

Austrian research, technology and innovation (RTI) competences in the domain of „Physical Internet and transport logistics“

Financed by bmvit within the program „Mobility of the Future“

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Vienna, 23.08.2017



Partner



Imprint

Proprietor, publisher and media owner

Federal Ministry of Transport, Innovation and Technology A - 1030 Vienna, Radetzkystrasse 2
Website: www.bmvit.gv.at

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1 Introduction

The diverse use of ICT technologies within the fourth industrial revolution is about to change the way how organisations are organized, are producing, offer services and communicate in various ways. The digitization and intelligent cross-linking (networking) of industrial production encompasses the entire value chain and thus also includes far-reaching changes in the transport and logistics (T&L) sector.

In 2011 the concept of “Physical Internet” (PI) was introduced as a framework for the global organisation of logistical networks based on physical, digital and operational interconnectivity for increased efficiency and sustainability¹. It represents a realization of the Internet of Things in the context of transport of goods and logistics networks, i.e. uniquely identifiable objects receive a representation in a virtual world. The objects, however, are not the goods themselves, but “intelligent” containers, which not only store information about their content, but are also capable of dynamically optimizing transport flows. The goal of the Physical Internet is to use the principles of sending data packets through the digital internet in order to create more efficient and sustainable logistics.

The European Technology Platform for Logistics ALICE² aims to develop a comprehensive strategy for research, innovation and market launch of logistics and supply chain management in Europe in order to increase European competitiveness and achieve targeted sustainability goals and advises the Commission in the implementation of Horizon 2020 in the field of logistics. The vision of ALICE for 2050 is based on the principles of PI.

However, for the full realization of PI, innovations in many areas are indispensable. This applies not only to new business models, but also to infrastructure, machines and tools as well as data exchange. Here, the question is whether it is possible to generate innovative potential from the area of PI, or whether the starting point for innovations can be seen in the underlying (digitized) logistics process.

In Austria, research institutes and companies have already taken up elements of PI as research topics. A number of specific national R&D and exploratory projects have already been or are being carried out as part of the research, technology and innovation (RTI) program “Mobility of the Future” and the strategic program “Innovative Upper Austria 2020”. In July 2017, the Fourth International Physical Internet Conference (IPIC) took place in Graz.

With regard to the future strategic positioning of Austria in this topic, the research question arises as to which RTI competencies and actors in Austria are currently available, or where the starting points for RTI policy support measures are.

This brief study is intended to give an overview of national RTI competences in Austria and the respective stakeholders. Basis of this was the analysis of contents and actors of already funded projects regarding PI in Austria. Sub-topics, strengths and potentials for development were identified and discussed in-depth with stakeholders. For this purpose, several expert interviews were conducted and a stakeholder workshop was organised at the IPIC conference. Thus with this stakeholder consultation, involving a small but influential community, awareness for the issue of PI was increased and some RTI policy issues were raised.

¹ The Physical Internet is a global logistics system based on the interconnection of logistics networks by a standardized set of collaboration protocols, modular containers and smart interfaces for increased efficiency and sustainability. See also Montreuil et al. (2011).

² See also ALICE (2017): A Truly Integrated Transport System for Sustainable and Efficient Logistics. <http://www.etp-logistics.eu/?p=1298>

2 Status Quo of PI Innovation in Austria

2.1 RTI Framework Conditions in Austria

Increasing mobility needs, simultaneous resource depletion and limited capacities require innovative solutions and approaches in research, innovation and technology policy. PI as a framework for the global organisation of logistics networks based on physical, digital and operational interconnectivity aims at increased efficiency and sustainability. Within five roadmaps the European Technology Platform ALICE especially addresses the following topics:

- Sustainable, safe and secure supply chains
- Corridors, Hubs and Synchromodality
- Information systems for interconnected logistics
- Global supply network coordination and collaboration
- Urban Logistics

The national research, technology and innovation (RTI) program 2012–2020 „Mobility of the Future“, run by the Austrian Federal Ministry of Transport, Innovation and Technology (bmvit), with an annual budget of approximately 20 million Euro, focuses on securing mobility while minimizing negative consequences of transport. Holistic solutions for the “Mobility of the Future” should aim at balancing the interest between society, environment and economy. The program line „organizing freight mobility in new ways“ thus aims at securing the supply of goods and services for society, the reduction of energy and resource depletion for the environment and a competitive transport sector as well as competence leadership in mobility for economy and research.

At the heart of the program are cooperative research and development (R&D) projects where companies co-develop new, respectively, improved products, processes and services for freight transport and transport industry with other companies or research institutes. 2013 and 2014 calls for RTI projects also addressed research relevant for the domain of PI³, e.g. sustainability of transport, especially within cities, intermodal hubs, and innovative transport means and media. According to the RTI roadmap of Mobility of Goods⁴ a flagship project in the considered research field is planned in order to create synergies, but especially a critical mass of relevant actors for increased visibility and impact. In 2015 within the RTI program “Mobility of the Future” bmvit announced an endowed professorship at Johannes Kepler University of Linz focusing at digital transformation and sustainable transport logistics including also activities towards the Physical Inernet which will be occupied in 2018.

Additionally to these major national strategic ambitions towards future mobility research, which strongly support research in the area of efficient and sustainable future transport, other funding possibilities for research related to this topic on a smaller scale were identified and are described in the following paragraph.

Upper Austria’s regional smart specialization strategy and current strategic economic and research program “Innovative Upper Austria 2020”, among others, focuses on research in the area of mobility and logistics. The program is being implemented from 2014 to 2020⁵. As a part of its implementation the “Smart Mobility” call was launched from November 2015 until March 2016. The areas focused on were intelligent and safe transportation systems, innovative drive concepts, materials technology and smart production. The call was issued jointly by the provinces of Upper Austria and Styria and had a budget of 3.8 million Euro.

Austria’s Climate and Energy Fund which is funded by the two ministries bmvit and The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) supports

³ See also <https://infothek.bmvit.gv.at/physical-internet-queteer-im-transportnetz/>

⁴ See also Bundesministerium für Verkehr, Innovation und Technologie – bmvit (2015): BMVIT-Programm „Mobilität der Zukunft“- Forschungs-, technologie- und innovationspolitische Roadmap zur Ausrichtung des Innovationsfelds Gütermobilität, August 2015

⁵ See also <http://www.ooe2020.at/aktionsfelder/mobilitaet-logistik/>

transport research. Funding opportunities for PI specific research can be found especially in the field of last mile and e-mobility research.

2.2 National R&D Projects and Explorative Studies

In Austria elements of PI were taken up by research organisations and companies in the past. National funded R&D projects as well as projects funded by the EU were taken into account to obtain an overview of actors and stakeholders within the field of PI. A distinct line was drawn between research projects that dealt with logistics and transport only to extract the projects referring to PI and its components in the strictest sense. Thus projects taken into account are listed in Table 1. Most projects were funded within the RTI program “Mobility of the Future” (MoF) - “Mobility of Goods” (see also previous chapter). Two projects by FH Logistikum Steyr were furthermore funded by the Initiative “Innovative Upper Austria 2020”.

Table 1: Austrian collaborative projects and exploration studies focusing on PI research⁶

Project	Short Description	Funding Progr.
ATRO-PINE	In accordance with ALICE the ongoing project designs a ‘PI Innovation Chain’ for the economic region involving research, regional businesses and logistics partners. In an applied R&D project with more than 15 regional logistics service providers and core industry partners the team will test several prototypes, such as the so-called ‘smart transport units’ that are able to communicate with transport means and or material handling devices. The project team also designs business models which support the idea of a sharing economy. The project addresses all main aspects of a PI model region, except intermodality.	Innovative Upper Austria 2020
Cinder-railer	In the project the first modular logistic systems as a future concept for railroad transport was implemented. The challenge of cinder, slag, gypsum and refuse-derived fuel transportation offers ideal conditions of developing a logistical service implying a substantial increase in productivity. This allows a significant increase with respect to competitiveness of railroad transportation in the future. The project mainly contributes to PI containers and their handling.	Mobility of Goods MoF 3rd Call (2013)
Daten-Verkehr	In order to produce sustainable traffic and environmental solutions in the vicinity of the transport of goods innovative services for vehicles, traffic management and logistics were explored. Fundamentals for data fusion of familiar and new data sources were defined. Based on the initial investigations a decision support tool was developed that assists in the prioritisation process of services to be developed based on benefit potentials and requirements from stakeholders. The project contributed to data issues within the PI information infrastructure.	Mobility of Goods MoF 5th Call (2014)
Go2PI	Based on the case study of an Austrian company, criteria and guidelines regarding aspects of technical and information systems as well as processes were evolved in order to develop a neutral and open business model in the area of distribution logistics. Thereby the use of future loading and transport devices of PI in combinations with future PI-ICT were postulated and further a roadmap to the PI-services was designed. The project addressed all main aspects of PI.	Mobility of Goods MoF 5th Call (2014)
Green-CityHubs	The research project developed a concept of sustainable inner-city delivery logistics using inner-city distribution centers (City Hubs) and alternative	Mobility of Goods

⁶ See also <https://mobilitaetderzukunft.at/de/artikel/medien/physical-internet.php>

	fuelled vehicles. The problem was addressed from the technical, urban planning and transit oriented view. This explicitly interdisciplinary research approach led to an economically, socially and ecologically balanced result, which was evaluated by metrics of delivery service, economics, energy usage, and environmental emissions. The project mainly addressed aspects of PI hubs, operational processes, and collaboration.	MoF 3rd Call (2013)
ILKÖ	The project aimed to develop an integrated end-to-end logistics network for rail freight transport focusing on Combined Transport in Austria. Existing barriers between the different players should be dismantled and an innovative, neutral logistic-network in the approach of a one-stop-shop should be designed. The essential output of the project consists of an innovative software-architecture and an implementable organisational and business model. The project mainly addressed aspects of PI information infrastructure and intermodal collaboration.	Mobility of Goods MoF 3rd Call (2013)
KoLaM-Bra	Within the project, a collaborative operating model and organisational concept for the last mile logistics industry was developed, with the aim to consolidate the flow of goods into or out of the city. The project mainly addressed PI through last mile logistics by aspects of collaboration and business models.	Mobility of Goods MoF 1st Call 2012
protoPI	The ongoing project will derive a smart logistic system for upper austrian and styrian supply chains by means of PI. Main impact will be generated by intelligent networking of shippers and senders with innovative web-technologies as well as smart business solutions and new container technologies. This will lead towards sustainable systems, transport volume reduction and improved competitiveness. The project addresses all main PI aspects.	Smart Mobility Call by Upper Austria and Styria
Q4	The combination of four modes of transport (water, rail, road and air) to multi-modal transportation networks is still a peripheral issue with many unknowns. The "Q4-project" was dedicated to filling this knowledge gap. It examined the contribution of quattro-modal freight hubs towards an economically, ecologically and socially sustainable freight transport system and identified questions for future R&D programs / projects. The project addressed PI by investigating the concept of quattromodal hubs.	Mobility of Goods MoF 5th Call (2014)
RTM-O and Upgrade	Project scope was the development of a capacity management and optimization tool for an "end to end (e2e) integrated rail supply chain (SC)" from the rail hub/feeder line of the shipping customer, to the rail hub/feeder line of the receiving customer. Rail Transport Mobility- Optimization "RTM-O upgrade" is the second stage of the project with the scope to develop a capacity management and optimization tool for an "end to end (e2e) integrated rail supply chain (SC)" from the rail hub/feeder line of the consignor, to the rail hub/feeder line of the consignee. Stage one focused on the development of a desktop-demonstrator. Stage two is building-up on the findings of the first part and will develop a prototype in the end. The project addresses all main PI aspects.	Mobility of Goods MoF 3rd Call (2013)/ 5th Call (2014)
Smart-box	The aim is to reduce traffic density by using a prospectively integrated system for autonomous general cargo, luggage and package transport and simultaneously promote passenger traffic by developing a system for public freight traffic. Passengers will be getting rid of their luggage as well as passenger traffic and freight mobility are going to be installed at once. The project mainly addressed aspects of PI containers, handling and storage, and a new business model.	Mobility of Goods MoF 3rd Call (2013)
Syn-chain	SynChain aimed on the one hand at a profound understanding of the underlying concepts of synchromodal transport in order to identify key enablers and present suggestions for establishing technical, organisational and systemic basic conditions. On the other hand it aimed to increase awareness for this transport system among stakeholders which is needed simultaneously to establish a working synchromodal transport system in Austria. The project addressed the concept of synchromodality, an important aim within PI.	Mobility of Goods MoF 3rd Call (2013)

In Table 1 projects are shortly regarded concerning their contents and relevance for PI. As main aspects of PI (physical, digital and operational interconnectivity of logistics for increased efficiency and sustainability) are regarded the four topics shown in Figure 3: Physical Infrastructure including smart containers, handling & storage; open & secure information infrastructure; operational processes including synchromodality & hub design; collaboration & business models, all together supporting the overall aim of increased efficiency and sustainability.

The following additional projects were mentioned by the interviewed experts. They were found relevant for PI research in a broader sense of raising efficiency and sustainability of transport and logistics but were not picked for further analysis in this study, funding programs in brackets (for further information see previous chapter):

CCONT - Cooperative Container Trucking (MoF, Mobility of Goods, 3rd Call (2013), PI aspects: optimized operational processes, collaboration):

This project addressed the organisation of the first/last mile of container transports by truck. The goals were to improve the competitiveness of the transport logistics providers in the local region and to meet the increasing requirements of the disposition of container trucking through research in three directions:

- a) optimization algorithms of the complex, multiple resource routing problem,
- b) dynamic vehicle routing enabled by real time GPS and event tracking of the vehicles, and
- c) a novel approach to cooperation between carriers resulting in shared, optimized routes.

ICIIT-TMF - Intelligent Cargo Infrastructures for Intermodale Transport Chains (MoF, Mobility of Goods, 5th call (2014) PI aspects: optimized operational processes, intermodality): ICIIT-TMF is the follow-up of the ICIIT project in which an innovative ant colony optimization⁷ (ACO) algorithm has been developed that is capable of solving complex problems regarding the automated formation and optimisation of intermodal transport chains.

TRIUMPH (IV2Splus – Intelligent Transport Systems and Services PLUS, program line I2V – Intermodality and Interoperability of Transport Systems) and TRIUMPH II- Trimodal transshipment centre port (MoF, Mobility of Goods 1st Call (2012), PI aspects: optimized operational processes, intermodality, and collaboration):

The projects were aiming at a self-learning system that estimates arrival times of container vessels and trucks, determines deviations and cross-links all participants in the intermodal transport chain.

Emilia - Electric Mobility for Innovative Freight Logistics in Austria (Climate and Energy Fund of the Austrian Federal Government, 7th Call - Austrian Electric Mobility Flagship Project, PI aspects: optimized operational processes and collaboration, esp. city logistics):

EMILIA primarily focusses on the development and experimental implementation of novel freight logistics concepts for urban areas especially tailored towards a significant use of electric mobility ranging from e-cargo tricycles to alternative fuelled road trains⁸.

LEEFF - Low Emission Electric Freight Fleets (Climate and Energy Fund of the Austrian Federal Government, 7th Call - Austrian Electric Mobility Flagship Project, PI aspects: optimized operational processes and collaboration, esp. electromobility):

In the LEEFF project, an advanced electric vehicle above 3,5t (eVan) together with an adapted bat-

⁷ In computer science and operations research, the ant colony optimization algorithm (ACO) is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs. Source: https://en.wikipedia.org/wiki/Ant_colony_optimization_algorithms

⁸ Road trains belong to long combination vehicles which are combinations of multiple trailers on tractor trucks. A road train has a relatively normal tractor unit, but instead of towing one trailer or semi-trailer, it pulls two or more of them. Sources: https://en.wikipedia.org/wiki/Road_train; https://en.wikipedia.org/wiki/Long_combination_vehicle

tery and a smart charging station for commercial use at logistical hubs will be developed and an innovative business model for fleet operators together with adapted planning and communication tools will be realized as a prototype.

COSIMA - Consistent Stochastic Inventory Routing Management (Austrian Science Fund, PI aspects: optimized operational processes):

The ongoing project integrates two core logistics decisions in supply chains typically investigated independently or sequentially: inventory management and transportation routing optimization.

FEAT- Fair and Efficient Allocation of Transportation (Austrian Science Fund, PI aspects: optimized operational processes and collaboration):

The main goal of the ongoing project is to study collaborative mechanisms to reallocate trips between carriers and thus improve the system-wide efficiency.

2.3 Austrian Activities on European Level

The European Technology Platform ALICE (Alliance for Logistics Innovation through Collaboration in Europe) aims to develop a comprehensive European strategy for research, innovation and market deployment of logistics and supply chain management innovation⁹. The platform supports and assists the implementation of the EU Program for research Horizon 2020. Within the working groups of ALICE a “vision for a transport system supporting sustainable and efficient logistics towards PI” was drawn up and working groups were established aiming to increase the efficiency in the EU logistic sector by 10-30%.

Gebrüder Weiss Logistics, Logistics Research Austria, and University of Applied Sciences Upper Austria – Logistikum Steyr represent Austria’s industry and academia within all ALICE working groups (WG): WG1: Sustainable, safe and secure supply chains; WG2: Corridors, hubs and synchronicity; WG3: Information systems for interconnected logistics; WG4: Supply chain coordination and collaboration; and WG5: Urban logistics.

In ALICE Mirror Group where discussions between the European Commission and the Member States take place Austria is represented by the Austrian Ministry for Transport, Innovation and Technology (bmvit) and the Austrian Logistics Network Association. Austrian Logistics Network Association is also part of ALICE’s Steering Group where strategic decisions are made and identified topics are prioritized.

Within Horizon 2020 three projects regarding PI in the strictest sense were funded, where Austrian organisations were involved: iCARGO, MODULUSHCA und NEXTRUST.

⁹ ALICE was originally created in the frame of the European WINN project (FP 7, 2012-2015) having the European Green Cars Initiative (logistics section) and EIRAC, European Intermodal Research Advisory Council, as background and supporting initiatives. ALICE was officially recognized as a European Technology Platform by the European Commission in July 2013. (Source: http://www.etp-logistics.eu/?page_id=29)

Table 2: European PI projects with Austrian participation

EU-Project	Long Title	Funding Program
iCargo	Intelligent Cargo in Efficient and Sustainable Global Logistics Operations	FP7 - ICT-2011.6.6 - Low carbon multi-modal mobility and freight transport
Modulushca	Modular Logistics Units in Shared Co-modal Networks	FP7-TRANSPORT - Towards sustainable interconnected logistics - development of standardised and modular solutions for freight transport vehicles, loading units and transshipment equipment
Nextrust	Building sustainable logistics through trusted collaborative networks across the entire supply chain	H2020 - MG-6.1-2014 - Fostering synergies alongside the supply chain (including e.commerce)

iCargo with FH Vorarlberg as partner from Austria aimed at advancing and extending the use of ICT to support new logistics services that: (i) synchronize vehicle movements and logistics operations across various modes and actors to lower CO2 emissions, (ii) adapt to changing conditions through dynamic planning methods involving intelligent cargo, vehicle and infrastructure systems and (iii) combine services, resources and information from different stakeholders, taking part in an open freight management ecosystem. **The project addressed PI research mainly through new operational processes and collaboration models by investigating new logistics services for efficiency and sustainability.**

In MODULUSHCA the Technical University Graz was involved as a partner of the consortium. The objectives of this project were achievements in the development of interconnected logistics at the European level, in close coordination with North American partners and the international PI Initiative. The goal of the project was to enable operating with developed iso-modular logistics units of sizes adequate for real modal and co-modal flows of fast-moving consumer goods (FMCG), providing a basis for an interconnected logistics system for 2030. **The project mainly focused on PI smart containers.**

In the still ongoing project NEXTRUST Wenzel Logistics GmbH, Borealis L.A.T. GmbH and Blue-wave GmbH are participating from Austria. NEXTRUST objective is to increase efficiency and sustainability in logistics by developing interconnected trusted collaborative networks along the entire supply chain. These trusted networks, built horizontally and vertically, will fully integrate shippers, logistics service suppliers (LSP) and intermodal operators as equal partners. NexTrust is coordinating 33 different pilots which address problems across the length and breadth of the logistics industry. These include: Bundling freight volumes to reduce the number of vehicles running empty, or at less than full capacity; Shifting freight from the road onto rail and waterways which are more carbon-efficient, and creating and refining technologies designed to optimise efficiency in logistics, including re-engineering networks and improving real-time utilisation of transport assets. **Regarding PI research the project mainly addresses a common information infrastructure and collaboration through new business models.**

In July 2017 the 4th International Physical Internet Conference (IPIC) took place in Austria at Graz University of Technology. At this international key event on PI research presentations and workshops were framed by keynotes from research, industry, and public authorities bringing PI contents and a strategic framework to the audience.

2.4 Network of Austrian Actors and their European Partners

In this chapter we regard Austrian actors involved in either national collaborative projects and explorative studies (as given in Table 1) or European projects (as given in Table 2), both focusing on important aspects of PI.

The Austrian actors involved in these projects fulfill various roles in the freight logistics innovation ecosystem: universities as producers of basic knowledge, research and technology organisations (RTOs) as producers of applied knowledge, intermediaries as knowledge brokers, and companies as key partners for downstream innovation in the value chain.

The current landscape of funded projects (see Table 3) shows that companies account for almost two thirds (25) of the total number of actors (38) which reflects the innovation-orientation of the research program(s). Classified by main economic activity, half of the companies (11) provide transport and storage and six provide technical/scientific services. Four companies have information and communication as main economic activity and three focus on the production of goods.

Table 3: Actor types involved in RTI in the domain of PI in Austria (based on Table 1 and Table 2)

Actor type	No.
University / Univ. of Applied Science	11
Research and Technology Organisations	1
Companies (in total and by ÖNACE*)	25
Production of goods (ÖNACE C)	3
Wholesale and retail trade etc. (ÖNACE G)	1
Transportation and storage (ÖNACE H)	11
Information and communication (ÖNACE J)	4
Technical/scientific services (ÖNACE M)	6
Intermediaries	1
Total	38

*) ÖNACE (Austrian Statistical Classification of Economic Activities) is the Austrian version of the European NACE.

In order to make nodes and key organisations in Austria visible a network of project partners was calculated for the projects listed in Table 1 and Table 2 using Pajek software. The resulting network (see Figure 1) shows Austrian actors (marked with labels) involved in recent PI collaborative projects and exploration studies and their European partners (non-labelled) as network nodes. The edges of the network occur between collaborating actors.

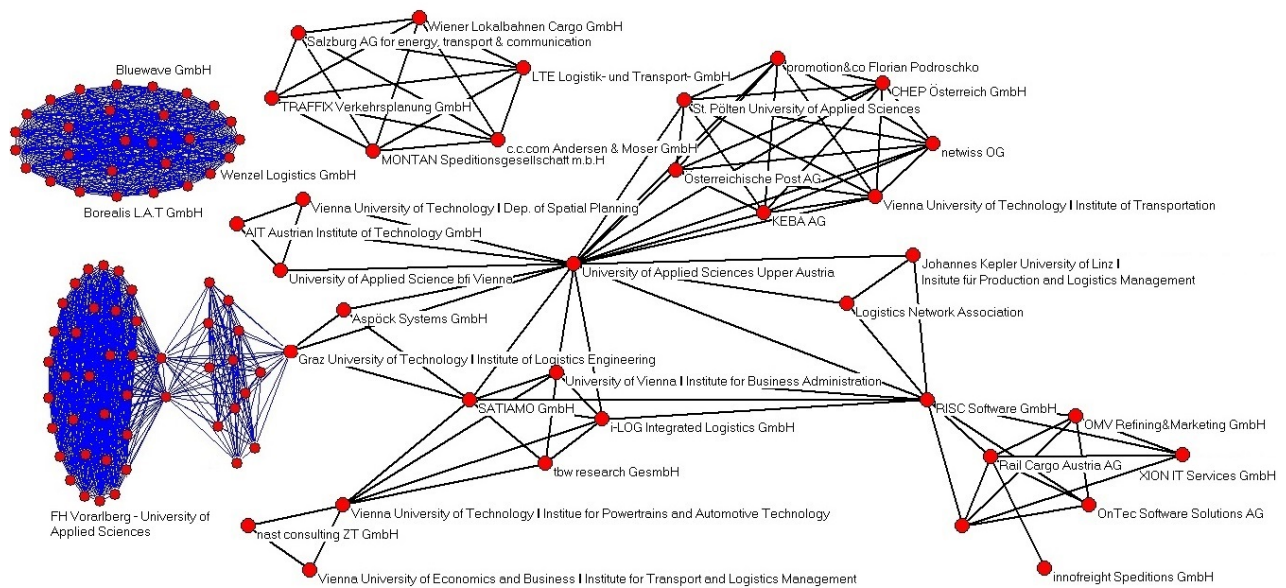


Figure 1: Austrian PI research actors plus their European partners (not labelled) based on Table 1 and Table 2; Network created with Pajek software

Table 4: Austrian PI network key players

Organisation	Type of actor	Role in the network	Collaborative Projects/Exploration Studies
University of Applied Sciences Upper Austria – Logistikum Steyr	University / Univ. of Applied Science	Most central actor and knowledge broker	Go2PI; ProtoPI, KoLaMBra; Q4; smartBOX; Synchain; ATROPINE
Graz University of Technology – Institute of Logistics Engineering	University / Univ. of Applied Science	International link	Modulushca; Go2PI; ProtoPI
SATIAMO	Company	Knowledge broker ¹⁰	ProtoPI; GreenCityHubs Go2PI; KoLaMBra
RISC Software GmbH (owner: 80% JKU, 20% OÖ)	Company	Knowledge broker	KoLaMBra; ATROPINE; RTM-O
University of Vienna – Institute for Business Administration	University / Univ. of Applied Science	Knowledge broker	GreenCityHubs; KoLaMBra
i-LOG Integrated Logistics GmbH (Schachinger Logistic-group)	Company	Knowledge broker	GreenCityHubs; KoLaMBra;

¹⁰ Knowledge brokers are linking different communities

Organizations at most relevant positions in the network are listed in Table 4. We regard actors as key players of the network here, who have most central or efficient positions in the network, i.e. they link different research communities. It is worth noting that the majority of these key players are located in the province of Upper Austria where the provincial government is going to set-up a model region.

2.5 Innovation Readiness

Research, technology and innovation development within the area of PI was regarded based on the described initiatives and conducted interviews. Figure 2 shows the estimated actual and possible future technology readiness of collaborative transport and PI in Austria including also organisational innovations, such as new business models and collaboration structures. These estimations specifically regard Austria, however, one country cannot be seen separately within this European or even worldwide topic. Most of the research fields are still at a very early stage all over Europe and are only starting to enter the technology development and prototype phase.

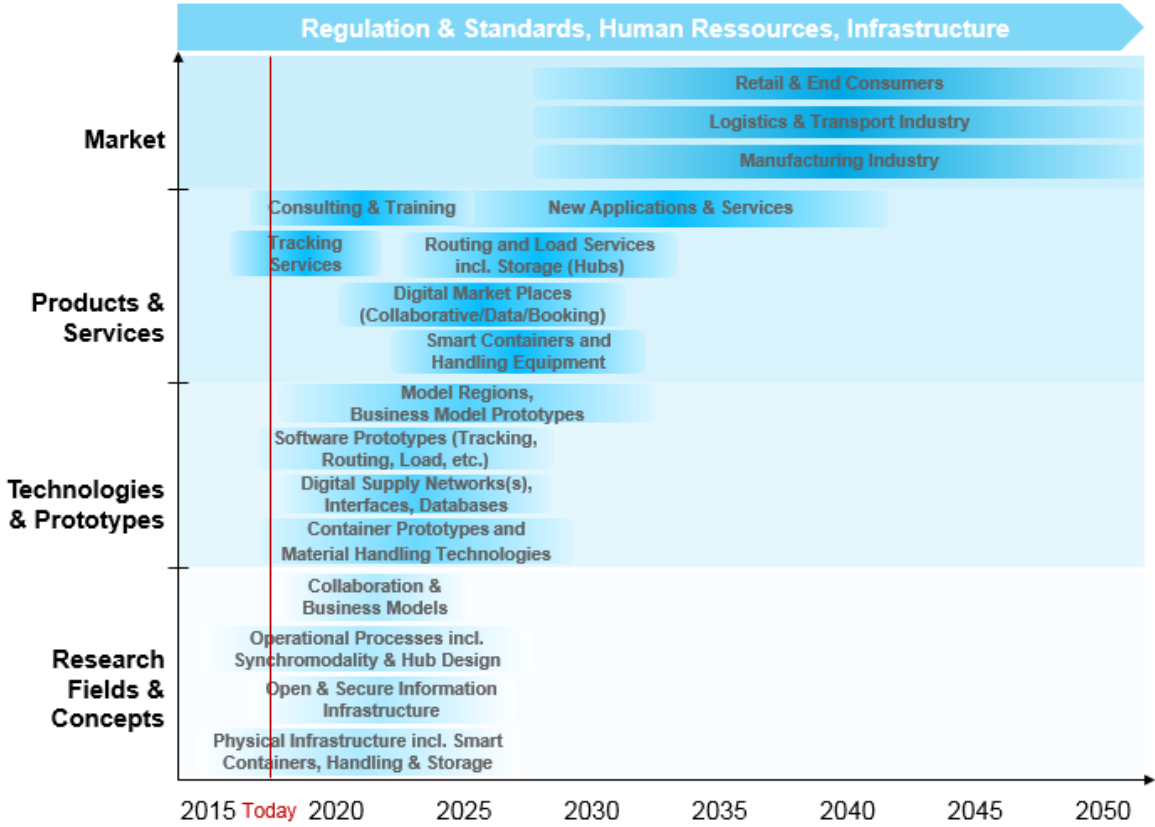


Figure 2: Estimated actual and possible future innovation readiness of collaborative transport and PI in Austria; Source: own depiction, based on Figure 3 and on interviews

From the main components of PI four main categories of research fields were defined, which of course have interconnections which each other, in order to give an overview of the needed developments. These will be further described in the next chapter (see Figure 3). Ongoing research in the

fields relevant for PI will be the basis for the development of technologies and working prototypes, later followed by products and services on the market.

First, a common European or even worldwide interconnected and standardized physical transport and logistics network needs to be developed. This includes also smart containers and their storage and handling along intermodal transport ways. For this strong efforts will be needed in the future. Major standardization issues, maybe supported by means of regulation, need to be solved in the future. Inter- and multimodal transport will have to be established and strongly supported in Europe for sustainability reasons. However, besides standardized and common transport ways also PI containers and their handling and storage technologies need a lot of further investigation and standardization. In the future existing transport containers will have to be substituted by more sophisticated solutions addressing all functions of PI, which will still take a lot of time and investments.

Parallel, a standardized network of information infrastructure for digital communication within PI needs to be established. Based on data exchange in the World Wide Web, any relevant information in a digital value network has to be delivered in real time by the players participating in PI. Here, also major standardization efforts are needed concerning data formats, system interfaces, etc. Also relevant questions of data ownership, transparency, and safety and security issues within the system will have to be solved in the future, building a reliable basis of trust within participating partners. Strong efforts are also needed to realize the digitalization of the logistics and transport system in Austria (and Europe). Investments in the necessary IT infrastructure and in respective human resources will have to be made by T&L partners.

Provided these infrastructural elements of PI, one major component of PI research and development consists of operational processes running on the system, providing the dynamic behavior of its elements and building “the brain” of the system. In addition, new software developments, services and applications will provide a great variety of opportunities, especially to fulfil higher customer needs in the future. Here, at the moment a lot of research is done in order to address optimization of e.g. load and transport routes and for providing tracking and other services. The processes performed by intermodal or even synchromodal hubs which will act as routing centers will play a central role within PI.

Based on these hardware and software elements of a collaborative and digitally communicating logistics and transport system new business and collaboration models are needed in the future. Actor roles within the innovation system are going to change considerably. Participating actors will need attractive solutions for collaborating and sharing profits which suit their businesses well. Organizational change processes will be essential to guide and enable companies in times of disruptive system changes. A variety of consulting and training services are going to accompany, push, and concertate these changes.

3 RTI competences of Austrian Actors

3.1 Research Topics and Austrian Strengths

The following chapters are based on desk research, interviews, and also include results from a stakeholder workshop which was organized in the framework of this study at the IPIC 2017 conference in Graz and hosted by bmvit¹¹. More than 20 participants representing academia, consultancy, T&L or manufacturing industry discussed questions of future transport and logistics in a national and European context. Some specific topics as well as Austrian strengths and potentials for development were discussed in small groups, awareness for the issue of PI was increased and some RTI policy

¹¹ See also https://www.ffg.at/sites/default/files/allgemeine_downloads/thematische%20programme/Mobilitaet/agenda_ws_ipic_final.pdf

issues were raised. Some of the results of group discussions are found in boxes in the following chapters.

PI as a whole concept of sustainable collaborative transport comprises several important components which are essential for its functioning as described in the previous chapter. However, these components can be seen and researched as elements of future logistics and transport by themselves as well. Hence, PI can be seen as a systematic consolidation of these components.

Figure 3 shows a visualization of such main components of PI to give an overview of the regarded research categories which are in correspondence with research fields and concepts of Figure 2. The following analysis of Austrian competences is based on these categories.

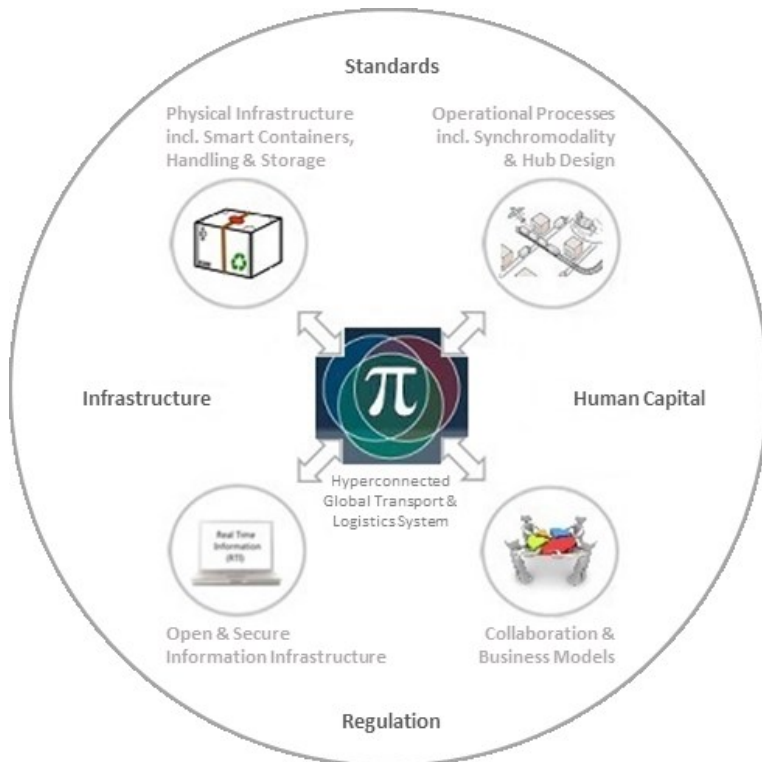


Figure 3: Key components of PI research in a framework of conditions for innovation support (standards, regulation, human capital, and infrastructure); Own depiction based on Ballot et al. (2014), Montreuil (2015), Kalt et al. (2016), and ALICE (2017)

As main research areas in the domain of PI (which aims at physical, digital and operational interconnectivity of logistics for increased efficiency and sustainability) are regarded the following (see Figure 3), all together supporting the overall aim of increased efficiency and sustainability:

- Physical infrastructure including smart containers, handling & storage:
The establishment of an interconnected physical infrastructure including smart containers and their handling and storage represents the physical basis of PI.
- Open & secure information infrastructure:
This component provides the basis for secure data exchange within the PI logistics network.
- Operational processes including synchronomodality & hub design:
Efficiency and sustainability strongly depend on operational processes running on the system. Here, hubs as routing centers have a crucial role. Intermodal, multi- and even synchronomodal transport processes are fundamental for a sustainable and efficient PI.

- Collaboration & business models:
Interconnected logistics and transport networks used commonly by T&L players requires their collaboration on the basis of suitable business models and a “sharing culture”.

On the basis of these four categories Table 5 summarizes Austrian RTI competences in the domain of PI. These are further described in the following text.

Table 5: Summary of Austrian RTI competences in the domain of PI

Research Area	Description	Austrian Competences
Physical Infrastructure including smart containers, handling & storage	Physical interconnectivity (road, rail, water, air); containers (standardized, modular, ecological, smart, with optimal dimensions); container handling & storage (hubs)	<ul style="list-style-type: none"> • Interconnectivity/intermodality (road/rail prototype) • Tri-/quattromodal concepts for model regions • Containers (concepts & prototypes) • Container handling and storage (concepts)
Open & Secure Information Infrastructure	Interfaces and network protocols for structuring of services; digitalization; open performance control and certification; reliability and resilience of networks; data banks, data structures, data sharing, data security	<ul style="list-style-type: none"> • Digitalization, standardization, interfaces, model development, data sharing, and test run in future model regions (ongoing projects) • Databank prototypes
Operational Processes including synchromodality & hub design	Optimization, synchromodality; hubs as routing centres	<ul style="list-style-type: none"> • Planning and optimisation of transportation and freight (model calculation and prototypes) • Automated formation and optimization of transport (logistic) chains, decentralised control and timing using Agent Based Modelling (Algorithms) • Synchromodal concepts
Collaboration & business models	Applications & services, e.g. online-platforms; last-mile delivery with alternative driving systems	<ul style="list-style-type: none"> • Business and accounting models for collaborative transport based on algorithms for automated formation and optimisation of transport chains (e.g. in model regions) • Data sharing & booking platforms, e.g. combination of road and rail (prototypes) • Urban logistics and e-mobility (concepts) • Training services for web based logistics system (in preparation)

Concerning physical interconnectivity of the transport system (road, rail, water, air) Austrian actors have gained competences regarding e.g. intermodal concepts and are even building a road/rail test

bed. Also tri- or quattromodal concepts for model regions have been developed. Regarding the PI containers and their handling & storage Austrian actors have already gained high competences even in a European environment. The functional design of the PI smart containers is essential for a successful PI in the future as these boxes need to fulfil high demands (standardized, modular, ecological, smart, safe, and with optimal dimensions).

Austria is also currently gaining competences in the establishment of an open information infrastructure. General questions of digitalization, automation, and interfaces of transport and logistics networks were addressed in research projects or are currently investigated in model regions. Questions of data structures, sharing, and security were investigated and prototypes of databases were built, on which e.g. a booking platform for intermodal (road/rail) transport was set up.

<p>Customer requirements? On time (information, delivery, payments)</p> <p>Tariff flexibility & transparency – possibly including ideas like CO2 bonus</p> <p>Transparency, estimated time of delivery/departure (ETD) and estimated time of arrival (ETA)</p> <p>Evaluation (of supplier)/certification</p> <p>Process reliability/safety/stability (on time)</p> <p>Simplicity/usability</p> <p>Overview of capacity</p> <p>Data security</p> <p>Value Added Services</p>

Rather broad expertise is being established in the field of building models for operational processes aiming at planning and optimisation of logistic processes, transportation, and freight. Even algorithms for automated formation and optimization of transport (logistic) chains with decentralised control and timing using Agent Based Modelling are being developed in Austria.

Exchanging real time information in the system is a basis of PI concept as well as of synchronomodal concepts. Austrian actors have gained expertise also in this specific research area which is substantially promoted within ALICE.

Box 1: Customer requirements as collected during the PI stakeholder workshop

Regarding business and accounting models for collaborative transport Austrian actors have also gained expertise and are about to develop models together with business partners and test them in a model region. Austrian actors have expertise in building a prototype of a data sharing and booking

platform, e.g. for combined transport of road and rail. Also specific concepts for collaborative urban transport, i.e. last mile solutions including e-mobility and other alternative driving concepts were investigated. Concerning the guidance and enabling of organisational change processes Austrian actors are for example starting to prepare training services for web based logistics systems.

Austrian RTI competences in the domain of PI are quite broad but with a distinct focus on operational processes. Very broad expertise is found in the area of logistics and transport modelling and simulation, aiming at respective software and services developments. In the future also autonomous driving and robotics applications might become interesting research fields specifically for Austria.

As shown in Table 5 research was or is carried out in all components of PI including future model region(s) which are involving all necessary actor types with diverse competences or cooperation potential and in some parts international partners¹².

¹² Shown box refers to stakeholder workshop which was organized in the framework of this study at the IPIIC 2017 conference in Graz and hosted by bmvit.

3.2 Challenges and Opportunities

Experts' expectations on opportunities provided by a future PI are relatively high, however the time horizon is questionable. Expected benefits are increasing efficiencies, benefits for the environment, greater benefits for customers, and new applications and services¹³.

Risks are regarded as comparable to the traditional system. Trust is mentioned as a key factor for good cooperations and for data sharing. Safety, security and reliability of data and the whole system are of course basic requirements. There is a big threat to be overcome by other systems (third party offers). Also some players might have problems to access the system (esp. SMEs) because of a lack of IT technology and unaffordable investments.

The establishment of a common physical network (including hubs and containers) with an interconnection of different means of transport, especially regarding rail traffic, is seen as major future challenge. Regarding PI containers, besides the compatibility and standardization issues, high demands and challenges of implementation occur.

Challenges are also seen in the establishment of an open and secure information infrastructure, especially solving certification issues will need further competences. Here, block chain technologies might deliver future solutions. Generally, skills to raise the digitalization and automatization grade of the Austrian T&L network need to be developed in order to broaden the integration of business partners and to specifically support the rail system, which is lagging behind in this aspect. The whole value chain/network has to be considered in this aspect. Therefore, it is necessary to integrate partners from manufacturing industry at an early stage.

Especially socio-economic aspects at different levels (micro/meso/macro) were addressed as future challenges in order to change business cultures and establish critical masses for data sharing communities. Coordination of partners, synchronization of production and transport are seen as future challenges as well as choosing the grade of transparency within the data network. New business models, cooperation and sharing models are needed. The creation of a collaborative culture in an open system with transparent performance design and pricing needs awareness regarding the (economic) benefit of the new models, new roles and performance of actors. Such competences are currently established within Austrian test regions but have to be further developed in the future.

In order to address systemic questions especially fourth and fifth party logistics providers could be supported and involved into the network of Austrian PI actors. PI competences of these actors should be strengthened in Austria in order to raise competitiveness on a European or global scale. In Austria lead logistics providers have taken up efforts in digitalization and collaboration, for example Gebrüder Weiss GmbH or Wenzel Logistics GmbH. With increasing complexity of the logistics innovation system actors with abilities to concertate logistics networks and collaboration activities, such

Data sharing – opportunities?

Recognize true customer requirements (biggest chance?)

Efficient use of resources – internal logistics

Reduction of inventory

Increase of frequency

More precise forecasts

Disaster Management - Proactive problem solving (natural disasters, politics)

Better communication with clients

Box 2: Opportunities from data sharing as collected during the PI stakeholder workshop

¹³ Shown box refers to stakeholder workshop which was organized in the framework of this study at the IPIIC 2017 conference in Graz and hosted by bmvit.

as the German company TRI-VIZOR¹⁴ are needed and lead actors should promote ongoing changes.

Table 6: Summary of Austrian RTI challenges and opportunities in the domain of PI

Topic	Description	Challenges and Opportunities
Physical Infrastructure including smart containers, handling & storage	Physical interconnectivity (road, rail, water, air); containers (standardized, modular, ecological, smart, with optimal dimensions); container handling & storage (hubs)	<ul style="list-style-type: none"> • Establishment of a common physical network (incl. hubs and containers), interconnection of different means of transport, compatibility and standardization especially regarding rail traffic • Containers: challenges of implementation (high demands), low acceptance • Standardization needs
Open & Secure Information Infrastructure	Interfaces and network protocols for structuring of services; digitalization; open performance control and certification; reliability and resilience of networks; data banks, data structures, data sharing, data security	<ul style="list-style-type: none"> • Digitalization and automatization of the whole network, broader integration of application partners esp. involvement of manufacturing industry • Integration of isolated applications, need of interfaces • Data sharing, data structures, rights of use, data security
Operational Processes including synchromodality & hub design	Optimization, synchromodality; hubs as routing centres	<ul style="list-style-type: none"> • Testing and implementation of prototypes • Potential for quattromodality in different regions (e.g. Vienna region, Upper Austria region Enns)
Collaboration & business models	Applications & services, e.g. online-platforms; last-mile delivery with alternative driving systems	<ul style="list-style-type: none"> • New business models, cooperation and sharing models • Transparent performance design and pricing • Awareness regarding (economic) benefit • New roles and performance of actors • Creation of a collaborative culture (open system)

As analysed previously framework conditions for RTI activities offer a lot of potential for this topic in Austria. National funding programs have brought Austria into a good position comparing RTI competences to the rest of Europe. However, potentials are seen in building critical masses, which will possibly lead to more visibility on a European level where activities, e.g. partnerships and Horizon 2020 projects should be intensified strongly.

¹⁴ TRI-VZOR sees itself as the world's first cross supply chain orchestrator, see also <http://www.trivizor.com/>

3.3 Austrian Competences in a European Context

Stakeholders see (complementary) pathways for achieving and promoting Austrian competences in Europe: focusing on areas where Austria already has RTI excellence (and reputation) and leveraging locational respective local advantages¹⁵.

Building PI & TL core competencies on existing excellence points towards a niche strategy. Areas of existing RTI competences include transport and traffic concepts, railway, linking physical and technical aspects and digital solutions.

Leveraging locational and local advantages refers to both Austria by itself and Austria in a European context: Within Europe, Austria's geographical position in the heart of Europe and its historical reputation as intercultural integrator can be used to develop PI core competences. Austria can use existing structures such as the Trans-European Transport Network (TEN-T)¹⁶ corridor infrastructure in South/East Europe and strategically interlinking with Austrian companies with local head quarters in these European regions.

Within Austria, concentrating on the last mile may be a first focal room for developing innovative solutions (impact ↑ risk↑). It is vital to integrate cities and communities in this endeavour for multiplication, showing best practice and drawing up master plans. In addition, business models need to be developed which address current and emerging challenges – including data exchange/open protocols and last but not least the establishment of necessary trust and will to take a deep dive into what may quite likely be a game-changing technology for the transport logistics industry

What can we achieve in Austria and where shall we move to on a European level?

Take a global perspective! (Upper Austria <-> south of Germany; Africa, USA); Austria is in the middle of Europe (core competence)

Use existing structures: 3 TEN-T corridors (SE Europe), company head quarters / cooperation partners

Concentrate on last mile as a first focal room for solutions – (impact ↑ risk↑), use local advantages

Integrate cities / communities (Steyr, Graz, Salzburg?) multiplicity, best practice, master plan

Business models, challenges: data exchange, will / trial, sensitivity / legal dimension (no need to share data => need for open protocols)

Public relations - breath new life into PI

Focusing core competencies in niches (& mindset): traffic concepts, railway competences, physical – technical, digital

Lobbying of core competences (BMVIT – ALICE...)

Alignment on all levels and stakeholders

Austria as intercultural integrator

Box 3: Citations as collected during the PI stakeholder workshop

From the stakeholders' point of view, the public sector – most notable bmvit - is perceived to have a crucial role in system transformation, including public relations to “breath new life into PI”, promote Austrian core competences at the European level (esp. ALICE) and support the strategic alignment in Austria on all levels and across all stakeholders. Beyond that, stakeholders suggested also transport political measures, such as e.g. higher tolls for long distance truck routes, in order to promote collaborative and sustainable solutions and especially intermodal transport.

¹⁵ Shown box refers to stakeholder workshop which was organized in the framework of this study at the IPIC 2017 conference in Graz and hosted by bmvit

¹⁶ See also <http://ec.europa.eu/transport/infrastructure/tentec/tentec-portal/site/en/maps.html>

4 International Context

In this chapter the vision of PI as a framework for the global organisation of logistical networks based on physical, digital and operational interconnectivity is regarded within a global context of digital transformation. Figure 4 shows the evolution of logistics, transportation, production and supply chains as sketched within the Physical Internet concept by Montreuil (2015).

The importance of shared transport is growing as a crucial strategy for reducing greenhouse gas and other emissions and mitigating the transport sector's impact on climate change – from Uber-style approaches to last-mile delivery, to more formal joint ventures and partnerships at corporate level, the whole sector is redefining collaboration. But much of this is hampered by inconsistencies in everything like shipment sizes, processes or IT systems.

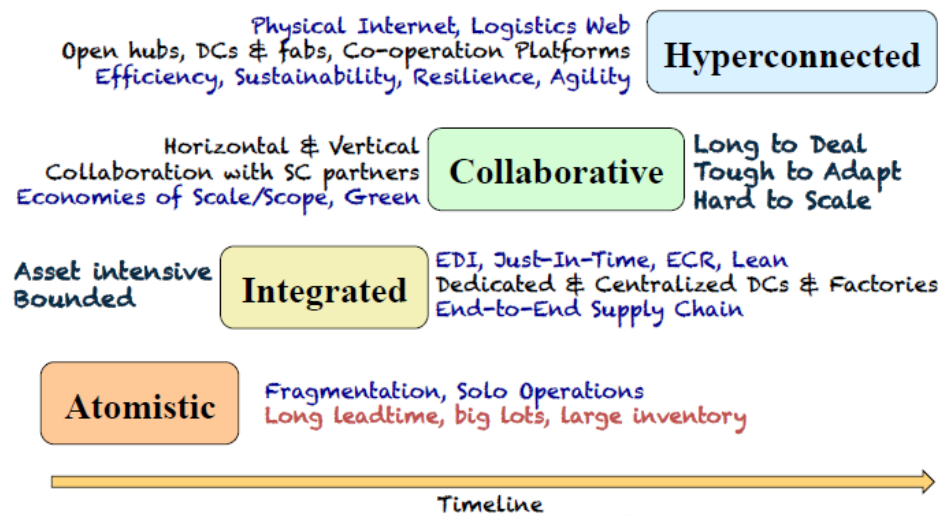


Figure 4: Evolution of logistics, transportation, production and supply chains¹⁷; Source: Montreuil (2015)

PI has a high potential with increased standardisation in logistics operations (as shown in **Fehler! Verweisquelle konnte nicht gefunden werden.** and Table 7). Referring to PwC analysts' research around PI needs to establish shared standards for shipment sizes, greater modal connectivity and IT requirements¹⁸.

The sharing economy has already transformed several industries through the popularity of apps such as Uber or Airbnb. It will also bring benefits to logistics, as it allows all participants to share fixed costs, enabling companies to make several smaller investments rather than a single large investment. Analysts see main applications for logistics in sharing cost-intensive physical assets, notably warehouses and freight-transporting vehicles. Coyote, founded in 2006, is an example of a company

¹⁷ Hyperconnection definition by Montreuil (2015): A system is said to be hyperconnected when its components (agents, things, etc.) are intensely interconnected on multiple layers, ultimately anytime, anywhere. Interconnectivity layers notably include digital, physical, operational, business, legal and interpersonal.

¹⁸ See also Price Waterhouse Coopers (2016): Shifting patterns – The future of the logistics industry. PwC's future in sight series. www.pwc.com/transport

that matches demand for client shipments with available carriers. The system specializes in scheduling shipments to travel on carriers' return trips (backhaul). In August 2015, UPS acquired Coyote for \$1.8 billion, demonstrating the merits of an asset-light business model in a mature industry¹⁹.

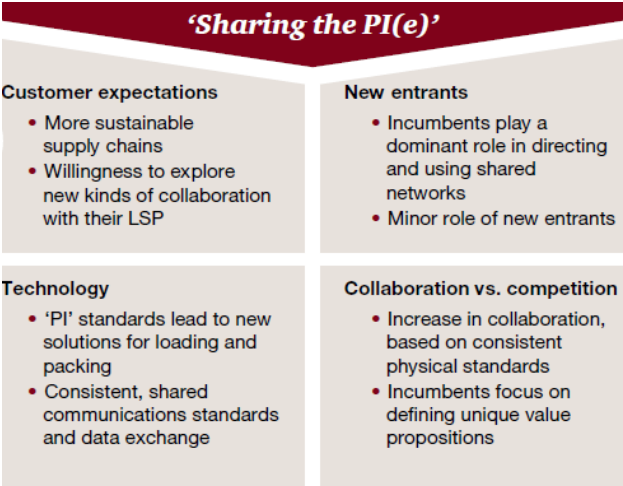


Figure 5: “Sharing the PI(e)” as one of four future scenarios, relying on PI (LSP = logistics service providers). Source: Price Waterhouse Coopers (2016)

One of the biggest digital trends of recent years has been the emergence of giant internet platforms such as eBay, Amazon or Alibaba. These companies connect consumers around the world to companies of varying size. As a consequence, startups and small businesses can now operate in a global market from their first day of business. Customers, whether they are businesses or consumers, benefit from having a broad range of alternative suppliers to choose from. In a growing customer base especially concerning e-commerce also customer expectations are increasing greatly. Some of the transport and logistics sector's own customers are starting up logistics operations of their own, and new entrants to the industry are finding ways to exploit digital technology or new 'sharing' business models.

Table 7: Most important technologies shaping the future of transport and logistics industry (Source: Price Waterhouse Coopers, 2016)

The technology	The impact	The uncertainties
Physical Internet (based on the IoT)	<ul style="list-style-type: none"> • Improved supply chain transparency, safety and efficiency • Improved environmental sustainability (more efficient resource planning) 	<ul style="list-style-type: none"> • Social expectations around data privacy and security may change • Regulation around data security and privacy may increase or be enforced more stringently • The sector's willingness and ability to invest in collaboration • Whether international bodies will drive standardization
IT standards	<ul style="list-style-type: none"> • Enabling collaboration horizontally • More efficiency and transparency 	<ul style="list-style-type: none"> • Companies' willingness to adopt is uncertain due to data security concerns
Data analytics	<ul style="list-style-type: none"> • Improvements in customer experience and operational efficiency in operations • Greater inventory visibility and management 	<ul style="list-style-type: none"> • Rate of development of data processing capacity is unclear • Question marks around data security

¹⁹ Source: World Economic Forum in collaboration with Accenture (2016): White Paper Digital Transformation of Industries: Logistics. World Economic Forum. Switzerland.

	<ul style="list-style-type: none"> Improved “predictive maintenance” 	<ul style="list-style-type: none"> Social expectations around data privacy and security may change Regulation of data security and privacy may increase or be enforced more stringently
Cloud	<ul style="list-style-type: none"> Enabling new platform-based business models and increasing efficiency 	<ul style="list-style-type: none"> Development of costs unclear (once a certain scale is reached physical data centres still tend to be cheaper) Uncertainties around data security
Blockchain	<ul style="list-style-type: none"> Enhanced supply chain security (reduction of fraud) Reduction in bottlenecks (certification by 3rd parties) Reduction of errors (no more paper-based documentation) Increased efficiency 	<ul style="list-style-type: none"> Rate of adoption uncertain Unclear whether one or two dominant solutions will emerge or multiple competing solutions
Robotics & automation	<ul style="list-style-type: none"> Reduction in human workforce and increased efficiency in delivery and warehousing (including sorting and distribution centres) Lower costs 	<ul style="list-style-type: none"> Speed of technology development unclear
Autonomous vehicles	<ul style="list-style-type: none"> Reduction in human workforce Increased efficiency in delivery processes 	<ul style="list-style-type: none"> Regulatory environments not currently in place in most countries Liability issues not yet clear Ethical questions remain especially in relation to emergency situations
UAVs / Drones	<ul style="list-style-type: none"> Increased cost efficiency (use cases: inventory, surveillance, delivery) Workforce reduction 	<ul style="list-style-type: none"> Regulation in most countries not sufficient for commercial use in public areas like delivery. Safety and privacy concerns may hamper market acceptance
3-d printing	<ul style="list-style-type: none"> Lower transportation demand Transported goods would mostly be raw materials 	<ul style="list-style-type: none"> Speed, scale, and scope of uptake by customer industries still unclear

Data-driven information services will use analytics to optimize routes, reduce maintenance costs and improve utilization. The big players will implement control tower solutions to augment these benefits with real-time visibility, which would generate incremental profits by reducing downtime and recovery costs. Kuehne + Nagel, for example, uses a logistics control tower to maximize cost efficiencies, while adhering to time constraints and complying with standards in security and document accuracy²⁰. Its tower uses order and transportation management software to exchange data between carriers, service providers, and senders and receivers of goods. Similar projects involving Unilever, P&G, Pfizer and Dell have substantially reduced inventories and lowered delivery costs.

First among technological trends has been the Internet of Things, a network of smart devices, sensors and the cloud that allow the physical world and computer systems to interact directly. The Internet of Things has been underpinned by recent advances in cloud computing. Cheaper data storage and increased computational power mean that big data streams can be collected, stored and analyzed much more efficiently. This is enabling logistics providers and customers to conduct a real-time analysis of supply chain data. Insights from this analysis allow logistics companies or their customers to predict events more accurately and react more quickly if they do happen.

²⁰ See also https://www.kn-portal.com/integrated_logistics/kn_controltower/

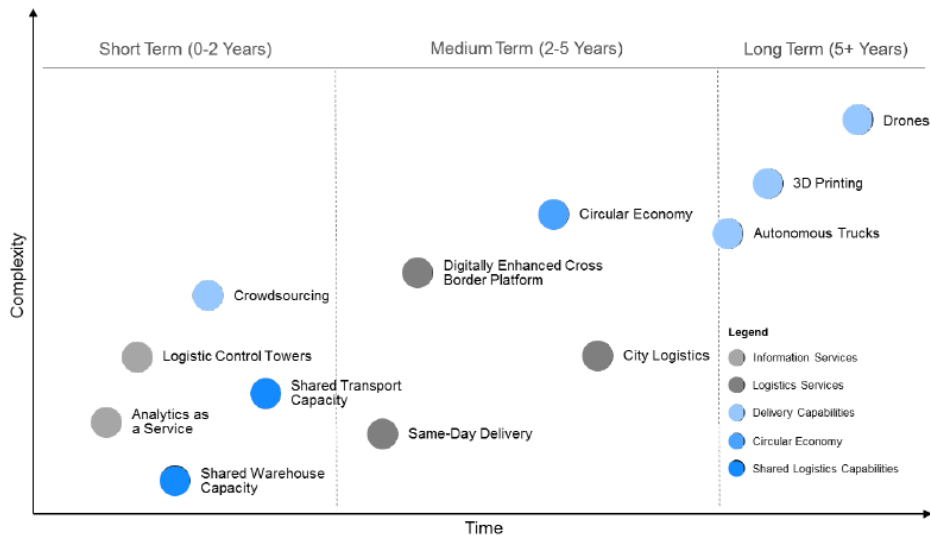


Figure 6: Digital initiatives and their future horizon; Time indicates full technology maturity and vast industry-wide adoption; Source: World Economic Forum in collaboration with Accenture (2016)

Potential applications for 3D printing, such as the printing of replacement parts or products on the spot, could have an impact on the logistics industry by reducing the need for parts and goods to be shipped. Considerable uncertainty, though, about the implications and applications of 3D printing still remains, and there may also be opportunities for logistics players that specialize in printing and delivering these products quickly and cheaply.

Table 8: Digital Initiatives in a table. Source: World Economic Forum in collaboration with Accenture (2016)

Digital Themes	Digital Initiative
Information Services Utilizing data to make informed decisions	Logistics Control Towers Analytics as a Service
Logistics Services New market offerings for additional revenue streams	Digitally Enhances Cross Border Platform City Logistics Same-Day Delivery
Delivery Capabilities New methods of physical transportation	Drones Autonomous Trucks 3D Printing Crowdsourcing
Circular Economy Reverse logistics for product after sales	Circular Economy
Shared Logistics Capabilities Sharing of physical assets in logistics	Shared Transport Capacity Shared Warehouse Capacity

Autonomous vehicles are another technology that could be transformational for logistics providers, by reducing operating costs while improving the reliability of deliveries. Mercedes-Benz is already pioneering autonomous trucks and Amazon is testing delivery drones. In parallel with efforts to develop autonomous vehicles, similar innovations are being tested for support services, such as the introduction of automated port operations in Hamburg.

Regarding to analysts the greatest impact from digital transformation in the logistics industry will come from societal benefits. These will come primarily from three initiatives:

- a. Crowdsourcing would offer better rates, convenience and real-time tracking to customers. These platforms could have a major benefit for society in the form of reduced emissions and congestion.
- b. Digitally enhanced cross-border platforms will increase trade flows by simplifying import-export processes. Logistics companies could earn additional profits as a result of this increase in trade. Digitally enhanced cross-border platforms would provide SMEs access to the global market and give them an opportunity to earn incremental profits. However, these increased profits would come at the cost of higher emissions.
- c. Shared warehouse agreements could allow companies to save operating costs. The use of these agreements would lead to major benefits to society in the form of reduction in emissions and congestion. See for example Nestlé and PepsiCo sharing warehouse capabilities with STEF as their logistics service operator while TRI-VIZOR acts as the independent agent guaranteeing the neutrality of their joint operation and its adherence to competition rules. The earnings from any synergies are shared on the basis of an equitable formula²¹.

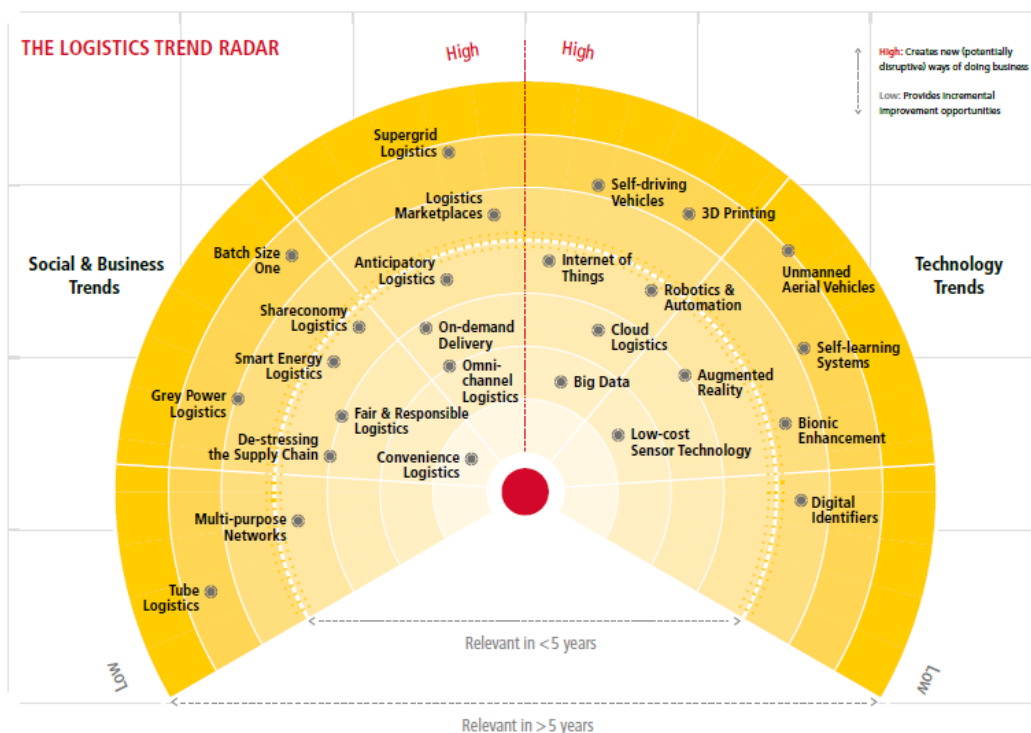


Figure 7: The logistics trend radar by DHL Trend Research²²

The logistics industry is currently facing a large number of social and business trends as well as technological trends. Figure 7 provides an overview as seen by DHL Trend Research. The potential of the digital transformation is high for the T&L sector but it is still a big challenge. With so many

²¹ See also <http://www.stef.com/our-group/news/nestle-pepsico-stef-and-tri-vizor-win-the-ab-european-gold-medal-for-supply-chain-and-logistics-2013-project-of-the-yearbb/>

²² Source: DHL Trend Research (2016): Logistics Trend Radar. Deutsche Post DHL Group. Germany.

technologies competing for management attention and investment, companies are struggling to define a clear digital strategy that is integrated into business strategy²³.

In 2016 the World Economic Forum recommended the following basic capabilities for T&L players to succeed within the digital transformation of the system²⁴: Collecting operational performance data along the entire value chain; building or buying analytical capabilities to derive information from big data sources; embracing shared transport; and having a strategy in place for emerging logistics concepts.

5 Summary and Conclusion

In 2016 analysts of the World Economic Forum estimated a high potential for logistics players and even more for societal benefits as a result of digital transformation of the transport and logistics industry. Industry stakeholders should come together to prioritize digital transformation initiatives given the potential for significantly higher value to be created for society than for industry. With the logistics industry suffering from some very significant inefficiencies digital transformation can also bring important social and environmental benefits, by increasing efficiency and cutting down energy consumption and emissions.

Central to the digital transformation of the logistics industry over the next decade will be the following topics:

- *Digitally enabled information services* will help in reducing operating costs while improving efficiency of operations. They will help in trade growth through the creation of digitally enhanced cross-border platforms. It will also allow logistics companies to satisfy the growing need of customers for faster same-day deliveries, and promote the concept of city logistics, which will allow companies to operate in 'megacities'.
- *New delivery capabilities* will allow logistics to harness technologies such as autonomous trucks and drones to find more efficient ways to deliver shipments, while 3D printing and crowdsourcing offer new ways to think of manufacturing and logistics processes.
- *Circular economy* will foster a more sustainable product life cycle, helping to lessen the logistics industry's environmental footprint by reducing carbon dioxide emissions, air pollution and waste material.
- *Shared logistics capabilities*, through shared warehouse and shared transport capabilities, are expected to increase asset utilization in the near future.

The European Commission's vision towards this digital transformation is PI which is promoted by the European Technology Platform ALICE. In a future scenario based on shared logistics capabilities incumbents need to increase their efficiency and reduce their environmental impact by collaborating more, and developing new business models, such as sharing networks. Research around PI needs to develop standards for shipment sizes, greater modal connectivity, and IT requirements across carriers. However, today a lack of digital culture and training is the biggest challenge facing transportation and logistics companies.

²³ See also Price Waterhouse Coopers (2016): Shifting patterns – The future of the logistics industry. PwC's future in sight series. www.pwc.com/transport

²⁴ Source: World Economic Forum in collaboration with Accenture (2016): White Paper Digital Transformation of Industries: Logistics. World Economic Forum. Switzerland.

In Austria, research institutes and companies have already taken up elements of PI as research topics. A number of specific national R&D and exploratory projects have already been or are being carried out as part of the bmvit RTI program "Mobility of the Future" and the strategic program 'Innovative Upper Austria 2020'.

Austrian RTI competences in the domain of PI are quite broad and can be summarized as follows:

- *Physical interconnectivity of the transport system* (road, rail, water, air): existing competences regarding e.g. intermodal concepts and are building a road/rail test bed. Also expertise on tri- or quattrmodal and even synchromodal concepts has been developed.
- *PI containers and their handling & storage* were investigated within a European environment.
- *Open information infrastructure*: Austria is also currently gaining competences here. General questions of digitalization, automation, and interfaces of transport and logistics networks are being addressed as well as questions of data structures, sharing, and security. Austrian T&L industry representatives are involved in developing interconnected trusted collaborative networks in Austria and on a European level.
- *Operational processes*: There is broad expertise in the area of logistics and transport modelling and simulation, aiming at software and services developments.
- *Business and accounting models for collaborative transport*: Austrian actors are about to develop models together with business partners and test them in a model region.
- *Data sharing and booking platforms*: Austrian actors have expertise in building prototypes, e.g. for combined transport of road and rail.
- *Specific concepts for urban transport* were established, i.e. collaborative last mile solutions, also including e-mobility and other alternative driving concepts.

However, there are several **key challenges** for the future, e.g.:

- The establishment of a common and standardized physical network (including hubs and containers) with an interconnection of different means of transport, especially regarding rail traffic is seen as major future challenge.
- This will also be the establishment of an open and secure information infrastructure. Especially solving certification issues will need further competences.
- A cultural shift towards collaboration will need to take place. The creation of a collaborative culture in an open system with transparent performance design and pricing needs awareness regarding the (economic) benefit of new models, new roles and performances of actors.
- Generally, the digitalization and automatization grade of the Austrian T&L network needs to be raised.

Building on existing and emerging RTI competences (described above), potential future **Austrian topics might be**:

- Physical interconnectivity of the transport system (road, rail, water, air) will still be a basic future topic and test-beds should continuously be developed.
- The establishment of an open and secure information infrastructure will also need further competences. Especially solving safety and certification issues will need further research. Here, block chain technologies might deliver future solutions.
- Business models based on sharing data/transport/warehouses need to be developed which address current and emerging challenges – including data exchange/open protocols and last but not least the necessary trust and will to take a deep dive into what may quite likely be a game-changing technology for the transport logistics industry.

- In response to changing customer demands, new logistics concepts will need to be developed. Companies may need to have strategies to address the growing demand for deliveries in urban areas, or same-day delivery, to meet increasing customer expectations of faster services. Austria has already built up expertise in this area and could potentially strengthen competences in the future.
- Concentrating on the last mile may be a first focal area for developing innovative solutions. It is vital to integrate cities and communities in this endeavour for multiplication, showing best practice and drawing up master plans.
- In the future also autonomous driving and robotics applications might become interesting research fields specifically for Austria.
- The question arises whether also capabilities to derive information from big data sources should be developed.

The topic of PI is still very research intensive and most deeply involved Austrian actors are research institutes. According to the RTI roadmap of Mobility of Goods a flagship project in the considered research field is planned in order to create synergies, but especially a critical mass of relevant actors which may eventually address the structural changes ahead.

Regarding the **involvement of specific actor groups** of the innovation system the following recommendations are given:

- Generally, skills to raise the digitalization and automatization grade of the Austrian T&L network need to be developed in order to broaden the integration of business partners and to specifically support the rail system. The whole value chain/network has to be considered in this aspect. Therefore, it is necessary to integrate partners from manufacturing industry at an early stage.
- In Austria lead logistics providers have taken up efforts in digitalization and collaboration. In order to address systemic questions especially fourth and fifth party logistics providers could be supported and involved into the network of Austrian PI actors. PI competences of these actors should be strengthened in Austria in order to raise competitiveness on a European or global scale.
- With increasing complexity of the logistics innovation system actors with abilities to concertate logistics networks and collaboration activities are needed and lead actors should promote ongoing changes.
- Therefore, in order to mobilize key players from the logistics industry crucial questions should be addressed, e.g:
 - How can logistics industry players be enabled in building strategies for new logistics concepts?
 - How can logistics industry players be supported to faster implement shared warehouse and transportation capacity for higher efficiency?
 - How can operational performance data along the entire value chain be collected as the basis of a successful digital transformation?

From the stakeholders' point of view, Austria's geographical position in the heart of Europe and its historical reputation as intercultural integrator can be used to develop PI core competences. Existing structures such as the Trans-European Transport Network (TEN-T) corridor infrastructure in South/East Europe can be used to strategically interlink Austrian companies with local head quarters in these European regions. The public sector – most notable bmvit - is perceived to have a crucial role in system transformation, including public relations to “breath new life into PI”, promote Austrian core competences at the European level (esp. ALICE) and support the strategic alignment in Austria on all levels and across all stakeholders. Beyond that, stakeholders suggested also transport political measures, such as e.g. higher tolls for long distance truck routes, in order to promote collaborative and sustainable solutions and especially intermodal transport.

Austria's major RTI program "Mobility of the Future" provides strategic support for PI competences of Austrian actors by systemically combining the support of technological with organisational innovations. Especially the ability to address structural changes in the upcoming digital T&L innovation system, altering roles and strategies of actors, and new economic and collaboration models will be crucial competences to be further developed in the future.

Prioritizing topics to establish specific Austrian strengths will be a necessary task for the future. According to the recent study IND4LOG4, the positioning of Austria as an innovation leader (according to the general FTI strategy of the Austrian Federal Government) or follower is of strategic importance²⁵. In order to systematically analyze and consider Austria's opportunities within this digital transformation an Austrian PI strategy and roadmap should be developed as soon as possible in a separate process. Key RTI policy questions to be addressed include the specific support of national RTI competences, Austria's positioning in Europe, and enabling Austrian actors to succeed on a European level.

²⁵ See also Schwarzbauer W. et al. (Hg. Bmvit, 2016): IND4LOG4 - Industrie 4.0 und ihre Auswirkungen auf die Transportwirtschaft und Logistik, <https://mobilitaetderzukunft.at/de/projekte/guetermobilitaet/ind4log4.php>

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7 Abbreviations

Table 9: Abbreviations

Term	Abbreviation
Alliance for Logistics Innovation through Collaboration in Europe	ALICE
Ant Colony Optimization	ACO
Carbondioxide	CO ₂
Estimated Time of Delivery	ETD
Estimated Time of Arrival	ETA
Fast-Moving Consumer Goods	FMCG
Federal Ministry of Agriculture, Forestry, Environment and Water Management	BMLFUW
Federal Ministry of Transport, Innovation and Technology	BMVIT
Information and Communication Technologies	ICT
Information Technologies	IT
International Physical Internet Conference	IPIC
Internet of Things	IoT
Logistics Service Providers	LSP
Mobility of the Future	MoF
Physical Internet	PI
Research and Development	R&D
Research, Technology and Innovation	RTI
Research and Technology Organization	RTO
Supply Chain	SC
Small and Medium Enterprises	SMEs
Trans-European Transport Network	TEN-T
Transport and Logistics	T&L
Working Group	WG

8 Appendix - List of Interviews

Table 10: List of Interviews

Organisation	PI - Collaborative Projects and Exploratory Studies	Interviewee, Date of Interview
AIT Austrian Institute of Technology GmbH	Q4; Synchain	M. Prandstetter and W. Ponweiser 23.05.2017
Graz University of Technology – Institute of Logistics Engineering	Modulushcar; Go2PI; ProtoPI	F. Ehrentraut, 29.06.2017
i-LOG Integrated Logistics GmbH	GreenCityHubs; KoLaMBra	B. Piekarz, 03.05.2017
Innofreight Speditions GmbH	Cinderrailer	H. Pichler, 11.05.2017
Nast Consulting ZT GmbH	DatenVerkehr	D. Elias, 08.06.2017
OMV Refining&Marketing GmbH	RTM-O	Ch. Herneth, 12.05.2017
RISC Software GmbH	KoLaMBra; ATROPINE; RTM-O	R. Keber, 09.05.2017
SATIAMO	ProtoPI; GreenCityHubs; Go2PI; KoLaMBra	M. Schwaiger, 04.05.2017
TRAFFIX Verkehrsplanung	ILKÖ	B. Fürst, 18.05.2017
TU Vienna - FB Verkehrssystemplanung, Department für Raumplanung	Q4	G. Hauger, 09.05.2017
University of Applied Sciences Upper Austria – Logistikum Steyr	Go2PI; ProtoPI, KoLaMBra; Q4; smartBOX; Synchain; ATROPINE	O. Schauer 04.05.2017
University of Vienna – Institute for Business Administration	GreenCityHubs; KoLaMBra	K. Dörner, 02.05.2017, A. Krawinkler, 11.05.2017

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