requires a stable and fast internet connection;
   c) data can be lost forever if backup as a service is not set up;
   d) security depends not only on the settings but also on the human factor;
   e) high cost with the wrong choice of configuration.

Most of these shortcomings can be minimised with cloud configuration and adaptation. For example, to differentiate access rights to prevent data leakage; use a Firewall to restrict traffic; carefully set up the secure sockets layer; choose flexible platforms with easy/ transparent migration.

4.3. Security

Related projects: CONTAIN (CONTAIN, 2022), COMCIS (COMCIS, 2022), CORE (CORE, 2022), Cyber-MAR (Cyber-MAR, 2022), eMar (eMar, 2022), E-AIRPORT (E-AIRPORT, 2022), SAFEPOST (SAFEPOST, 2022), DataPorts (DataPorts, 2022), EUROSKY (CORDIS, 2022).

The main findings and issues are presented below.

Security is essential for the European projects in logistics. Risks emerge with new opportunities offered by AI in freighting (COM, 2022c). The damage from a cyberattack can reach EUR 50 million or more, which concluded to EUR 20 billion in 2021 (BCG, 2021). A recent issue happened with the BCG company, which reported about incident on September 15, 2021. BCG predicts ten times raise in ransomware damage, up to EUR 265 billion in 2031. As the reach of potential cyberattacks in the Transport and Logistics (T&L) sector increases and the nature of the risk becomes more diverse, the costs of hacking have dropped significantly. Moreover, the main source of vulnerabilities is not systems but people.

(1) To counter cyber risks in the T&L industries, action must be taken on three fronts: technology, regulation, and people and processes. It is highly recommended to increase cooperation with projects focused on T&L security solutions, starting from container security, and ending up with protecting the whole logistic network.

(2) FLYAPS (2020) emphasises that AI has become the most dominant force; it enters many areas of our life, becoming increasingly ubiquitous, and thus the topic of AI solutions for ethical decision-making is gaining a sharper look nowadays. To provide useful details which can help in the discussion on ER, we start with the definition of AI, which is still under debate (Juho, 2019). In the view of Accenture (2020), AI is “a constellation of technologies that allows machines to sense, comprehend, act and learn in order to extend human capabilities”. EPRS (2020) defines that intelligent behaviour means 'doing the right thing at the right time', while Machine Learning (ML) is the term used for AI which is capable of learning or adapting to the environment. European Commission's Communication on AI (ECCAI), defining AI and its sub-disciplines, emphasises that “AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behavior by analysing how the environment is affected by their previous actions” (COM, 2020; A Definition of AI, p.6).

The importance to focus on human-aligned AI (Vamplew *et al*., 2017), means that AI objectives are “aligned with human interests”. They stressed the gap between the abstractions defined at the theory stage, and the practical implementation of AI ethics. The importance of the human-aligned approach implies the need of examination for ethical issues for all categories and participants (Auernhammer, 2020).

(3) Automation of the process of ensuring transport security (TS) is of crucial importance. It is aimed primarily at information support for monitoring and controlling work on the formation of a given security regime, as well as preparing proposals for making management decisions during the operation of objects included in the concept of "transport security".

(4) Consideration of such an automation object as TS should be divided into two components: legal regulation in the field of TS and organizational prototypes of the operation of objects that are targeted by the safety action. Based on the international situation (COM, 2022b) possible TS threats are determined:

a) Vehicle capture.
b) Bombing threat.
c) Attempt to plant explosive devices.
d) Dangerous substances exposure.
e) Capturing a critical element of the TS facility.
f) Explosion of a critical element of the TS facility.
g) Route blocking.
h) Theft.

The possibility of a particular threat must be assessed for each safety Transport and Logistics & Transport Security (TL&TS) Object in the process of vulnerability assessment and considered in the future when planning measures to increase the security level of the safety facility.

Given international circumstances (COM, 2022b) EU T&L Network might be subject to hybrid attacks. Hybrid attacks on the transport network are a type of hostile action in which the attacking side does not resort to a classic military invasion but suppresses its opponent using a combination of covert operations, sabotage, cyber warfare, and supporting rebels operating in enemy territory.

Any T&L Project operating in the EU must be compliant with security measures, hybrid attacks resistant. Complex measures should be performed, so that TS would not become an object of hybrid warfare.

Hybrid attacks on the transport network pose a threat to the environment. They can cause direct or indirect damage to Europe's ecosystem, affect the total amount of CO2 emissions from a transport project, harm infrastructure, community, and people. It is important to achieve a potential minimum effect from hybrid attacks on the transport network to ensure the conditions of an environment-friendly transport network.

(5) Significant results are achieved by EUROSKY (CORDIS, 2022). EUROSKY replaced traditional X-ray technology with an innovative system that uses true multi-energy spectroscopic X-ray sensors in place of conventional scintillators. 'The resulting air cargo inspection system demonstrates significant improvement over existing capabilities by providing greater penetration of dense cargo, better image resolution and first-of-its-kind material discrimination,' notes Mark McCarthy of Rapiscan. The new X-ray systems are undergoing the necessary homologation before being commercialised.
One of the two mass spectrometers developed by EUROSKY is already available and used by border agencies in North America. The second will arrive on the market, however estimates are not clear. It will be the first such high-resolution portable instrument for accurate mass measurements in the field that promises to considerably increase the number of substances that can be detected.

(6) Key innovation is real-time logistics and supply chain software. Air freight operators can achieve significant improvements and cost savings, while benefiting from the increased security provided by the developed screening solutions.

4.4. Environmental Leverage in IoT

Related projects: DataPorts (DataPorts, 2022), COREALIS (COREALIS, 2022), AEOLIX (AEOLIX, 2022), BE LOGIC (BE LOGIC, 2022), BESTFACT (BESTFACT, 2022), E-FREIGHT (E-FREIGHT, 2022), eMar (eMar, 2022), JOULES (JOULES, 2022), PortForward (PortForward, 2022), EMMA (EMMA, 2022), Scandria2Act (Scandria2Act, 2022), Big-data-driven management system for trans-Arctic maritime transportation (Zhang *et al*., 2019), NEXTRUST (NEXTRUST, 2022).

Below is presented most important findings and analysis result.

Research points out that the sustainable development of communities and urban environments requires the use of green technologies in logistics, desiring to create a low-carbon society. To achieve the goal, the cohesive efforts of the government (UN, 2022), the private sector and research intuition are paramount to translating scientific results into the achievement of Sustainable Development Goals (SDGs). The Sustainable Development Goals Report 2021 accepts and reviews a wide range of green initiatives to achieve the SDGs (UN, 2021). It includes basic research on alternative fuels, smart and sustainable materials to reduce waste and environmental impact; technology systems design tools to develop sustainable consumption and production for communities; sustainable waste management system; circular economy and enabling strategies, for example through public policies and smart partnerships. Benefits for EU TL&TS:

a) economic, by increasing the revenues or reducing the costs;
b) environmental, by reducing energy footprint and pollution levels;
c) innovative, by offering newly introduced services.

ICONET significantly extended state-of-the-art research and development around the Physical Internet concept in pursuit of a new networked architecture for interconnected logistics hubs that combine with IoT capabilities and aim towards commercial exploitation of results.

JOULES project case: reducing emissions from shipping has increasingly become a challenge over the last years, both as a countermeasure against global climate change and to protect local environments and populations from waste, gas emissions, and noise.

In response to topic SST.2013.1-2 of the Sustainable Transport Work Programme 2013 the JOULES proposal aims to significantly reduce the gas emissions of European-built ships, including CO2, SOx, NOx and particulate matters.

JOULES follows an integrated and holistic approach, not only limited to integrating the components of the simulation of the energy grid, but through the consideration of other viable options for emission reduction. However, due to recent issues in the energy market related to the international situation project needs realignment according to the current situation.

The sustainability of the system plays an even more important role than three years ago in 2019. NEXTRUST (NEXTRUST, 2022) case can be interesting for future research. The NEXTRUST project objective was to increase efficiency and sustainability in logistics by developing interconnected trusted collaborative networks along the entire supply chain. These horizontally and vertically built trusted networks were integrated shippers, Logistic Service Providers, and intermodal operators as equal partners. To reach a high level of sustainability, the project not only bundle freight volumes but shifted them off the road to intermodal rail and waterway

The PortForward project (PortForward, 2022) can enhance sustainable development and manage the resources to be invested and their employment for a competitive advantage. Therefore, the port of the future needed to be oriented to port community and have an operative strategic capability to work, in line with European purposes, on the following:

a) smart, through ICT solutions, because it is important to improvement exchange of information flows between port and port community;
b) interconnected with the use of a combination of different modes of transport and the integration of different technologies, because it is important to achieve better monitoring and controlling of the freight flows;
c) green through the adoption of green technologies because it is important to reduce the environmental impact of port operations saving the resources.

The PortForward supports EU TL&TS to overcome the 2022-2023 energy crisis via increased system operation ability and effectiveness.

4.5. Blockchain technology

Related projects: DataPorts (DataPorts, 2022), Connect2SmallPorts (Connect2SmallPorts, 2022), HANSEBLOC (HANSEBLOC, 2022), ROboB (ROboB, 2022). Below are described the general outcomes and importance.

Blockchain in logistics increases the reliability and transparency of the supply chain (Champagne, 2014). It helps to avoid discrepancies in the documentation: for example, if the carrier and the consignee interpret the delivery time differently, the on-time delivery indicator suffers. With blockchain, this can be avoided, since all participants in the supply chain have access to the same version of all shipping documents. In addition, all data exchange is recorded in blocks, it is impossible to delete or change this information, therefore, in case of disagreement, it is much easier to find the root of the problem.

According to the Organization for Economic Co-operation and Development (OECD, 2021), the global counterfeit market reached EUR 420 billion in 2018, more than the GDP of countries such as Austria or Israel. Other studies show an annual loss of 1.6 billion tons of food (worth about EUR 1.2 trillion), 40% of which is spoilage during transport. At the same time, according to US Centers for Disease Control and Prevention estimates, a significant part of this spoilage ends up on the consumer's table, which in the US alone leads to 128,000 hospitalizations and 3,000 deaths (CDC, 2022).

As for the problem with counterfeit products, blockchain technologies make it possible to trace the origin of goods from the counter in the store to a specific manufacturer: a plant, a farm, an enterprise, or a person. And this data has a high degree of truth, since each batch of goods (or each product, if it is something large and/or expensive) is equipped with a radio-frequency identification (RFID) tag that constantly tracks the location of the goods and interactions between participants in the supply chain.

In addition, RFID sensors can also measure speed, temperature, humidity, and other empirical indicators. In this way, transport violations can be detected, and food spoilage can be detected, as well as the process or participant who is responsible for this can be traced. In addition, if a product is contaminated, for example, with the E. coli bacterium, then a blockchain-based system can identify the source of infection in a matter of seconds and track all infected batches of goods.

A typical delivery scenario involves about 30 parties: shippers and consignees, 3PLs, carriers, government agencies, banks, insurers, and others. At the same time, during the delivery of only one batch of goods, they exchange more than 200 paper messages: POD (delivery confirmation), invoices, and bills of lading (BOL). The maintenance fee for this paperwork is circa 10-15% of the shipping cost.

Blockchain adoption (Deloitte, 2018) could save the logistics industry 36 billion EUR a year. This will be possible thanks to smart contracts that automate most of the workflow and business processes. In addition, the distribution registry will reduce the number of errors, reduce delivery time, enable fraud detection and make cross-border operations more efficient (SOTATEK, 2022).

In its current state, the EU freight market lacks transparency (COM, 2018). There are no clear standards and rules that would regulate the issues of responsibility of the parties for compliance with transactions and explicit or implicit fraud. In addition, this market becomes less transparent during the COVID-19 period, which quite often leads to unpredictable changes in the cost of freight, despite the absence of significant changes in supply and demand.

5. Conclusion

Lessons learned analysis includes fifty-five relevant projects, with synergies towards ePIcenter. Projects have been analysed and clustered in terms of the most relevant topics with relevance for ePIcenter research. Research provides the following recommendations:

a) analysis demonstrates increasing growth of demand in cloud technologies in building logistics information pipelines;
b) the demand increased for information exchange inside the logistic ecosystem;
c) action must be taken to counter cyber risks in the T&L industries. It includes three fronts: technology, regulation, and people and processes;
d) research revealed the sustainable development of communities and urban environments require the use of green technologies in logistics and the desire to create a low-carbon society;
e) blockchain in logistics increases the reliability and transparency of the supply chain;
f) data mesh is a trending tech in logistics information systems.

Finally, lessons learned have been formulated with a focus on ePIcenter research and application partners to address specific project needs. They are identified for the sake of activating synergy potentials and assuring an efficient transfer of knowledge in joint fields of research and application between those projects and ePIcenter pilots being developed.

The research was implemented by the Transport and Telecommunication Institute (Latvia), in cooperation with Logistics Initiative Hamburg (Germany). The results are used as input for the ePIcenter relevant applications, that can easily be transferred to other end-users. Considering emerging technologies (e.g. hyperloop, automated vehicles) and trade routes (Silk-route, Arctic-route) in the simulation modules, the project also prepares for the future and challenges ahead. Ultimately project contributes to a more efficient and sustainable multimodal freight transport system and logistics.

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