Traceability Towards Sustainability in Inland Waterway Transport

An Empirical Research with Causal Modelling

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Para las dos estrellas que iluminan nuestro firmamento,

y para ti mi sol que mantienes cálido mi corazón.

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Abstract

Considering the challenges posed by climate change, the attention to achieving sustainable transportation systems has been rekindled. Although inland waterways (IW) offer a more environmental-friendly transportation mode and favourable geographic conditions for cargo movement into urban areas, the modal split is gaining at a low pace. IW requires comprehensive connectivity to tackle this challenge to improve multimodal performance and increase services diversification. Nowadays, traceability on IW is assured until the vessel unit. This level of traceability is enough for bulk and liquid cargo. However, making the transportation mode more attractive for other kinds of cargo requires implementing new Information Sharing (IS) systems allowing gapless traceability up to small-scale freight such as pallets, bags, or boxes through enhanced Tracking and Tracing Systems (eT&T).

This thesis explores how eT&T systems could support more sustainable IW transport operations. The study is empirical qualitative research following a multi-stage methodology. In the first stage, expert interviews with leading practitioners from the Lower Rhine region in Germany were conducted. In the second stage, the study took an Action Research orientation with a participatory-creative workshop to increase research productivity.

Attempts to measure interdependencies between IS and sustainability are scary. Thus, an analytical model was developed to analyse the study's cause-effect relationships between variables. The model is a reference for future research to analyse interdependencies between IS technologies and sustainability. Through a qualitative content analysis, benefits and brakes from the introduction of eT&T perceived by different stakeholders in IW and potential system users were mapped and fully characterized. A value-adding approach to generalize findings was followed to formulate the ground theory to maximize these outcomes.

Finally, through a Systems Thinking approach, a causality model was developed that visualizes interdependencies between factors affecting the implementation of eT&T in IW in serval dimensions, such as economic, ecological, and social. The model arose that more complex constructs, besides supply chain visibility, arise from the implementation of eT&T in IW. The most relevant is the diversification of freight type with new urban distribution logistic concepts and new forms of cooperation between IW operators. This evolution will depend on developing the required infrastructure, vessel type, and technology and implementing harmonization of legal and technical instruments such as data protection and data exchange protocol. The model reveals the interdependencies between the implementation of eT&T and the better integration of IW in multimodal and even synchro modal chains leading to higher utilization of IW capacities with energy-efficient consumption effects.

The study confirms that eT&T IS systems have an effect over all dimensions of sustainability and discuss how can they turn into a core enabler to boost sustainability in IW networks.

Zusammenfassung

Angesichts der Herausforderungen durch den Klimawandel ist der Focus auf nachhaltige Verkehrssysteme stark gestiegen. Obwohl die Binnenschifffahrt einen umweltfreundlicheren Verkehrsträger und günstige geografische Bedingungen für den Frachtverkehr in städtischen Gebieten bietet, gewinnt sie nicht an Attraktivität im Modal Split. Das Binnenschifffahrtsnetz benötigt eine umfassende Konnektivität und Diversifizierung der dazugehörigen Dienste, um die multimodale Leistung zu verbessern. Heute ist die Rückverfolgbarkeit auf Wasserstraßen und Kanälen bis zur Schiffseinheit gewährleistet. Dieses Maß an Rückverfolgbarkeit reicht für Massen- und Flüssiggüter aus. Um die Binnenschifffahrt ebenfalls für andere Arten von Fracht attraktiver zu machen, ist jedoch die Implementierung neuer Systeme zum Informationsaustausch erforderlich, die eine lückenlose Rückverfolgbarkeit bis hin zu kleinen Frachten wie Paletten, Säcken oder Kartons durch verbesserte Sendungsverfolgung (eT&T) ermöglichen.

Das Ziel dieser Arbeit ist auf explorative Weise zu bewerten, wie eT&T-Systeme einen nachhaltigen Binnenschifffahrtsbetrieb unterstützen könnten. Die Studie ist eine empirische qualitative Forschung, die einer mehrstufigen Methodik folgt. Im ersten Schritt wurden Experteninterviews mit führenden Praktikern aus der Region Niederrhein in Deutschland geführt. Anschließend nahm die Studie eine Aktionsforschungsorientierung mit einem partizipativ-kreativen Workshop zur Steigerung der Forschungsproduktivität auf.

Gegenwärtige Ansätze für die Messung von Interdependenzen zwischen den Konstrukten Informationsaustausch und Nachhaltigkeit sind gering. Für ein besseres Verständnis der Kausalität zwischen dieser Untersuchungsvariablen wurde ein analytisches Modell entwickelt. Das Modell stellt eine Referenz für zukünftige Forschung zur Analyse der Wechselwirkungen zwischen Informationsaustausch-Technologien und Nachhaltigkeit dar. Von verschiedenen Stakeholdern in der Binnenschifffahrt und potenziellen Systemnutzern wahrgenommene Vorteile und Hindernisse für die Einführung von eT&T wurden auf Basis einer qualitativen Inhaltsanalyse abgebildet und vollständig charakterisiert. Um den Nutzwert zu steigern, wurde für die Formulierung der Grundtheorie ein wertschöpfender Ansatz zur Verallgemeinerung der Ergebnisse verfolgt.

Zur Visualisierung der Wechselwirkungen verschiedener Faktoren, welche die Implementierung von eT&T in der Binnenschifffahrt in ökonomischen, ökologischen und sozialen Dimensionen beeinflussen, wurde ein Kausalitätsmodell durch einen Systemdenk-Ansatz entwickelt. Das Modell führt zu der Schlussfolgerung, dass durch die Implementierung von eT&T in der Binnenschifffahrt neben der Sichtbarkeit der Lieferkette auch komplexere Konstrukte entstehen. Zu den relevantesten zählt die Diversifizierung der Frachtarten mit neuen Konzepten für die städtische Logistik-Verteilung und neue Formen der Zusammenarbeit zwischen Binnenschifffahrt-Betreibern. Diese Entwicklung wird von dem Ausbau der erforderlichen Infrastruktur, des Schiffstyps und der Technologie abhängen. Ebenfalls die Umsetzung rechtlicher und technischer Instrumente wie dem Datenschutz und der Harmonisierung von Datenaustauschprotokollen spielen eine wichtige Rolle bei der Weiterentwicklung. Das Modell zeigt die Wechselwirkungen zwischen der Implementierung von eT&T und der besseren Integration von Binnenschifffahrt in multimodale und sogar synchromodale Lieferketten. Das führt zu höherer Auslastung von IW-Kapazitäten mit energieeffizienten Verbrauchseffekten.

Die Forschung bestätigt, dass Informationsaustausch-Systeme eT&T in allen Dimensionen der Nachhaltigkeit wirken und erörtert, wie dadurch ein Beitrag zur Erreichung der Klimaziele geleistet werden kann.

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List of abbreviations

ADN	European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways
AI	Artificial Intelligence
AIS	Automatic Identification System
APCS	Antwerp Port Community System
APERAK	Application error and acknowledgement message
AR	Augmented Reality
ATA	Actual Time of Arrival
ATD	Actual Time of Departure
BAW	Bundesanstalt für Wasserbau (Federal Waterways Engineering)
BfG	Bundesanstalt für Gewässerkunde (Federal Institute of Hydrology)
BICS	Binnenvaart Informatie en Communicatie System (Inland Shipping Information and Communication System)
BMVI	Bundesministerium für Verkehr und digitale Infrastruktur (Federal Ministry of Transport and Digital Infrastructure)
BSR	Baltic Sea Region
CCNR	Central Commission for the Navigation of the Rhine
CDNI	Convention relative à la collecte, au dépôt et à la réception des déchets survenant en Navigation rhénane et Intérieure (Convention on the Collection, Storage and Reception of Waste Generated during Navigation on the Rhine and Other Inland Waterways)
CH	Carrier's Haulage
CLNI	Convention de Strasbourg sur la limitation de la responsabilité en navigation intérieure (Limitation of Liability of Owners of Inland Navigation Vessels)
CMNI	Budapest Convention on the Contract for the Carriage of Goods on Inland Waterway
CODECO	Container gate-in/gate-out report message
COEDOR	Container stock report message
COPINO	Container pre-notification message
CO2	Carbon Dioxide
CR	Corporate Responsibility
CSR	Corporate Social Responsibility

CS	Corporate Sustainability
CTU	Cargo Transport Unit
DFMOM	Digital Freight Matching Open Market
DIN	Deutsches Institut für Normung (German Institute for Standardization)
DINA	Digital Inland Navigation Area
DOI	Diffusion of Innovation
D&M IS	DeLone and McLean Information Sharing
EAN	European Article Number
ECDIS	Electronic Chart Display and Information Systems
ECE	Economic Commission for Europe
ECOA	European Court of Auditors
EDIFACT	Electronic Data Interchange for Administration, Commerce and Transport
EIBIP	European Inland Barging Innovation Platform
EPC	Electronic Product Code
ERP	Enterprise Resource Planning
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
ETA	Estimated Time of Arrival
etc.	Et cetera “and other similar things”
ETD	Estimated Time of Departure
eT&T	enhanced Tracking and Tracing
eT&T-SusInWa	enhanced Tracking and Tracing Implementation for Sustainable IWT Operations
EU	European Union
FEU	Forty-Foot Equivalent Unit
FHNW	Fachhochschule Nordwestschweiz (University of Applied Sciences Northwestern Switzerland)
g	Grams
GD MOVE	Generaldirektion Mobilität und Verkehr (Directorate-General for Mobility and Transport)
GDP	Gross Domestic Product
GHG	Greenhouse gas
GHz	Gigahertz
GNS	Good Navigation Status
GPS	Global Positioning System
GS1	Global Standards One

GSM	Global System for Mobile Communication
HF	High Frequency
HGV	Heavy Goods Vehicles
ICT	Information and Communication Technologies
IFTMIN	Instruction message
IFTSTA	International multimodal status report message
IISE	Institute of Industrial & Systems Engineers
IoT	Internet of Things
IS	Information Sharing Systems
ISO	International Organization for Standardization
ISPS	International Ship and Port Security Code
ISRBC	International Sava River Basin Commission
IT	Information Technology
IVS90	Informatieen Volgsysteem voor de Scheepvaart (Information and Tracking System for Shipping)
IW	Inland Waterway
IWNS	Inland Waterway Network Simulator
IWT	Inland Waterway Transport
JIS	Just-in-sequence
JIT	Just-in-time
KM	Knowledge Management
LE	Bluetooth Low Energy
LF	Low Frequency
LSP	Logistics Service Provider
MCC	Mobile Cloud Computing
MH	Merchant's Haulage
MHz	Megahertz
NAIADES	Navigation and Inland Waterway Action and Development in Europe
NFC	Near-field communication
NGNSW	Next-Generational National Single Window
NGO	Non-governmental organization
NSPE	National Society of Professional Engineers
OECD	Organization for Economic Co-operation and Development

OEM	Original Equipment Manufacturer
PCS	Port Community Systems
PDF	Portable Document Format
PM	Particulate Matter
RFID	Radio Frequency Identification Device
RIS	River Information Services
Ro-Ro	Roll-on-Roll-off
RTA	Requested Time of Arrival
SCM	Supply Chain Management
SME	Small- and Medium-Sized Enterprises
SSCM	Sustainable Supply Chain Management
SSG	Serious Simulation Game
SWOT	Strengths Weaknesses Opportunities and Threats Analysis
T	Tonnes
TAM	Technology Acceptance Model
TAPA	Transported Asset Protection Association
T&T	Tracking and Tracing
TBL	Triple Bottom Line
TEN-T	Trans-European Transport Networks
TEU	Twenty-Foot Equivalent Unit
tkm	tonnes-kilometre
TKN	Transnational Knowledge Network
TMS	Transportation Management Systems
TOE	Technology, Organization, and Environment framework
TOS	Terminal Operating Systems
TPB	Theory of Planned Behaviour
TTI/STI	Tactical/Strategic Traffic Information
UHF	Ultra High Frequency
UN	United Nations
UNEP	United Nations Environmental Programme
UTAUT	Unified Theory of Acceptance and Use of Technology
VAT	Value Added Tax
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
VHF	Very High Frequency

VR	Virtual Reality
VTS	Vessel Traffic Service
VTT	Vehicle Tracking and Tracing
WMS	Warehouse Management Systems
WSD	Wasser- und Schifffahrtsdirektion (Water and Shipping Directorate)
WSV	Wasserstraßen- und Schifffahrtsverwaltung (Federal Waterways and Shipping Administration)

1. Introduction

This chapter introduces the thesis. In section 1.1 the background for the research topic is explained following by section 1.2 where the research gap on the dissertation topic is clarified. Section 1.3 defines the research's focus to close this gap, and the main research questions are formulated. In section 1.4, a research design is developed to adequately address the central questions. As a result of section 1.4, this dissertation's work plan is described in stages. Section 1.5 introduces the research's nature and principal components in a compact, but informative fashion. Section 1.6 provides the geographical limitation of the area where the study was performed. In section 1.7 potential matters such as the researcher's background and own experiences with the topic that could influence research results are discussed. Section 1.8 presents a reflection on ethical considerations to anticipate during the research. Finally, in section 1.9, the thesis structure is explained.

1.1. Background

This section establishes the context for this work, explaining why this dissertation topic is relevant and essential for formulating the main research question. For developing this section, reports from the most relevant lobby organizations in the European inland navigation sector and documentation from topic-related technology research and development European Union (EU) projects were analysed. A comprehensive list of these projects can be found in Appendix A.

Given the increasingly negative environmental impacts and the impending traffic collapse on the road, the recurring discussion about climate change in freight transport has recently been rekindled. Compared with the competing rail and road modes of transport, the inland waterway vessels offer the largest capacity per traffic unit with the lowest energy consumption per cargo unit (Bundesverband der Deutschen Binnenschifffahrt e.V. 2018). The geographic transport conditions for developing Inland Waterway Transport (IWT) are also favourable: half of the European population lives close to coastal or inland waterways (European Court of Auditors 2015). In addition, all major European industrial and urban centres are accessible by waterways. Other markable advantages of the inland waterways are their reliability and flexibility, especially for transporting dangerous goods, heavy and oversized goods, and free access into densely populated urban centres. Nevertheless, compared to other transport modalities, inland waterways have capacity reserves to be exploited. Phenomena such as poor harvest periods, low water, the inefficiency of locks, long cargo loading and unloading times at inland ports, scarce transhipment possibilities, missing cargo, and vessel visibility can negatively affect gaining modal split for the inland waterway sector.

Inland waterways require comprehensive connectivity, innovative concepts, business models, digitalizing processes, and the development of companies and intermodal platforms that promote efficient but sustainable operations to tackle such challenges. Tracking and Tracing systems (T&T) are indispensable for digital processes to control traffic efficiently, reduce emissions, and increase environmental protection. Due to the ever-increasing digitalization in adjacent logistics areas, inland shipping will increasingly have to get involved in digital technologies if it wants to be considered in equal measure when planning transport chains. While truck drivers are already optimizing their capacity and route planning thanks to improved and faster information on traffic and weather conditions, inland waterway vessels still report port callings and compulsory registration by phone.

According to the German Climate Action Plan 2050, required under the Paris Agreement, the aim is to achieve a broad greenhouse gas neutrality and reduce greenhouse gas emissions for the transport sector by almost 40% by 2030 (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety 2016). To reduce fuel consumption and emissions in inland waterway transport, the Central Commission for the Navigation of the Rhine (CCNR) identified three main measurement groups:

1. Technical measures: such as use of alternative fuel, vessel design, exhaust after treatment,
2. Operational measures: such as journey planning, speed reduction and optimal maintenance, and
3. Traffic and transport management encompasses all measures related to the organization of the logistical chain and interfaces between inland waterway vessels and other transport modes or infrastructures (CCNR 2017).

With an improved organization of transports, better interfaces with transport modes for the pre- and on-carriage, and consistent data exchange about the location and status of vessel and cargo, a high decrease in energy consumption, applicable to all types of vessels, could be achieved (CCNR 2017). Introducing new disruptive technologies on other transport modes, like "Uber of Trucks," enables free capacities to be sold on an open market, increasing the utilization rates and therefore assuring a profit for carriers. On inland navigation, nevertheless, the utilization rate of the fleet remains between 55 % and 85%, providing the type of vessel, which is below those levels experienced before the economic crisis (CCNR 2017). As the transport of containerized cargo has tripled over the last 20 years, the share of time charter in the container sector is around 45 %, whereas 50 % of all these contracts are long-term contracts (CCNR 2017). Increasing such utilization rates and customer loyalty levels is imperative to achieve more cargo shifting from other transport modalities to the inland waterways and developing new services designed and tailored to customers' needs by inland waterway companies. A visionary view would be inland navigation in the city and regional logistics for the supply of metropolitan regions. As a result, there is a need to develop new logistics concepts that with innovative ship designs, enable loading, unloading, and monitoring of smaller-scale freight transport through enhanced Tracking and Tracing (eT&T) systems.

Enhanced Tracking and Tracing for IWT should be understood in this work as *a digitalized network that allows verifying information about the history, location, and status of up to small-scale freight and related services along canals and rivers—through seamless data-synchronization between supply chain stakeholders, providing real-time flow visibility at any hierarchical level (box/pallet/containers/vessel)*.

Currently, developments in other transportation modes and new trends in digital technologies make possible the introduction of such eT&T technologies in inland waterway transport to achieve intelligent transport systems (Punter and Hofman 2017):

1. Increasing adoption of e-transport documents in combined transport promotes cargo shifting and opens new possibilities for the process's digitalization in inland waterways,
2. Shifting from electronic data exchange using messages towards cloud-based controlled data sharing makes possible surveyed access to real-time data using more efficient exchange protocols, and
3. Adoption of future generation 5G wireless networks for the smart grid that allows massive broadcasting data to provide more heterogeneous services with uniform, uninterrupted, and consistent connectivity across the world.

1.2. Shortcoming of existing research

The evolution of intelligent transport systems in inland waterways have been mainly focused on the introduction and extension of River Information Systems (RIS), Booking Solutions, Terminal Operating Systems (TOS), AIS (Automatic Identification System), Electronic Chart Display Information System (ECDIS), and Traffic Management Services such as Vessel Traffic Services (VTS), and TTI/STI (Tactical/Strategic Traffic Information) as well as technical initiatives for more green vessel motors.

These developments have contributed a significant amount to increasing safety levels of transport through inland waterways itself. Nevertheless, there still needs to do more research and development of technologies and concepts to better organize cargo flows for the optimal integration of inland vessels in multimodal logistics chains.

The European Commission White Paper Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system highlight that to optimize the performance of multimodal logistic chains, 30% of road freight over 300 km should shift to other modes such as rail or waterborne transport by 2030 (European Commission 2011). Inland waterways are a good alternative to road transport as Greenhouse gas (GHG) emissions per tkm in this transportation mode are 24 % of those of Heavy Goods Vehicles (HGV) (Doll et al. 2020).

However, in 2019 only 6.1 % of tkm was moved by waterways in EU-28 (Eurostat 2021). The main part of these flows is high-volume freight, generally transported in bulk. Unitized cargo (containers, pallets, etc.) represented only 10 % of total inland waterways transport in the EU in 2020 (Eurostat 2021).

This kind of freight is usually transported in small volumes, often by SMEs. Pallets must be gathered to be loaded in containers or vessels. This consolidation requires practical logistic engineering, with an accurate synchronization between operators, whereas small supply chain partners generally have stand-alone organization practices. Thus, the critical element for the modal transport shift is to improve cooperation between all the stakeholders, including supply chain actors and public administrations, enabling them to share their resources, bundle their transport volumes, and synchronize their operations.

Nowadays, traceability on inland waterways goes until the vessel unit with AIS -if indeed the device is on (Ninnemann et al. 2019). This level of traceability is enough for bulk and liquid cargo. However, making inland waterway transport more attractive for other kinds of cargo such as containers, big bags, pallets, or even boxes require the development of new enhanced Tracking and Tracing systems, thus allowing gapless traceability of smaller-scale freight transport along canals and rivers through seamless synchronization between supply chain stakeholders. Thus, enabling automatic traceability data acquisition and providing natural flow visibility at any hierarchical level (box/pallet/containers/vessel), boosting the sustainability of inland waterway networks through a modal shift and more sustainable operations.

The European Commission identified, in a study about the future digitalization of inland waterway transport, the generic needs of each actor on inland waterway systems to digitalization. It was revealed that IWT is considered a 'black box' by many shippers and logistics service providers as, during the execution of the shipment, there is usually no way for shippers to track the status of the cargo (Punter and Hofman 2017). The need for actual cargo and not only vessel visibility is evident.

1.3. Research focus and central questions

As introduced in section 1.1, a lack of information exchange between stakeholders involved in a supply chain with transports through inland waterways can lead to significant problems. The different actors often have only a part of the overall process in view. In many cases, a holistic view of the processes along the supply chain is missing, which hinders fast and proactive action in the event of disruptions. Thus, transparent supply chains are gaining importance, and Tracking and Tracing systems are indispensable to close data gaps throughout processes and enable a true digitalization of inland waterway systems. This digitalization is expected to positively influence the sustainability of inland waterway systems, increasing carrying voluminal along canals and rivers and making the complete multimodal chain more sustainable.

This thesis addresses the research gap identified and described in section 1.2. Thus, the main research question has been formulated in an exploratory type as follows:

"How can new enhanced Tracking and Tracing systems support more sustainable Inland Waterway Transport operations?"

The connotation "more sustainable operations" on the main research question implies improvement in inland waterway transport operations. Performance measurement systems are involved to a vast extent in addressing the improvement of processes. "A performance measurement system can be defined as the set of metrics used to quantify both the efficiency and effectiveness of actions" (Neely et al. 2000). Metrics measure quantitative assessment, and performance data would be necessary for their calculations. The proposed idea of enhanced Tracking and Tracing systems has yet to be widely implemented, so collecting performance data to answer the main research question regarding process improvement through metrics is impossible. The explanatory nature of this research and its aim to provide a comprehensive understanding of the research problem with varying levels of depth is confirmed. Thus, the unit of analysis was set as the perception of benefits and impediments linked to the implementation of enhanced Tracking and Tracing systems from the point of view of different stakeholders in the IWT and current or potential customers.

By mapping the benefits, it would be possible to analyse in an exploratory way how eT&T can support more sustainable operations in IWT operations. By identifying the impediments, these first findings will be complemented to finally design a causal model to analyse the implementation process of eT&T in the IWT sector.

When addressing the main question, valuable knowledge will be generated for the following specific concerns:

1. Which benefits arise from introducing enhanced Tracking and Tracing systems for small-scale freight transport?

2. How do these benefits have repercussions on the sustainability of inland waterway networks?
3. Which are the impediments to implementing enhanced Tracking and Tracing systems in inland waterways?
4. How can the identified benefits and impediments be considered in formulating an analytical model to analyse the implementation of enhanced Tracking and Tracing systems for more sustainable inland waterway operations?

1.4. Research methodology

Based on the research focus, a multi-stage research methodology was developed for this dissertation. The basis of the research is the main research question, from which the work's title is generated, in addition to specific concerns and the associated theoretical and empirical procedure. The individual elements of the research design shown in Figure 1-1 are explained in the following sections.

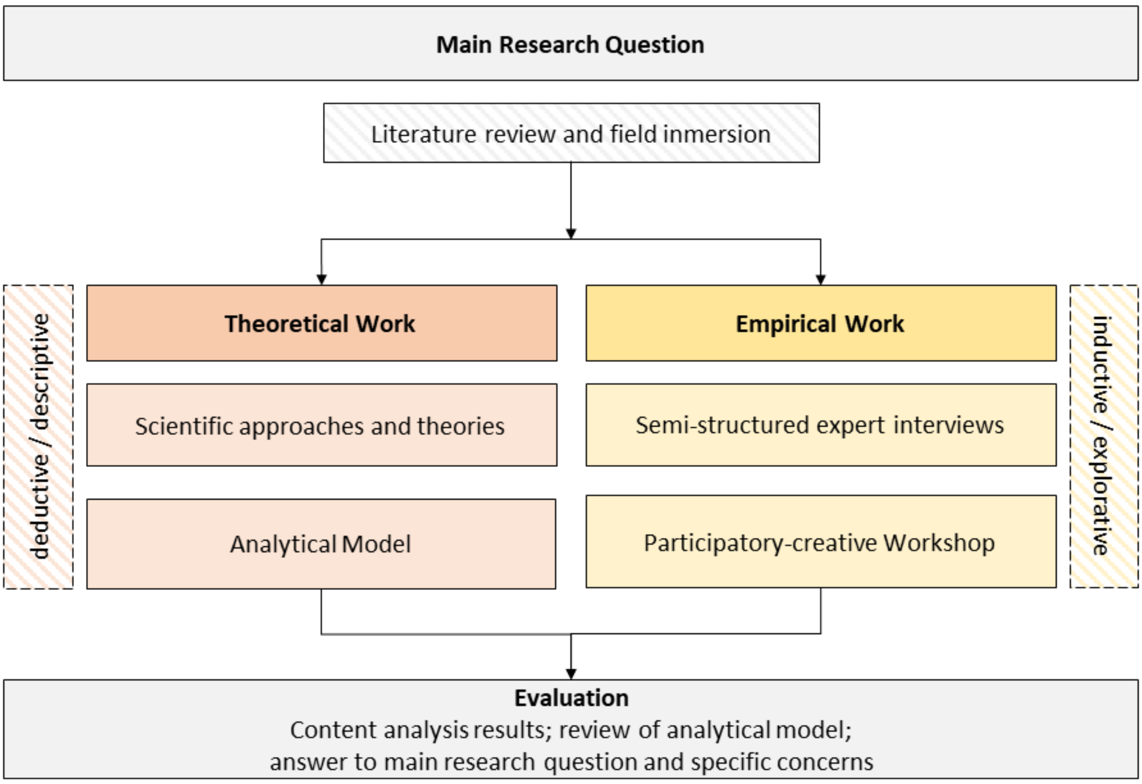

Figure 1-1 : Research design of dissertation

Main research question

Quantitative methods are preferred to improve the efficiency of value chains and logistical processes. With sustainability and Tracking and Tracing, economic, strategic, and political relevant factors cannot be determined from a purely quantitative point of view. Therefore, qualitative methods are considered the best approach to address the present main research question. It combines the topics of inland navigation, sustainability, information exchange, and cooperation and their various complex interactions to yield integral results.

Literature review and field immersion

A fundamental element of the research design is the separate literature review, prepared at the beginning of the dissertation research for industry-specific and scientific familiarization with the theme and is included within this dissertation. The findings from the literature review on the examined topics of Inland Navigation, Tracking and Tracing Systems, Supply Chain Integration, Sustainable Supply Chain Management (SSCM), and Transport Data Legal Framework are the foundations for formulating key questions and proposed models.

The field immersion provided an in-depth insight into the organizational life and the role of inland waterway stakeholders who deal with technology implementation and climate change management. The field immersion section has been designed to complete the theoretical work with practical knowledge. This work provided invaluable understanding, which far from learning the "sectorial language," showed real day-to-day business and operations of inland waterways stakeholders, discovering the main concerns of the sector and position of governmental, lobby, research, and technology development involved players.

Activities conducted for the field immersion included joining two research and development projects (one national and the other at the European level); collaboration with commerce and industry chambers and innovation centres; communication with federal ministries and associations; participation in conferences and sector networking events; visits to fairs and inland ports; as well as personal interviews with practitioners.

Theoretical and Empirical Work

The structuring preparatory work of the dissertation is completed with the formulation of the main research question and specific concerns followed by the preparation of the literature review. The next step is to work it out. This section, referred to as the central part, can be divided into a theoretical basis, a literature section, and a practical-empirical section.

The literature section provides the basics and key figures of inland navigation in general and the research subject. Furthermore, the literature section refers to selected approaches and theories from the scientific literature. The primary outcome of the theoretical work is a reference model that defines the key variables, which enable the analysis and discussion of the data findings and their relationships to address the research question fully.

The heart of the empirical part is the expert interviews and the participatory-creative workshop. Interviews are semi-structured by an interview guide, and the content of the raw material collected is processed by qualitative content analysis. The results of the interviews are the identification of benefits and brakes of enhanced Tracking and Tracing systems for inland waterway transport. Following the interviews, a participatory-creative workshop is planned to review these benefits and brakes with a dynamic methodology on work groups and get information to support the process of formulating measures to overcome the brakes identified.

Evaluation

In the final step, the empirical and the literature sections are brought together. The results of the content analysis and participatory-creative workshop are at the centre of the evaluation. The proposed analytical model will be reviewed and polished, and the main research question will be answered, giving the final insights into the specific concerns. Findings will be translated into a causal model to analyse the implementation of enhanced Tracking and Tracing systems aiming at more sustainable operations in inland waterway transport. Furthermore, the eT&T benefits map and measures to address eT&T implementation´s brakes will be defined. Interpretation techniques are used for the hermeneutic and interpretative assessment of qualitative material, completed with the knowledge gained in the participatory-creative workshop.

1.5. Research description

The nature of the research for this thesis can be described in brief as empirical qualitative research with a social constructivist philosophical orientation. New ideas are generated mainly in an inductive way (bottom-up logic) with epistemic uncertainty. The study follows two main strategies of inquiry: revision of theoretical background and conduction of semi-structured interviews for data collection, followed by content analysis for this data. As a significant result, a new model (grounded theory) is developed. The rigorous research process, provided by the research methodology explained in section 1.4, will result in trustworthy findings. The verification of findings will be based on the criteria of plausibility, credibility, and coherence of the results. For this purpose, three verification strategies will be deployed: data triangulation from theory and interviews/workshops, implementation of participative-creative workshops as participatory modes of research, and clarification of the researcher's bias (researcher role). Finally, the results will be qualitatively controlled after implementing the methods. This double process: verification process and method´s quality control represents a two level-procedure to assure the quality of the research process. Figure 1-2 summarizes the main characteristics of this study.

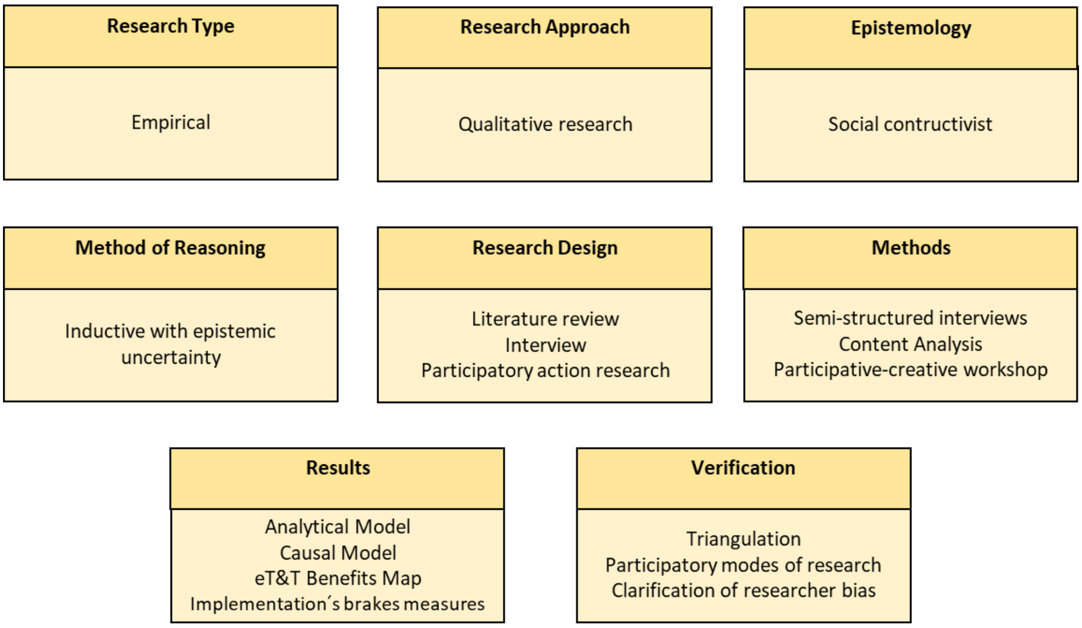

Figure 1-2 : Main components of research for this study

1.6. Geographical area of study

The present work deals primarily with the processes of inland navigation on the heavily frequented sections of the Rhine below Duisburg. Although the so-called Lower Rhine on the German side cannot be separated from Dutch inland waterways and deep-sea ports because of strong functional interdependencies, the focus of research and empiricism of this work is on processes and actors on the German side.

While around 78% of the German freight transport service in inland navigation is carried out on the Rhine, it still lies at 41% in the much smaller section of the Lower Rhine. With its short route lengths yet relatively high cargo transportation, the Lower Rhine is thus the German waterway area with the highest freight transport density (Statistisches Bundesamt 2019). Furthermore, concerning the European significance of the Rhine, the Lower Rhine is the most critical waterway section in the European Union regarding transportation economy and logistics.

Thus, due to the enormous significance of the total Rhine, including the Lower Rhine sections considered for European inland shipping, conclusions can also be drawn about the overall Rhine and European situation. The inconsistent view of the geographic levels of the Lower Rhine - total Rhine - European waterways and European inland waterway transport is, therefore, not a contradiction but a concrete inductive or deductive research approach. Figure 1-3 is a graphical representation of this approach.

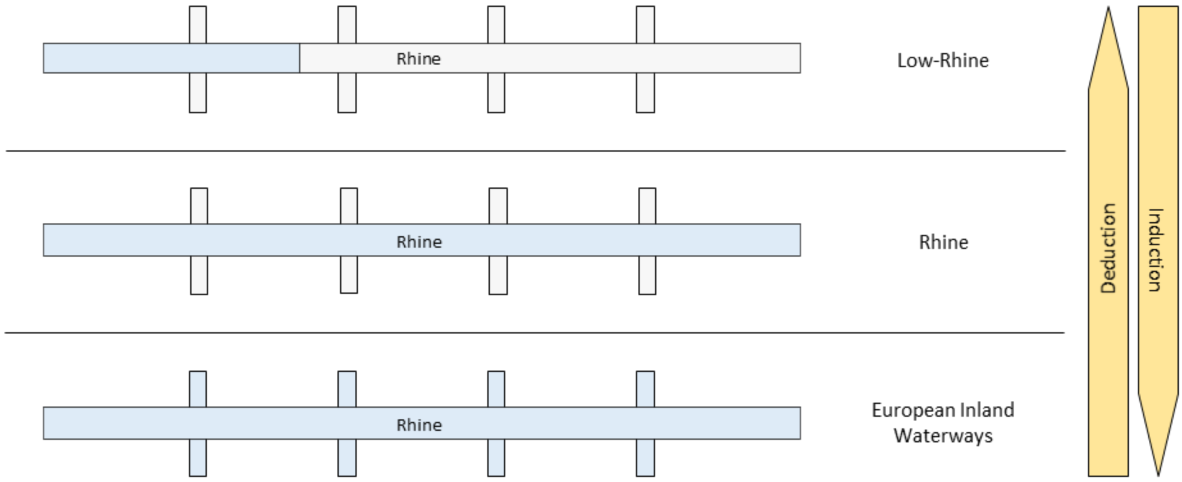

Figure 1-3 : Relation between geographical area of study and research approach

1.7. The researcher´s role

"Knowledge is not value free, and assumptions underlying any research effort, whether associated with a quantitative or a qualitative method, are laced with values. Some values are more implicit than explicit." (Allen-Meares 1995)

As qualitative research is interpretative research, avoiding bias in the results is an important task of the researcher to ensure research rigor (Creswell 2014) (Mackieson et al. 2019) (Chenail 2009). The researcher is therefore required to reflect throughout the complete work about potential matters, such as researcher background and own experiences, that could be extended to relationships with the study participants (such as interviewees). These elements might mark the way the researcher look at things and could influences the research results.

Just from the beginning of this research, the author reflected on her role as the researcher to identify potential biases early and reflect on measurements to minimize them and strengthen research rigor. This section briefly introduces this analytical-introspective and continuous process performed throughout the entire study.

Previous work

Knowledge acquired from previous work provided the first introduction to the theme of this dissertation. Number one is the study "Transport Optimization of Container Networks," where two models (a multi-stage and an integrated optimization mathematical model) were developed for the optimization of linear shipping in the inland waterway. These models aim to support inland shipping companies to select their lines configurations properly. The model yields the optimal network configuration with end ports for each line and sequence of calling ports and scheduling of containerships within these lines. The resulting network maximizes the direct-through container flow density, minimize the total operational costs and total idle time costs of the entire fleet, and minimize idle ship capacities along voyage edge distances.

Number two is developing a simulation tool for the route planning of multimodal supply chains on the project OrGoLo of the EffizienzCluster LogistikRuhr. The tool allowed the calculation of travel times and travel costs for multimodal transport routes with country-specific rates with the inclusion of times and costs for handling operations as well as times and costs for customs clearance processes. The inland waterway transport was one of the modalities simulated on the tool.

Both experiences addressed route planning issues on the inland waterway. None of the projects addressed elements extensively nor from sustainability neither Tracking nor Tracing issues. Thus, potential bias due to these former experiences is non-viable.

Conducting Interviews

It was identified that bias could be introduced while conducting the interviews by the author at two stages: formulating the questionnaire guidelines for interviews with experts and during the interviews themselves. As the author possesses former experiences in the domain of inland waterway transport systems, it could be possible that she strongly tends to formulate questions on art related to these experiences. These possible biases were reduced by the review and comments that work colleagues from different backgrounds did to the questionnaire, from running research and development projects in IW.

Regarding the interview itself, the survey quality largely depends on the appropriate interview situation and conduct. Influence or indirect control of the interviewee by the interviewer should be avoided. Therefore, interview techniques were employed, as later introduced in section 4.1 such as macro and micro planning of the interview, setting the right atmosphere, and the proper moderation techniques of the interviewer. To avoid missing information, exaggerated attention, or misunderstanding of issues revealed during the interview; protocols were sent to interviewees asking for correction or comments to minimize bias that the author could bring as she is the instrument through which data is collected. Furthermore, good governance best practices for conducting qualitative research were applied. Appendix B presents an extract of ethical issues in qualitative, quantitative, and mixed methods (Creswell, 2014) followed for this dissertation.

Finally, the author has no previous relationships with the interviewees and, as an external observer (scientific researcher), did not belong to the research theme setting of the inland waterway industry. Thus, potential bias due to these matters are hardly possible.

Interpretation of data collected in interviews

Thematic analysis requires relatively more involvement, including intellectual contribution from the researcher (Staller 2015). To increase the rigor, transparency, and replicability of the data analysis results, the author analysed the data collected in interviews with the step-by-step (Mayring 2014) Content Analysis Method to be fully introduced in section 4.2. This method guarantees a systematic data categorization that allows an objective data interpretation to minimize bias at this stage.

1.8. Ethical Issues

"Scientific integrity forms the basis for trustworthy research" "Taking this responsibility into full account and embedding it in individual conduct is an essential duty for every researcher and for the institutions where research is carried out." (Verein Deutscher Ingenieure 2022)

As a technological university member, the author recognizes the importance of considering ethical issues when conducting this research. On the one side, there are ethical issues related to good research practices for every research at any stage, such as collecting, sharing, storing data, reporting, and disseminating results. On the other side, the ethical principles of the engineering profession should be commanded by the researcher and guide her actions throughout the study.

The author considers that the fact that the development of this study carries relationships with industrial partners, non-profit and innovation organizations, and governmental and the academic community requires immersion in ethical issues that could arise from such interactions. Indeed, (Taebi et al. 2019) claim that "while universities aim to disseminate knowledge, industry aims to appropriate knowledge" (Taebi et al. 2019). Further, the thesis's theme dealing with future sustainability challenges in an active transport sector requires the highest moral standards of academic conduct and research integrity. Furthermore, it is expected that the consideration of ethics will increase the valorisation of this study through the creation of tangible benefits for society through trustful processes (No science without ethics) and moral decisions by helping to evaluate the consequences of action options.

Intricate ethical questions can arise when conducting any type of research. For this reason, the author exerts on defining an ethics infrastructure to properly acknowledge and address ethical questions that could emerge during this study. For this purpose, the author defined for this study an ethic infrastructure based on four action edges:

1. Ethics in research,
2. Ethics in exercise of engineering profession,
3. Ethics in qualitative research, and
4. Ethics related to engineering sciences and T&T technologies.

An extended description of these action edges and how they were explicitly implemented in the study is out of the context of this thesis. Therefore, the author briefly presents the ethical dimensions in which she worked by analysing related publications, collecting guidelines for good practices, and analysing cases for more specific ethical issues. (Appendix C.)

All these inputs will form the ethics infrastructure for this work based on the four action edges mentioned above.

1.9. Thesis outline

The research work is discussed in eight chapters (2, 3, 4, 5, 6, 7, 8, 9). These chapters describe the different work stages conducted to achieve the research objectives. Finally, Chapter 10 summarizes the knowledge gained and formulates conclusions for work implications and future research.

The flow chart in Figure 1-4 illustrates the content and outcomes of each chapter and how they flow in other chapters. The flow gives a timely notion about how the study was conducted. It presented an accurate plan conceived for a deep and well-structured inquiry and was an important management input for keeping focused on the proposed topic. Through this flow chart the thesis is presented on a logical and structured way for the reader.

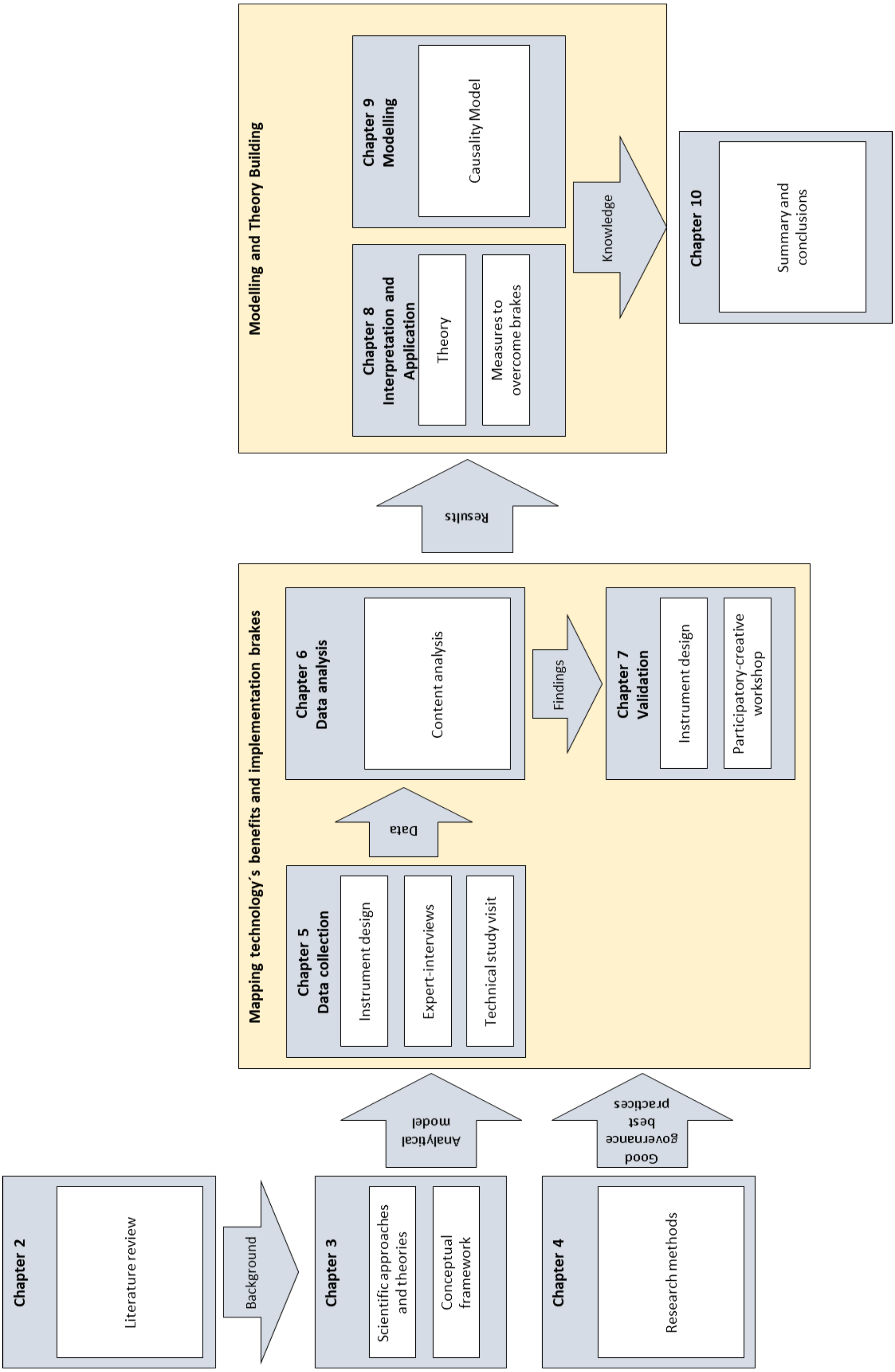

Figure 1-4 : Thesis outline and relationships between chapters

2. Inland Waterway Transport System

Chapter 2 introduces the Inland Waterway as a transport system. Section 2.1 is a technical introduction to IWT focusing on network structure and cargo volumes of the Lower Rhine, vessel types, as well as identification of stakeholders, explanation of business processes, market organization, goods, and information flows. Section 2.2 collects main legal provisions on the IWT and specify the ones relevant for this work. Section 2.3 is a reflection about the assumed development in the future (trends) that will have a long-term and lasting effect on inland waterway sector and therefore indispensable information to identify effects and implications for the study.

2.1. Technical introduction to inland waterway transport systems

The supply chains of inland freight navigation observed in this dissertation comprise the well navigable Lower Rhine areas from the largest inland port in Europe – Duisburg – to the mouth of the Rhine at Rotterdam (Wasserstraßen- und Schifffahrtsverwaltung des Bundes 2017) with focus on the German side. Therefore, the additionally significant sea traffic, seaports and sea supply chains are only relevant to this work insofar as they affect inland traffic of relevant transport arteries and transhipment points of the geographical area of study.

With a cargo volume of 330 mio tonnes, the Rhine has a share of two thirds of the overall cargo volume in European inland waterway traffic, making it by far the most important inland waterway of the European Union (CCNR and European Commission 2016). Its great significance is derived from the economically strong hinterland in west and south-west Germany, the Netherlands, Belgium, Luxembourg and Switzerland (CCNR and European Commission 2016). As a result of an interdependent development, the mouth of the Rhine at Rotterdam, with a cargo volume of almost 432 mio tonnes, has developed into the most important seaward transhipment hub for Rhine transportation and to the largest seaport in Europe (Eurostat 2019). After Rotterdam, Antwerp is the second largest European seaport and the second most important seaward transhipment port for Rhine transportation (Notteboom 2007). The location of the port at the mouth of the Schelde is connected to the Rhine via the Dutch and Belgian canal network and is in direct competition with Rotterdam, for the transhipment of the Upper Rhine areas (Notteboom 2007).

The largest German Rhine ports are Duisburg, Cologne, and Mannheim. However, with an overall transhipment of 52.15 mio tonnes, Duisburg clearly stands apart from the rest of the competitive field with its favourable location at the mouth of the Ruhr. Cologne, the second largest German inland port, tranships 10.7 mio tonnes, only round 20% of the Duisburg ports. The transhipments of the five largest inland ports on the Rhine are broken down in Table 2-1.

Port	Total transhipments	Traffic within Germany	Cross-border traffic	
			Dispatched	Received
Duisburg	52,151	5,723	7,869	38,559
Cologne	10,757	4,195	3,894	2,668
Mannheim	9,655	2,235	1,790	5,630
Neuss	8,001	1,849	1,802	4,350
Karlsruhe	7,232	2,516	2,047	2,669

in 1,000 tonnes

Table 2-1 : The five largest German inland ports according to tonnage 2017 (Statistisches Bundesamt 2018)

With a share of almost 70%, the standard 40 ft container (FEU) is the primary type of container in the Rhine area (Statistisches Bundesamt 2019). According to the Federal Statistical Office, the three largest German container ports on the Rhine are Duisburg, Wörth and Germersheim (see Table 2-2). Based on the ratio of overall transhipment, Duisburg also stands at first place as only outlier in container transhipment. However due to the different locations of the port, only a part of the overall transhipment was recorded by the Federal Statistical Office. For example, Duisburg ports, talks of 4.1 mio TEU instead of 560,000 TEU transhipments for the year 2017. In addition, the larger Middle Rhine locations, such as Cologne for example, are not listed in the top places. Due to a lack of consistent sources however, the Federal Statistical Office is referred to for this work.

Port	Container transhipments
Duisburg	560
Wörth	171
Germersheim	139
Mainz	135
Mannheim	127

in 1,000 TEU

Table 2-2 : The five largest German container ports on the Rhine 2017 (Statistisches Bundesamt 2018)

The cargo transported on the Rhine (measurement point Emmerich) with the highest tonnage are the typical bulk goods. An overview of the five largest cargo sectors is available in Table 2-3.

Container traffic in inland navigation can be described as part of a combined transportation concept. In combined transportation, the freight is transported, without long temporary storage times, on different modes of transport in the same loading unit. This applies especially to container traffic with a connection to international sea traffic. Bulk goods movements are generally not a part of combined transport as they do not use behaviour on loading units and are often put in temporary storage over longer periods of time (Walter 2015) (Arnold et al. 2008).

Cargo sectors	Cargo transhipment
Ores, stones and soils	28,900
Coal, crude oil and natural gas	19,367
Coking plant and petroleum products	15,689
Chemical products	12,087
Non-identifiable goods	10,683

in 1,000 tonnes

Table 2-3 : Cargo transportation according to cargo sectors at the Emmerich measurement point, Jan.-Sep. 2017 (Statistisches Bundesamt 2019)

2.1.1. Vessel types

Different vessel types are used for transportation on the Rhine. There is a common classification according to the cargo vessels categories, tankers and motor vessels or cargo barges. The cargo vessel category includes all vessels used for the transportation of dry bulk goods and containers, while liquid and gas bulk goods are transported on tankers. Motor vessels describe vessels with their own engine. However, cargo barges, as generally non-powered cargo vessels, are dependent on a self-propelled push tug. Together with a self-propelled push tug they form a push tow (Research & Education in Inland Waterway Logistics 2018).

Barges with an open cargo hold are primarily used for container transport on European inland waterways. Even though the acceleration forces impacting on the freight are low and a cell structure is not necessary for structural reasons, it is now frequently used on quite a lot of barges because of its advantages in terms of loading. The largest container barge on the Rhine holds 515 standard containers (twenty-foot equivalent unit, TEU) over five tiers (Notteboom 2007). Vessels that are also used on the adjoining canal network are significantly smaller than these with a capacity of up to 224 TEU in two to three tiers (Arnold et al. 2008).

Table 2-4 clearly shows that – analogous to the previous findings – motor cargo vessels ranking before self-propelled tankers constitute the most important vessel types on the Rhine. Following close behind are cargo barges and the collective category of others to which ro-ro (roll-on roll-off) vessels belong. However, the importance of tanker barges is low.

Waterway area	Total*a	According to vessel type*a					Freight transport density*b
		Motor cargo vessels	Self-propelled tankers	Cargo barges	Tanker barges	Other	
Lower Rhine	1,259	653	293	185	6	120	6,070
Rhine total	2,382	1,367	531	286	13	184	1,322
Germany total	3,048	1,816	682	341	15	193	397

*a *in 1,000 tonnes*
*b *in million tkm*

Table 2-4 : Cargo transportation in inland navigation according to vessel types, September 2018 (Statistisches Bundesamt 2019)

2.1.2. Players

There are many private and public players along the transport network on inland waterways. In (Wagenaar, 1992) classification approach shown in Table 2-5, four primary player groups are identified. The shipper and consignee in the *Commercial Group* are the starting point for the shipment order and thus all involved in business processes. The coordinating carrier or agent (forwarder) is the only player in the *Organizing Group*. The *Physical Group* includes all players who are involved in the physical logistics processes and movement of goods. In addition to the hinterland haulage contractors (pre-/post-carrier operator) and the terminal operators, stevedore companies and vessel operators also belong in this category. Inspectors, customs, and port authorities with a mainly supervisory function are classified under the *Authorizing Group* (Wagenaar, 1992).

Commercial Group	Organizing Group	Physical Group	Authorizing Group
Shipper *Customer*	Forwarder *Carrier, Agent*	Pre-/post-carrier operator *Haulage contractor*	Customs
Consignee *Recipient*		Terminal operator	Port authority
		Stevedore company	Inspection *Inspectors*
		Vessel operator *Shipping company or, where necessary, barge operator*	

Table 2-5 : Player groups in the maritime and waterway industry based on information from (Wagenaar 1992)

Not included in (Wagenaar 1992) classification are locks and district Vessel Traffic Service (VTS) centres; institutions that are relevant for operative inland navigation (Ninnemann et al. 2017). In addition, strategic-political institutions such as associations, interest groups, river commissions, lobby organizations and research institutions must be added for this thesis. More detailed explanations on the players relevant to regulation processes will follow in sections 2.1.3, 2.1.4, 2.1.5 and 2.1.6.

2.1.3. Business processes

Source ports and destination ports are generally not source and destination of the goods being transported (Walter 2015). Just as in maritime transport, in inland traffic, the freight is delivered by truck, rail or ocean-going vessel to the respective terminals or transported away from there. The resulting inter-modal transport chain is broken down into pre-carriage, main carriage, and on-carriage (Walter 2015).

The pre-carriage describes the transportation of goods from the shipper to the first inland terminal (concentration point). The main carriage or haulage is the process of transportation from the first inland terminal to the second inland terminal (break-bulk point). Analogous to the pre-carriage, in on-carriage the goods are transferred from the break-bulk point to the consignee (Pontow 2017). At the same time, at a higher level, the main carriage of inland traffic can depict the pre-carriage or on-carriage of sea traffic (e.g., for scheduled services between Rotterdam and Singapore). This can result in an interleaving of this relationship (Arnold et al. 2008).

If the shipping company active in its role as carrier in the main carriage is simultaneously agent for the pre- and on-carriage, the business process is described as carrier’s haulage (CH). However, if the shipper independently undertakes the organisation of pre-carriage and processes, we speak of a merchant’s haulage (Walter 2015). Vertically integrated companies, which combine several player functions, are described as system service providers (Arnold et al. 2008). The number of these companies who are active as system service providers or full-service providers has risen significantly in recent years (Notteboom 2007).

2.1.4. Market organization

European inland navigation is influenced by a high share of independent companies, particularly in the container market (Notteboom 2007). In the Netherlands, around 50% of the companies active in inland navigation dominated by the Rhine are independent companies. In Belgium, this share is even at around 60% (PLANCO Consulting 2003). There is a similar but not consistently verifiable picture in Germany (PLANCO Consulting 2003). The fragmentation of the market and the inefficient organizational structure of inland navigation originate from this is depicted by (Ninnemann et al. 2017).

In contrast, the container services in inland navigation are organized in consortia in a similar manner to the container services of the major shipping lines. The aim here is to achieve greater economies of scale and capacity utilization rates through a stronger consolidation of goods flows. The development of these alliances has been extremely dynamic in recent years. (Notteboom 2007) confirms a change fewer but more heavily centralized consortia towards smaller, vertical, and decentralized full-service providers along the Rhine. The reason for the rising vertical integration of the companies is said to be the demand for door-to-door and system solution approaches (Notteboom, 2007). This trend can also be verified by the interconnection of companies: around two thirds of the shipping companies active on the Rhine are involved in one or more of the waterway's transhipment terminals (Notteboom 2007).

2.1.5. Goods flows

The starting point for all goods flows is the shipper. The pre-carrier collects the goods by truck or rail from the shipper and transports them to the first inland terminal. Break-bulk cargo is stowed on the vessel by stevedore companies. Containers and bulk goods are loaded onto the vessel with the help of the terminal's cranes and suction or hopper systems. Subsequently, the goods are handled by inland shipping companies, i.e., their inland boatman or private owner operators, i.e., self-skippering vessel owners.

At the inland terminal of the destination port, the freight is unloaded and transported to the consignee by the post-carrier (Ninnemann et al. 2017) (Walter 2015). Wet dispatch or receipt sites are locations that are directly on the waterway and therefore do not require a pre-carrier or post-carrier in the goods flow (Walter 2015). Carriers with an agent function (forwarders) who organize the entire transportation of the goods are often not involved in the physical transportation of the goods (Ninnemann et al. 2017).

Figure 2-1 is a representation of goods flows in IW with information about players and business processes describe in sections 2.1.2 and 2.1.3 respectively.

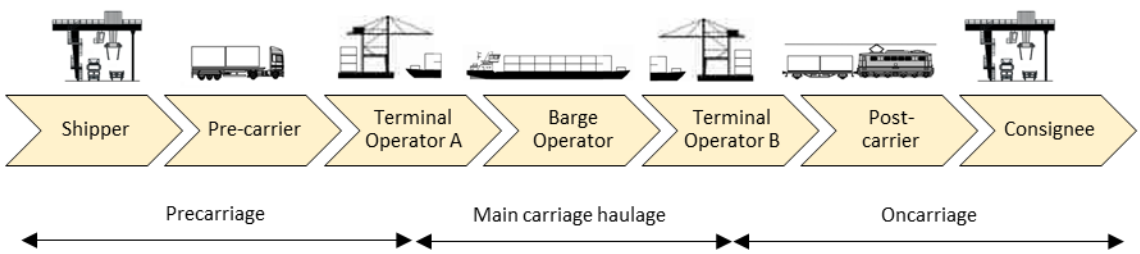

Figure 2-1 : Goods flows and business processes in IWT

2.1.6. Information exchange

The following section deals with operative information flows, i.e., the direct exchange of information for the purpose of the development of business processes. In this work, operative information flows must be clearly distinguished from strategic information flows, i.e., information flows for the organization of business processes, to better understand data exchange and visibility through Tracking and Tracing systems as a way of cooperation (Walter 2015) and (Pontow 2017).

As mentioned, the organizational structures in inland navigation, introduced in section 2.1.4. Market Organization are considered a major obstacle for the integration into modern logistics processes (Ninnemann et al. 2017). Central overviews or consistent systems for (IT)-interfaces often don’t exist. While the flow of information in ocean shipping is researched and documented extremely well, the scientific penetration of this field into inland navigation is low. The following information flows in inland navigation refer to the study performed by the Hanseatic Transport Consultancy on the process digitalization of the river Elbe corridor (Ninnemann et al. 2017). As various cooperation models are conceivable, and a vertically integrated system service provider can combine myriad player functions into one, there are several possible information flows. The information chain described in Figure 2-2 represents the standard case of separate player functions.

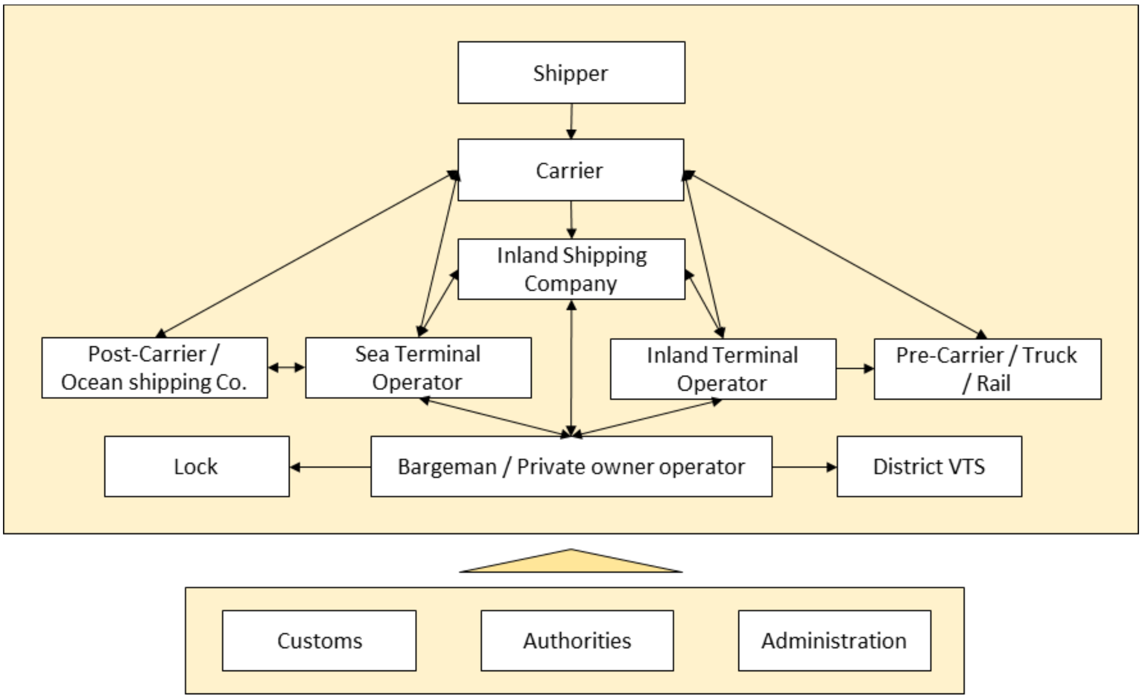

Figure 2-2 : Information flows in inland navigation based on (Ninnemann et al. 2017)

(Ninnemann et al. 2017) categorize the information flow into three process levels or sub-processes. The information chain begins with the arrival of the order. Therefore, the first level is order processing. Then, the information flows continue into transport preparation and finally transport execution (Ninnemann et al. 2017). Figure 2-3 is a graphical representation of the three mentioned above process levels to be described below.

Figure 2-3 : Process levels of the information flows in inland navigation based on (Ninnemann et al. 2017)

Information flows: Order processing

Request, creation, and acceptance of the order are normally carried out within order processing by telephone or e-mail. The customer data or order data are usually sent by e-mail in a PDF file format and then entered the respective software manually. At this point, there is no synchronized data exchange what means that the order data must be entered manually into the inland shipping company's scheduling and invoicing software again. Further arrangements with the inland boatman are made by telephone. As soon as the general planning is completed, the terminals involved are informed of the goods to be transported and their loading and unloading times by an advanced shipping notification. A comparison of statuses between shipping company/vessel operator and terminal is mostly carried out in the field of containers via automated platforms, while the exchange of information for all other goods classes takes place by telephone. The final loading and unloading times are also recorded by e-mail, sometimes also only by telephone (Ninnemann et al. 2017). Figure 2-4 give a graphical representation of these information flows between players for the processing of transport orders.

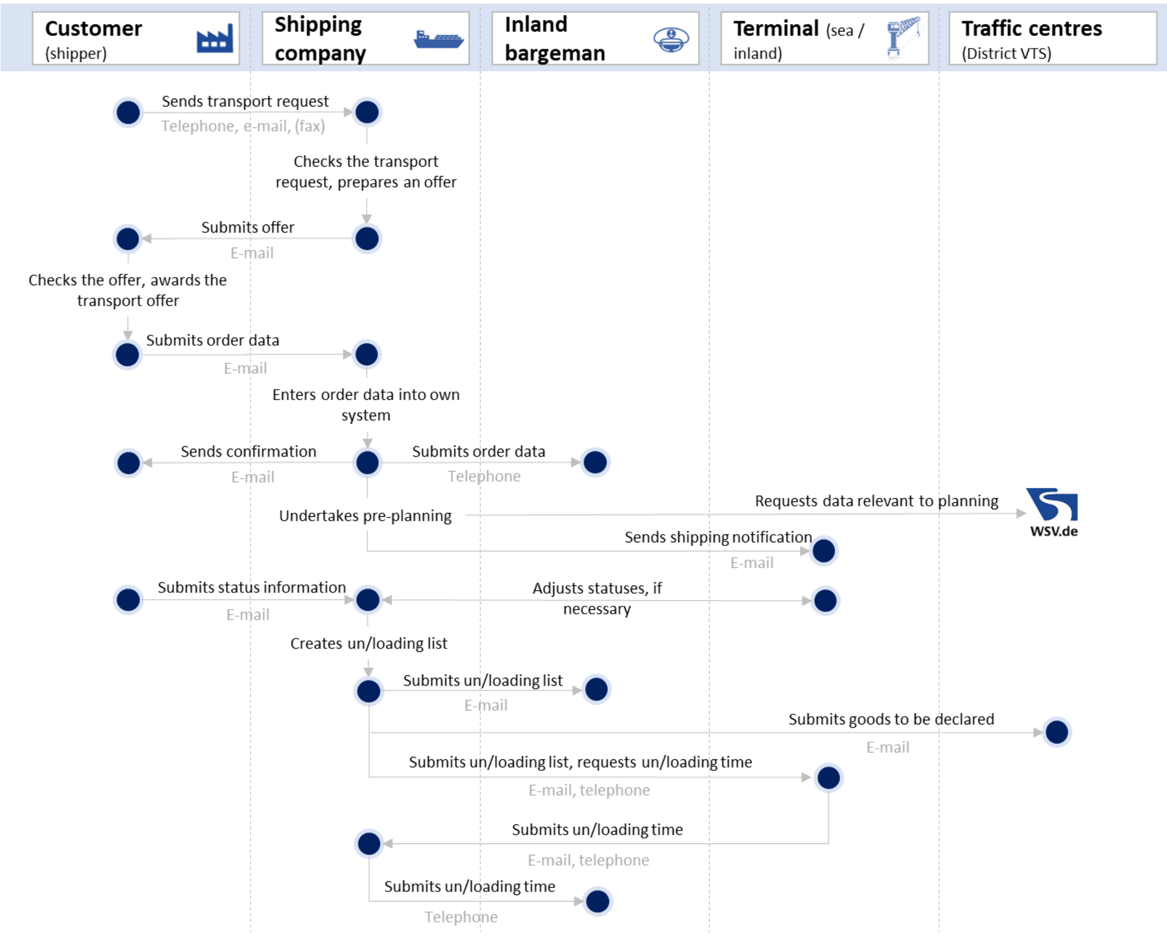

Figure 2-4 : Information flows in order processing based on (Ninnemann et al. 2017) with little adjustments

Information flows: Transport preparation

Transport preparation begins when the vessel sails into the port. However, the compulsory advanced registration by radio with the vessel traffic service centre is often disregarded. At the port, i.e., at the terminal itself, static and dynamic vessel data such as load, size and draught or loading/unloading ports are sent by e-mail or fax. Based on the loading and unloading times, the vessel operator creates a stowage plan, which is forwarded to the terminal. This is carried out in paper or in digital form depending on requirements and possibilities. After the goods have been loaded, the vessel operator sends the final stowage plan to the shipping company and the destination terminal by e-mail. From this point onwards, the customer is only in active contact with customs and only insofar as they are transporting goods, which must be declared. Shipping company and carrier work self-sufficiently (Ninnemann et al. 2017). Figure 2-5 give a graphical representation of these information flows between players for the transport preparation.

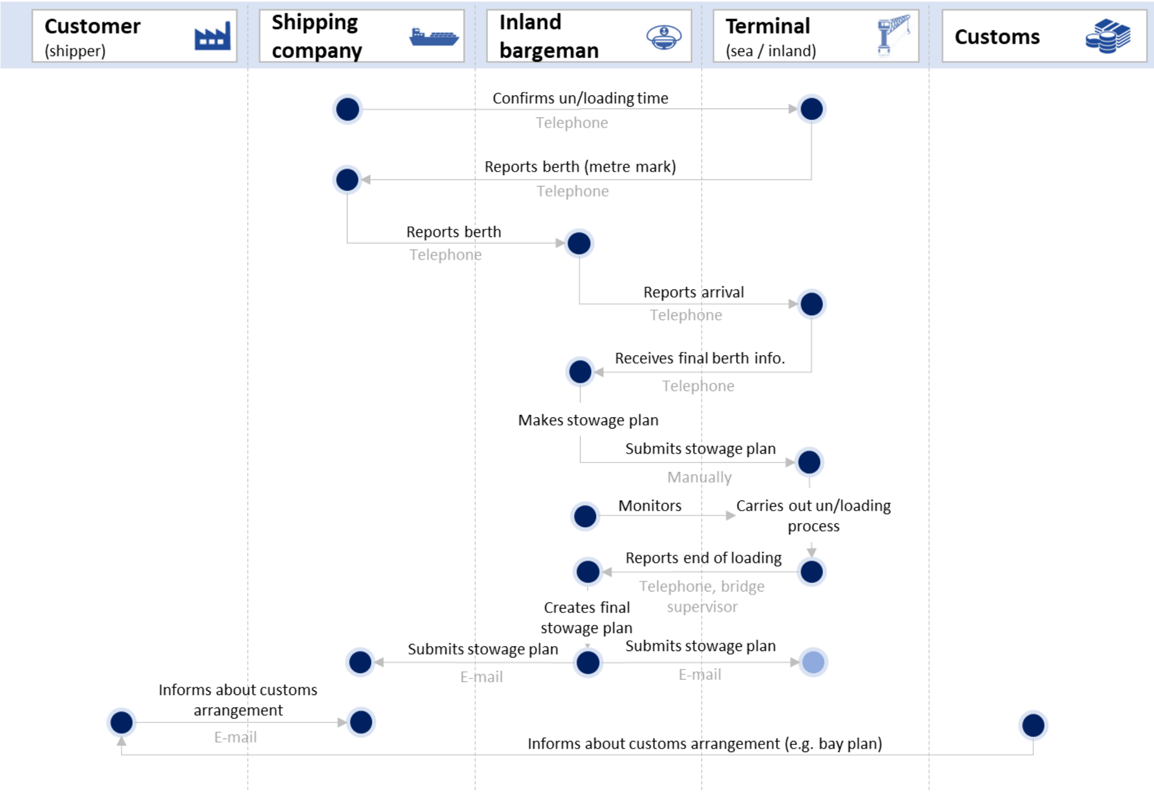

Figure 2-5 : Information flows in transport preparation based on (Ninnemann et al. 2017) with little adjustments

Information flows: Transport execution

During transport execution, communication is primarily among those involved in the active navigation process. The most important players are therefore the Vessel Traffic Service centres, locks, and vessel operator. Coordination, i.e., signing on and off with the district Vessel Traffic Service centres and locks is carried out up to an hour before arrival. The vessel operator is informed of the passing time (rank) by the lock. The administrative process for the purpose of lock statistics and invoicing is carried out in writing, partly also by radio. This is the basis on which invoicing of the lock and canal charges is carried out later between the waterway's operator and the inland shipping company. Cash payments are no longer common. Communication of arrival at the destination terminal is carried out by telephone or radio, however the loading and unloading lists must be forwarded in writing (Ninnemann et al. 2017). Figure 2-6 give a graphical representation of these information flows between players for the transport execution.

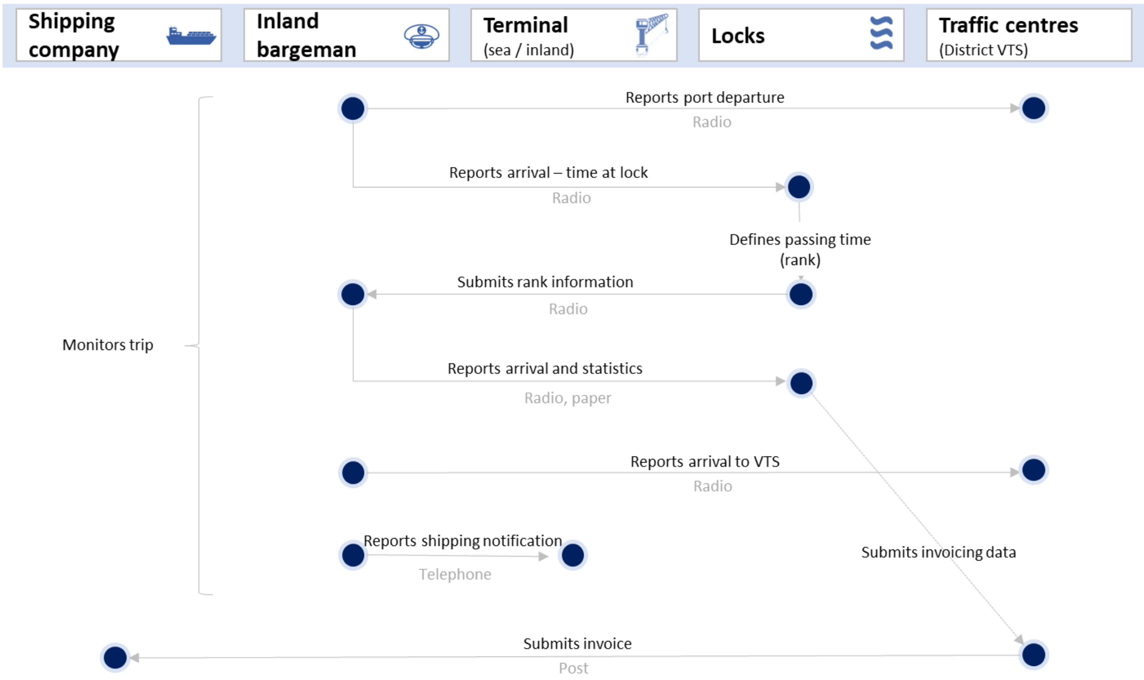

Figure 2-6 : Information flows in transport execution (Ninnemann et al. 2017)

A comparison with the processes in truck and rail transportation carried out by (Ninnemann et al. 2017) argues that the business processes in inland navigation have the worse operative networking of the involved players (Ninnemann et al. 2017). This situation is also verified in a study by the University of Applied Sciences and Arts Northwestern Switzerland in cooperation with the logistics service provider and terminal operator Swissterminal, which examined information flows in combined transportation. It was identified that system performance in terms of the indicators waiting time and throughput time could be improved by 100% with the use of a simple digital advanced notification system (Swissterminal 2016). Papers by (Walter 2015) and (Pontow 2017), which primarily deal with information flows in ocean shipping, also conclude that broken information chains are a major obstacle in the development of maritime logistics processes.

Figure 2-7 summarizes the players described in the previous sections as well as the goods and information flows shaping them.

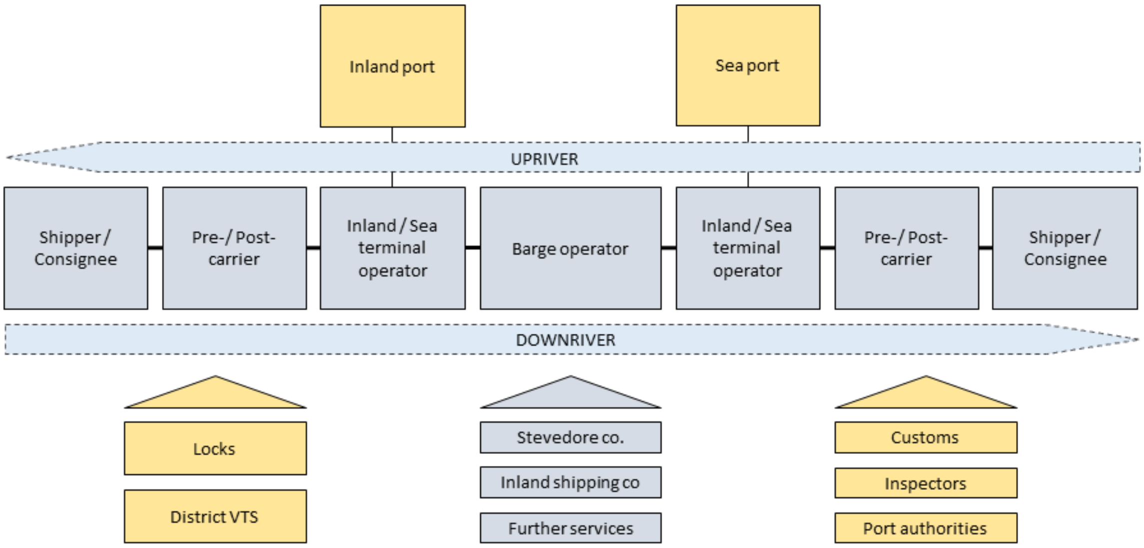

Figure 2-7 : Public (yellow) and private (grey) players, goods, and information flows in inland navigation

2.2. *Main legal provisions in the inland waterway sector*

In this section, the most important players, levels, and objects relating to the regulations in European inland navigation with focus to Rhine River are described.

2.2.1. Regulatory players

As river commission of the largest European inland shipping route, the Central Commission for the Navigation of the Rhine (CCNR) or ZKR can be named as the most important player in the regulation of German inland navigation. It is above the Danube Commission and the International Sava River Basin Commission and forms the head of the three most influential European river commissions (Erceg 2018). The tasks of the waterway committees lie in the organization of the processes, players as well as compliance of legal and technical frameworks. As the largest and oldest commission, the CCNR plays a special role. In contrast to the two other river commissions mentioned, as well as many more unmentioned commissions, the resolutions made by the CCNR are legally binding for its member states (Germany, Netherlands, Belgium, Switzerland, and France) without any further legislation processes (CCNR 2019) (Erceg 2018). Due to the major national and international significance of the three waterways, in particular the Rhine, these committees are often also called upon to draw up regulations on all three levels of regulation.

After the CCNR, the European Union is the second most important regulator over the Rhine. The EU particularly comes into play in the harmonization of standards, digitalization and the development and classification of the infrastructure. Analogous to the national Ministries of Transport and Digital

Infrastructure, the Directorate General for Mobility and Transport (GD MOVE) is the highest authority with jurisdiction for inland navigation on an European level (European Court of Auditors 2015). It is responsible for the implementation and development of the commission's division strategy (European Commission General Direction MOVE 2019). The most important juridical acts of law are stringent legally binding regulations as well as less legally binding directives for all member states (European Union 2019). CCNR and DG MOVE signed a cooperation agreement in May 2013 staying a closer collaboration on concerns in inland navigation (European Commission 2013). EU regulations and directives are non-binding for the riparian state of Switzerland.

As one of the five regional commissions in the United Nations (UN), the Economic Commission for Europe (UNECE) also has its own area of work for inland navigation (United Nations Economic Commission for Europe 2019). However, as their resolutions are not legally binding and compete with the approaches of the nation-states, the river commissions or the EU, there are few relevant regulations in which the UNECE is explicitly mentioned. Nevertheless, there are several norms published by the UNECE such as Resolution 63 on vehicle Tracking and Tracing systems (VTT) (United Nations Economic Commission for Europe 2015).

The nation-states amend the portfolio of their own regulations and translate the resolutions, regulations and directives by the river commissions, the EU and other organizations as well as international contracts into national law. The Ministries of Transports and their respective authorities are significantly involved in formulating and implementing these acts of law. In Germany, the Federal Ministry of Transport and Digital Infrastructure (BMVI), together with the Federal Waterways and Shipping Administration (WSV) and their associated offices as well as specialist departments such as the Federal Waterways Engineering and Research Institute or the Federal Institute of Hydrology (BAW and BfG) (Wasserstrassen- und Schifffahrtsamt Schweinfurt 2019) (Bundesanstalt für Wasserbau 2019) look forward to implement these regulations into national law.

Table 2-6 provides an overview of these last and Figure 2-8 provide a graphical representation of the most important regulatory players and their action levels.

Organization	Abbreviation	Activity or field of activity
Permanent International Association of Navigation Congresses	PIANC	Congresses for shipping & waterways
International Organization for Standardization	ISO	Standardization
Inland Navigation Europe	INE	European inland navigation
European Federation of Inland Ports	EFIP	European inland ports
International Electrotechnical Commission	IEC	Electrotechnical standards
European Barge Union	EBU	European inland navigation
International Maritime Organization (UN specialized organization)	IMO	Ocean shipping
European Skippers Organization	ESO	Association of boat masters
European Sea Ports Organization	ESPO	European sea ports
International Hydrographic Organization	IHO	Hydrographic standardization

Table 2-6: Selection of organizations in European inland navigation

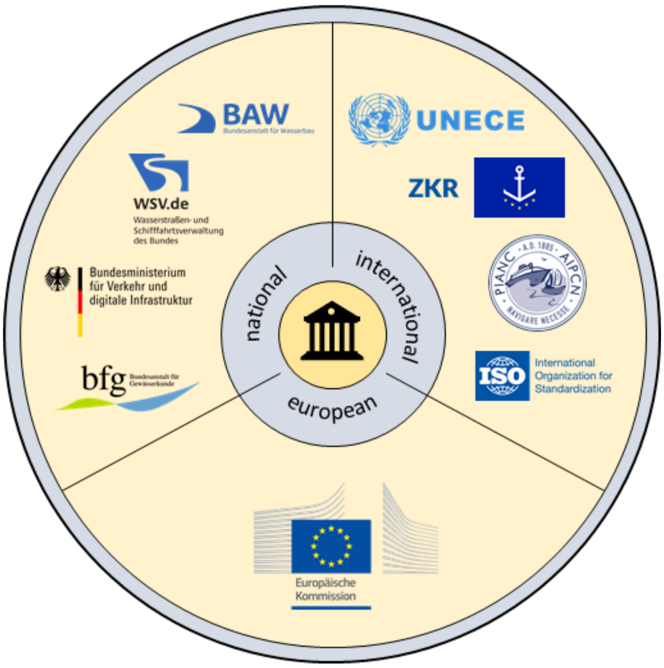

Figure 2-8 : Levels and selected players in the regulation over the Rhine

2.2.2. International level

The international level of regulation in inland navigation is influenced by the work of international organizations as well as state conventions.

There are various examples of concrete norms and directives, which were drawn up by international organizations and regulate the German and European inland navigation. Three applications are given here as an example:

1. The PIANC association commission for IWT (InCom) publishes RIS directives which have been taken on by the CCNR and other international entities (Willems and van Gils 2018),

2. Information systems in IWT use the syntax of the EDIFACT standards according to ISO 9735 (International Organization for Standardization 2019), and
3. IHO, IMO and IEC define the technical sea chart standards used by ECDIS.

The following table provides an overview of the most important intergovernmental contracts and agreements on the regulation of inland navigation at an international level. Apart from the Revised Convention for the Navigation of the Rhine, which determines the current position of the CCNR, the most important European river commission was involved in drawing up the content of all agreements. Intercontinental contracts are not usual due to the separate waterway systems.

To an international level, most relevant player for this work is the International Organization for Standardization as they released the EDIFACT standards for message exchange that are nowadays used on the communications between inland and seaports. For international contracts, the ADN will be an important reference for consecutive work as this contract regulates use of packaging, processes of dispatch, loading, carriage and unloading as well as transport documentation, which represent interfaces with the traceability of goods through inland waterways. Table 2-7 summarizes the international contracts on the regulation of inland navigation.

Name of the contract (year, without ratification/amendment)	English translation	Participants or signatories	Contents
CMNI *Convention de Budapest relative au contract de transport de marchandises en navigation intérieure* (2000)	Budapest Convention on the Contract for the Carriage of Goods by Inland Waterway	Hungary, Luxembourg, Romania, Switzerland, Croatia, Czech Republic, Bulgaria, Netherlands, Russian Federation, France, Germany, Slovakia, Moldova, Belgium, Serbia, Ukraine	- Definition of the rights and obligations of the contract parties in inland navigation - Contractual documents - Rights of disposal - Liability of the carrier - Claim periods
Revidierte Rheinschifffahrtsakte / Mannheimer Akte (1868)	Revised Convention for the Navigation of the Rhine / Mannheim Act (1868)	Germany, Belgium, France, Netherlands, Switzerland	- Official establishment of the CCNR - Freedom of Rhine navigation - Simplification of customs duties - Maintenance of infrastructure by member states
CLNI *Convention de Strasbourg sur la limitation de la responsabilité en navigation intérieure* (2012)	Strasbourg Convention on the Limitation of Liability of Owners of Inland Navigation	Germany, Belgium, France, Netherlands, Switzerland, Serbia, Poland, Luxembourg	- Right to limitation of liability - Limitation of liability - Limitation fund
CDNI *Convention relative à la collecte, au dépôt et à la réception des déchets survenant en navigation rhénane et intérieure* (1996)	Convention on the Collection, Discharge and Reception of Waste arising from Rhine and Inland Navigation	Germany, Belgium, France, Luxembourg, Netherlands, Switzerland	- Polluter pays principle for waste and removal costs - Safety and separation of waste disposal - Agreement of waste disposal standards
ADN *Accord européen relatif au transport international des marchandises dangereuses par voie de navigation intérieure* (2000)	European Convention concerning the International Carriage of Hazardous Goods by Inland Waterway	Russian Federation, Netherlands, Hungary, Austria, Bulgaria, Luxembourg, Germany, Moldova, France, Romania, Croatia, Slovakia, Ukraine, Poland, Serbia, Switzerland, Czech Republic, Belgium	- Classification of hazardous goods - Regulations for the use of packaging, tanks and CTUs - Regulations on dispatch, loading, carriage and unloading - Construction and testing regulations - Regulations for crew, operation, equipment and documentation

Table 2-7: International contracts on the regulation of inland navigation (Central Commission for the Navigation of the Rhein 2000, 2012, 2017, 2018, 2019) (Transportrecht.de 2019)

2.2.3. European level

Regulation on a European level is carried out through many directives and regulations. As a detailed description of all individual acts of law would overstretch the boundaries of this work, Table 2-8 presents the most authoritative directives on technical, economic, and legal questions (Erceg 2018).

Act of law	Year	Contents
Council Regulation (EEC) No. 2919/85	1985	Laying down the conditions for access to the arrangements under the Revised Convention for the Navigation of the Rhine in the Union
Council Regulation (EEC) No. 3921/91	1991	Conditions under which non-resident carriers may transport goods or passengers by inland waterway within a Member State
Council Regulation (EC) No. 1356/96	1996	Common rules applicable to the transport of goods or passengers by inland waterway among Member States
Council Directive 87/540/EEC	1987	Access to the occupation of carrier of goods by waterway in national and international transport and on the mutual recognition of diplomas, certificates, and other evidence of formal qualifications for this occupation
Council Directive 91/672/EEC	1991	Reciprocal recognition of national boat masters' certificates for the carriage of goods and passengers by inland waterway
Council Directive 96/50/EC	1996	Harmonization of the conditions for obtaining national boat masters' certificates for the carriage of goods and passengers by inland waterway in the Community
Council Directive 2005/44/EC	2005	Harmonized river information services (RIS) on inland waterways in the Community
Council Directive 2006/87/EC	2006	Technical requirements for inland waterway vessels and repealing Council Directive 82/714/EEC
Council Directive 2009/100/EC	2009	Reciprocal recognition of navigability licenses for inland waterway vessels

Table 2-8 : Authoritative European acts of law on the regulation of inland navigation (Council of the European Union 1985, 1987, 1991, 1991, 1996, 2005, 2006, 2009)

In addition, the European Commission promotes, harmonizes, and regulates water-bound inland transportation to explode the ecological, economic and logistical potentials of inland navigation through programs and projects. The central lever is the program of action Navigation and Inland Waterway Action and Development in Europe II (NAIADES II), which is intended to produce extensive improvements in the areas of infrastructure, innovation, market functions, environmental quality, personnel development and inter-modality in the period of 2014 to 2020 (European Commission 2013). Table 2-9 provides an overview of a selection of program in inland navigation that were set up or co-financed through the EU or EC.

Program	Period		Goals / contents
	from	to	
Iris Europe	2006	2008	- Implementation of pilot projects for EU-RIS Council Directive 2005/44/EC in Austria, Hungary, Slovakia, the Netherlands, Belgium, and France
NAIADES II	2014	2020	- Framework programs by the EC for the promotion of inland navigation - Improvements in the key areas: infrastructure, innovation/digitalization, market functions, environmental quality, personnel development, and inter-modality
NAIADES I	2006	2013	
PLATINA II	2013	2016	- Platform for the implementation of NAIADES I and II - Project and player coordination
PLATINA I	2008	2012	
LOT 1 – 4	2016	–	*Follow-up program for PLATINA II, broken down into four areas:* - LOT 1: Analysis of potential in seaports and inland ports, inland waterways, and associated politics - LOT 2: Concept planning for digital services – Digital Inland Navigation Area (DINA) and RIS - LOT 3: Development of a good navigation status (GNS) in European waterways - LOT 4: Promotion of innovation – implementation of the European Inland Barging Innovation Platform (EIBIP)
Prominent	2015	2018	- Increase of competitiveness and efficiency to a road transport level - Certification and monitoring of emissions - Harmonization and modernization of existing systems

Table 2-9 : Significant European programs supporting inland navigation (European Commission 2012) (Viadonau 2019) (European Commission and Ernst & Young 2016) (STC-NESTRA 2016 and 2018) (Viadonau and STC-NESTRA 2019) (DG MOVE 2018) (IRIS Europe 2009)

However, the European Court of Auditors (ECOA) which, as European auditor, examines projects financed by the EU, draws the conclusion that many projects for the promotion of inland navigation do not achieve their initially defined goals (Stevens 1989).

For this dissertation work, programs NAIADES I and II together with LOT 2 were revised when working the model to check possible interdependencies with eT&T systems. Even though the Program Lot 3 aims the development of a “good navigation status” (GNS) this should not be confused with “cargo status”. GNS means the status of inland navigation transport network such as waiting times, physical dimensions of bridges, incident management, waste reception, and further navigability and process components.

2.2.4. National Level

National legislation primarily controls the operative process on local waterways. This ranges from very fundamental matters such as the definition of responsibilities or infrastructural and technical facilities to the regulation of hazard prevention and including specialist regulations for very small individual waterways (Rhein-Rhur-Institut für Sozialforschung und Politikberatung e. V. 2004). The most important German regulations are presented in Table 2-10. Regulation by national legislation is significantly different in other European or Rhine-riparian states.

Act of law	Abbreviation	Contents
German Inland Waterways Act	BinSchG	- Limitation of liability for commercial shipping - Rights and obligations of associated groups - Regulations on charges
Federal Waterway Act	WaStrG	- Definition of federal waterways and their construction or expansion - Maintenance of federally owned shipping facilities - Rules of law and fines
Shipping Register Regulations	SchRegO	- Regulation of the entry of vessels in the registry of vessels, corresponding legal relationships and documents
Inland Navigation Duty Act	BinSchAufgG	- Responsibilities and ordinances of the state authorities - Data acquisition and processing - Regulations on diverse file systems (law infringements, certification of competencies, etc.)
Regulations on access to the occupation of the carriage of goods by inland waterways	BinSchZV	- Definition of the description of activities, prerequisites, and evidence of ability to work in inland navigation
Inland shipping routes and police regulations	BinSchStrO	- General and waterway-related regulation of transportation on inland shipping routes
Ordinance on the transport of dangerous goods by road, rail and inland waterways	GGVSEB	- General regulations, partly specific to inland navigation, concerning the transportation of hazardous goods - Obligations of the associated parties and the respective federal offices
Law on the transportation of hazardous goods	GGBefG	
Law on the rights of registered vessels and vessels under construction	SchRG	- Content, assertion as well as transfer, alteration, and termination of vessel mortgages

Table 2-10 : German acts of law on the regulation of inland navigation (Bundesamt für Justiz 2019) (Wasserstrassen- und Schifffahrtsverwaltung des Bundes 2019)

At a national level it is identified that the Inland Navigation Duty Act could provide important regulations about data acquisition and processing to be considered in eT&T systems.

2.3. Last trends in the Inland Waterway Transport

The 2018 European Inland Navigation Market Observation report of the Central Commission for the Navigation of the Rhine shows significant market evolutions concerning various aspects of inland navigation, including transport demand, fleet evolution, inland waterway transport companies and river cruises are presented. After analysing these indicators, the Commission identified new growth opportunities for inland waterway transport. These represent long-term trends for the Inland Waterway market which this dissertation is based on. First, limited growth is foreseen transporting agricultural products through inland waterways in Europe (Central Commission for the Navigation of the Rhine 2018). The Commission forecast that Europe´s iron and steel production is expected to stagnate in Europe in the long-term (CCNR 2018). This could be explained by the transfer of production plants to cheaper countries. Nevertheless, with its strong automobile industry, Germany escapes from this tendency. On the other hand, the construction activity and chemical production are the main growing segments for inland waterway transport (CCNR 2018). This seems to be promoted by the strong urbanization tendencies and the growth on demand of higher-value-added products such as agrochemicals and engineering plastics (Keller et al. 2015). Other growing segments are new markets such as the biomass, the urban logistics and container transport (CCNR 2018).

From these last three segments, urban logistics has the most relevance for this work. Under *Urban Logistics*, also known as *City Logistics*, is understood "any service provision contributing to efficiently managing the movements of goods in cities and providing innovative responses to customer demands" (Dablanc 2019). These movements could include delivery of goods (business and home); service transport and demolition traffic; shopping trips made by private households; reverse logistics for waste removal and for returns management as well as service vans for maintenance, supply and removal of parts (Alliance for Logistics Innovation through Collaboration in Europe 2019). For example, in the Brussels region, one of most densely populated and transit areas in Europe, urban freight transport represents about 10–15% of vehicles-km but is responsible for 19% of energy consumption of road transportation, 25% of CO_2 emissions, 30% of NO_x emissions and 50% of particles (Janjevic and Lebeau 2013).

In most cities, urban freight transport is, to its vast majority, performed by road (Taniguchi et al. 2000). This confirms that the high potential is still unexploded to shift freight flows to more sustainable transportation modes like train and waterways. Although Europe is a leading region in sustainable transportation, inland waterways are almost exclusively used to transport bulk materials over longer distances. Nevertheless, several cities have begun to develop new delivery concepts for freight delivery in cities using barges and shifting the paradigm that inland navigation can be competitive for bulk transportation over long distances and smaller-scale freight transport in dense urban areas. These concepts promise the release of city roads, better utilization of waterways capacities, improved life quality for citizens (emission, security, stress), and new forms of cooperation for suppliers. eT&T systems are of great value for the competitive transportation of small-scale freight.

Table 2-11 presents examples of these new delivery concepts for city logistics using inland waterways are presented. For this work, these concepts are labelled as "Aqua City Logistics" by the author.

Aqua City Logistic Concept	City	Concept´s description
FLUDIS ®	Paris	FLUDIS concept is based on a mobile boat warehouse with a hybrid engine to transport cargo into the centre of Paris through the Seine River. Goods are loaded and grouped outside urban centres, sorted on-board the boat during navigation times, loaded onto cargo bikes equipped with a removable container, and unloaded during stops in town centres.
Pallet Shuttle Barge (PSB)	Brussels	PSB from Blue Line Logistics was designed to operate on inland waterways to transport goods on pallets or in big bag into the city centre of Brussels. The adapted barge, with a capacity of 198 pallets, collect and deliver cargo of several customers through different stops over the city.
Beer Boat	Utrecht	The City of Utrecht looking to preserve its historical city centre, implemented a new electric vessel traveling six times four days per week to supply more than 60 catering businesses on the city centre with beer and beverages.
DHL Floating Distribution Center	Amsterdam	Several bicycle couriers are connected to an especially reconstructed boat with a radio receiving set. The messengers deliver and collect letters and packets to load on this boat at given landing stages through the city of Amsterdam to deliver mails per boat and bicycle.
Franprix	Paris	The supermarket chain transport through boats over the Seine River swap bodies to daily deliver to 300 stores in Paris city west. The transhipment point is located only 500 meters from the Eiffel Tour, where the swap bodies are loaded onto EUR-6 trucks.

Table 2-11 : Examples of delivery concepts for city logistics using inland waterways (Caisse des Depots 2015), (Blue Line Logistics 2018), (CIVITAS 2013), (ELTIS 2015), (Garrido 2018)

Technological and organizational trends in the inland waterway sector drive these market evolutions. In the following section, a brief introduction to these trends is given as they are expected to influence the direction of new developments in the sector and therefore fix the conditions for coming Tracking and Tracing systems in IWT.

2.3.1. Technological trends

The 21st century has been shaped by the extended application and quick development of new information and communication technologies (ICT). ICT has become an integral part of people’s daily lives and a game changer in doing business. Follows a short introduction to current technological trends in the IWT:

1. Cloud computing

“Cloud Computing is the delivery of computing services—including servers, storage, databases, networking, software, analytics, and intelligence—over the Internet (“the cloud”) to offer faster innovation, flexible resources, and economies of scale" (Microsoft 2018). Companies that offer these computing services are referred to as "cloud providers"; they typically bill these cloud computing services based on their usage. Cloud computing vendors such as Amazon Web Services, Microsoft Azure and IBM Cloud operate and manage the network-connected hardware needed for these application services. Through cloud computing could be for example, digital platforms shared among the inland ports operating in a same corridor.

2. Blockchain

Blockchain technology is a reliable, difficult-to-hack database of transactions shared and synchronized across multiple computers and locations (ledger) as a collection of blocks in an unmodifiable chain to highly secure records information (SAP 2019). Blockchain promises more secure and faster processes through transparent and automatic execution of transactions. IWT stakeholders can use blockchain to track and trace cargo back to the source proving certified source and stopovers through the transport chain.

3. Internet of the Things

The Internet of Things (IoT) is the concept of connecting any object that has a power switch to the Internet with other connected entities. IoT is a vast network of connected things that collect and share data about their use and the environment around them (Clark 2016). The information can then be used to identify patterns, make recommendations, and identify potential issues before they occur. With the knowledge of advanced analytics, processes can be made more efficient while specific tasks are automated, especially if they are repetitive, trivial, time-consuming, or even dangerous. A use case of IoT in the inland waterway sector could redefine cargo transhipment processes between barges and terminals with the implementation sensors connected to IoT platforms.

4. Artificial Intelligence

Rather than a single technology, Artificial Intelligence (AI) is "a constellation of technologies that allows machines to sense, comprehend, act and learn in order to extend human capabilities" (Accenture 2019). AI-powered computing can significantly change how supply chains operate and disrupt them to be self-learning, intelligent and agile through the implementation of advanced big data analytics (to data generated e.g., by IoT platforms). Machine learning-based algorithms to predict exceptions in the supply chain, evaluate corrective plans and resolve them in real-time. With AI, the organization and control of transports through IW could be redefined by providing vessel operators with optimal corrective measures for waterways channels, terminals, or locks disruptions.

5. Automated and autonomous driving

Automated and autonomous driving systems on the IWT refers to vessels' navigation through waterways that consequently guide themselves with fewer human intervention. Autonomous carriers can increase fleet's productivity by cutting operating costs per kilometre (Daimler 2019). Autonomous vessels are a condition to operating platoons (convoys) that comprise two or more vessels to be coupled and navigate with a notably reduced distance between them to improve aerodynamics and save fuel.

6. Virtual and Augmented Reality

Virtual Reality (VR) typically refers to computer technology that simulates a user´s physical presence in an artificial, computer-generated environment. VR creates an environment in which the user can interact and thus artificially reproduces a sensory experience, which can include sight, touch, hearing and smell. VR implementation on navigation simulators could better prepare vessel operators for challenging situations.

Augmented Reality (AR) is the superposition of reality and elements that are artificially calculated by a computer system in real time. This includes the different methods that allow virtual objects to be realistically embedded atop an existing reality and be able to interact with it. Just pointing a mobile phone or a tablet in a specific direction or location can stimulate virtual elements that deliver all the relevant information needed in real time. Errors caused by too much information on too many monitors with its own presentation concepts can be avoided with AR (von Lukas et al. 2019).

2.3.2. Organizational trends

The new technologies introduced above enable greater efficiency and more collaborative operating models in supply chains. They are reshaping the marketplace of different transportation modes with distinctive intensity. However, not only technological trends define new organizational developments on the sector; regulations, new lifestyle and consumption patterns, trade flow between countries and regions also have a tremendous influence. Follows a short introduction of current organizational trends on the IWT:

1. Synchromodality

In the 90s, the concept of intermodality for the movement of more cargo through rail and waterborne gain popularity. Nevertheless, the movement of goods using various modes of transportation implies transhipment processes, making this solution less flexible, less reliable, and more expensive due to transhipment costs, with longer delivery times and leading to a less robust chain (Zhang and Pel 2016). These constraints for intermodality are especially notable for transport distances under the 300 Km (Tavasszy and van Meijeren 2011). In response to these circumstances the concept of synchronization of intermodal transport arose.

On a synchromodal freight transport system "A shipper agrees with a service operator on the delivery of products at specified costs, quality, and sustainability but gives the service operator the freedom to decide on how to deliver according to these specification" (Mes and Iacob 2016). A synchromodal transport aims to improve integration and cooperation between transport services and modes. This gives the service operator more choices to organize better transport alternatives by optimizing factors such as utilization rates, services, and costs among multiple ways according to real-time information on available capacity of their service network (Zhang and Pel 2016).

2. Cooperation

The Inland Waterway sector is a fragmented market were vessel operators own, on its great majority, only one vessel. By building large cooperative of individual vessel operators, this form of cooperation has allowed then to increase market power when negotiating with LSPs. Further, cooperative provides better conditions for value-added services and increased certainty. Cooperatives are still a rarity but the example of the NPRC cooperative (the largest one in Europe) proves the benefits of cooperation in this sector. In the case of disruptions, NPRC ensures non-stop transport through the 200 vessels working with the cooperative. Further, the cooperative invests in the development of digital solutions to optimize processes like the App iBarge for shippers to report back their progress to the head-office and the development of dashboards where inland shipping companies forward all information about dry cargo transport digitally and, in cooperation with the Port of Rotterdam, clients can find sea-going vessel arrival times and their unloading locations (Striegl from NPRC in personal communication on 22 Mar 2019).

3. Increasing scale and small ships

Over the last decade, a general trend of scaling up of ship size in Europe has been observed (UNECE 2019) (Bundesanstalt für Wasserbau 2016). The evolution of the Rhine fleet follows this trend with a reduction in the total number of vessels operating in the market (-12%) but an increase in the available loading capacity (20%) (CCNR 2017). This means that newly built vessels in the IWT sector were built with higher loading capacity. Nevertheless, an increased interested in developing and promoting smaller vessels is observed, especially after the drought in 2018, as a further increase in drought periods and flash floods due to global warming is expected (Inland Navigation Europe 2020). Fleets with large vessels are more vulnerable to these hazards while smaller and low-draughts vessels show more flexibility over shallow waterways (Meißner et al. 2017). Further, smaller vessels allow families to private run their vessels and easily access to urban areas. Running projects like Watertruck+, DeConTrans and Rotterdam Water Taxi prove this initiative. The economics of scale will remain an essential factor in this evolution. A vessel of 86 meters long can carry about 1,600 tons and can be navigated by only two crew members (800 tons per crew member). However, a vessel of 110 meters long can carry 3,600 tons of cargo but needs three on board (1,200 tons per crew member) (van Weenen et al. 2013).

4. Labour market

The author considers the claimed shortage of skilled professionals on the inland waterway market over years reported on several German publications, after analysis of different sources, as a national issue more than a European one. In countries like Luxembourg e.g., the labour force has significantly increased (van Ween et al. 2013) in the same period. Lower taxes for business and personnel, the possibility of accelerated depreciation, tax credits for investments, and the lowest VAT in Europe attract many inland navigation companies to shift their offices and registered labour force there. Nevertheless, the national trend of skilled professional shortage in the IW sector remains an issue for this study, as it was several times encountered during the field immersion.

5. Harmonization

Another observation on the inland waterway market is the lack of harmonization of rules. This has as well an influence over the attractiveness of the sector as a potential employer. Depending on routes, covered, vessel crews might be subject to different laws and regulations. They sometimes may even fall through gaps in laws and regulations that cause legal uncertainty for workers and companies. Unlike the maritime law, which has a long tradition, inland waterway navigation laws are generally newer. As explained in section 2.2, legal navigation regime in international rivers is established explicitly for each international river. This leads to differences on the regulations in specific corridors, and therefore, the arrangement of contracts, which may raise the transport insurance costs (Erceg 2018). Further, some countries integrate river transport law with maritime law, while others combine it with land transport. Thus, efforts are canalized to close these gaps. The Convention on the Contract for the Carriage of Goods by Inland Waterway (CMNI) and the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) are good examples of them.

3. Theoretical Framework

Chapter 3 presents the existing knowledge of the dissertation topic and introduces the theories selected for the research. By reviewing relevant literature on key concepts in section 3.1, the author has gained a deep insight into relevant existing knowledge.

After the key concepts related to the theme of this dissertation were introduced, a review of models and theories is conducted in section 3.2. A justified selection of the models and theories, which best fit this research work, is as well explained. The critical analysis and structural processing of information from numerous sources to develop the theoretical framework ensures a strong scientific foundation for the following work on this thesis.

3.1. Literature review of key concepts

In this section the key concepts related to the problem of the research focus and central question are introduced. Often, concepts have multiple definitions, so this section clearly defines them and delimitates their extension of interest for this research. Sub-section 3.1.1 covers background literature on sustainability. Sub-section 3.1.2 introduces Supply Chain Sustainability as the new approach of Supply Chain Management to cope with the challenges of sustainability. To achieve gapless traceability, cooperation over the complete chain is imperative. Therefore, a sub-section 3.1.3 reveals foundations of Information Sharing and Supply Chain Integration. Sub-section 3.1.4 introduces the background for Tracking and Tracing Systems.

3.1.1. Sustainability

The term Sustainability was first introduced in an ecological context as “the capacity of ecosystems to maintain their essential functions and processes; and retain their biodiversity in full measure over the long-term” (Business Dictionary, 2019). The concept of sustainability implies the capacity to maintain an entity. Therefore, the idea of Sustainability can be extended to almost any entity: environment (ecological sustainability), mankind (social sustainability), and business (economic sustainability). A discussion about sustainability would lead to the term sustainable development. Both sustainability and sustainable development are very close concepts with strong interdependencies. The most used definition of sustainable development is the one given by the Brundtland Commission “Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (Brundtland

Commission 1987). Thus, it could imply that sustainable development leads to sustainability. Even though both concepts are not new, the attention to sustainability became bigger in the last decades when, because of period of industrialization, evidence of the apparent inefficiency of our current products and production processes to cope with the preservation of planet's resources, is remarkable.

As the importance of sustainability increased, the focus on key elements to achieve sustainable development got stronger. In this way, Supply Chain Management (SCM) should be identified as an important element of sustainable efforts as it encompasses processes such as procurement, production, transport, distribution, and packaging that deeply impact the components of sustainability. A most complete definition of Supply Chain Management is provided by the Council of Supply Chain Management Professionals as: "Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. It also includes coordination and collaboration with channel partners, such as suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies." (Council of Supply Chain Management Professionals 2013). Enriching the context of Supply Chain Management with Sustainability results on more socially responsible products and practices that are good for the planet and the people and for building positive brand awareness, minimizing environmental impact and improving long-term profitability (Govindan et al. 2014).

3.1.2. Supply Chain Sustainability

Globalization challenges the supply chain management, not barley in economic issues but also social an environmental such as fair working conditions and low-emission manufacturing. This increase the interest in the interfaces between SCM and sustainable development, which is usually understood in an economic, environmental, and social dimension (Wilding et al. 2012). Redefining the concept of Supply Chain Management to cope with sustainability challenges, the term of Sustainable Supply Chain Management (SSCM) was coined and formalized as "the strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key interorganizational business processes for improving the long-term economic performance of the individual company and its supply chains." (Carter and Rogers 2008). This definition of SSCM is based on the Triple Bottom Line model proposed by (Elkington 1994) in the mid-90s.

With this model, (Elkington 1994) endeavoured to calculate sustainability by enclosing a new structure to measure the performance of US companies. He called this explanatory framework, the Triple Bottom Line (TBL), which goes beyond the traditional measures of income, recovery of investments and value for the shareholder to include dimensions of social and environmental responsibility. By focusing on the results of inclusive investment, that is, with respect to performance in the integrated dimensions of profits, people and the planet, the triple track of results can be an important tool for developing sustainability objectives (Slaper and Hall 2011). In Figure 3-1 a graphical representation of this model is provided.

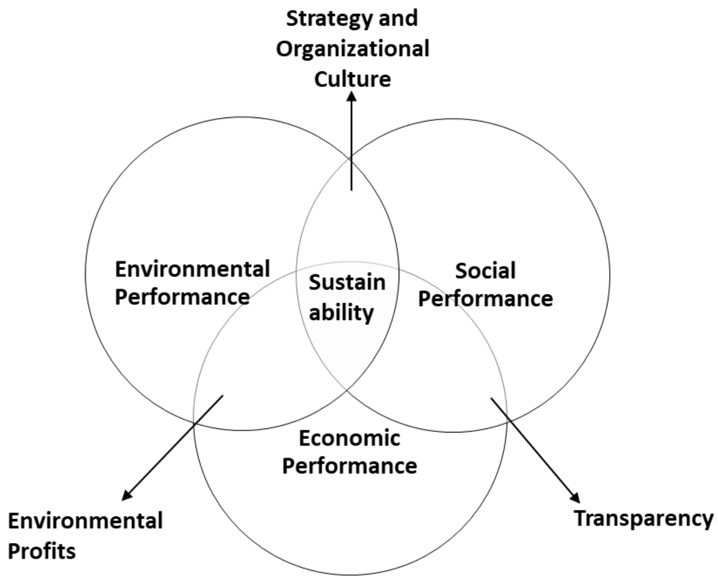

Figure 3-1 : Graphic representation of The Triple Bottom Line Model (Xu and Cong 2011)

When companies and organizations concentrate only on making money, they invest everything in the economic aspects. But now with the pressure from government, the customers, employees, shareholders, etc., they are also investing in the social and environmental dimensions (Seuring and Müller 2008). Only after this, the companies started to realize that creating positive effects in the society and in the environment also benefits economically in the long run their bottom lines (Carter and Rogers 2008; Markley and Davis 2007). They also understood that all these dimensions are interconnected what means that creating a positive or negative effect in one dimension is also reflected in the other two dimensions.

The dimension of **environmental performance** has a set of rules and objectives that mainly focuses on the welfare of our environment such as promoting eco-friendly products, waste management, creating awareness for a greener environment. When it comes to sustainability, very often a significant amount of attention is given to this dimension.

The objective of the **economic performance** dimension is to sustain in the competitive market, and to gain a long-term success with an increase in the profit. This dimension can be measured with the profit generated and the status value in the market. But the other two dimensions cannot be assessed in the same way. In a case-study, it is found that the organizational practices that have a combination of best practices of the SCM and a proactive interest towards sustainable behaviour have led to successfully implementation and follow-up of sustainability (Pagell and Wu 2009). It is also important that there is an interactive interface between these dimensions since a small change in one can have drastic changes in other dimensions.

The **social performance** dimension refers to both the people such as the employees and the employers who are inside and stakeholders, the supply chain partners, and the customers who are outside of an organization, which happens most of the times resulting in an imbalance due to different interest. So, this dimension involves a plethora of issues, which makes it difficult to assess (Lehtonen 2004).

The importance of sustainability for the transport sector was highlighted on the Background in the context of regulatory compliance. However, sustainability on the transport and logistic sector should be considered rather than obligations as an approach. A McKinsey article outlined how leading companies use sustainability initiatives to improve their business. The study demonstrated how companies that built sustainability into their operations saw immediate benefits, and got the momentum to do even more, creating the conditions for long-term success. By integrating sustainability on their business agendas these companies reported several benefits: cutting costs, improving company´s reputation, achieving higher compliance levels with regulatory constraints and opportunities, experimenting with new growth opportunities to reach new customers or markets and improving human capital retention (Bonini and Görner 2011).

Sustainability led to new benchmark approaches to evaluate companies´ performance by focusing in social, environmental, and economic benchmarks rather than financial ones. The incorporation of sustainability work agendas has demonstrated that sustainability could lead to a continuous path of improvement to reach excellence through responsible targets throughout the company.

Figure 3-2 summarizes different ways how companies can create value over a long term by pursuing sustainability.

Figure 3-2 : Companies pursuing sustainability in a way that creates value (Bonini and Görner 2011)

Returns on capital

Most companies creating value through sustainability look first to improve returns on capital, which often means reducing operating costs such as energy, water, or packaging waste through improved natural-resource management (sustainable operations). Improving resource management along the value chain looking forward reducing environmental impact has proven to reduce supply chain costs by improving company´s reputation among customers, clients, providers, and authorities (sustainable value chains). Furthermore, how products and services marketing is organized allows companies to increase their market shares by offering environmental/socially responsible products (green sales and marketing).

Growth

New regulations and trends related to sustainability represent for companies not only redefinition of processes and strategies to comply; but also, opportunities to explode such as identifying new niche market opportunities through psychographic, behavioural, or geographic market segmentation (new markets). This market segmentation could be performed for existing services or products. However, it could also be conducted when developing innovative products or services related to sustainability to address unmet demands that arise with the latest sustainability trends (innovation and new products). These considerations will lead companies to evaluate current business portfolios and adequate them to meet these new regulations or trends (composition of business portfolios).

Risk Management

The proper management of risks that arise from sustainability issues will lead companies to identify, asses and control threats from operational disruptions such as resource scarcity, climate change impact and legal/social risks such as boycotts and commercial measures (operational risk management). Another threat to consider is damage to company´s reputation due to possible scandals where the company could be related to unsustainable practices (reputation management). New regulations related to sustainability would here lead not only to mandatory actions but to opportunities to explode (regulatory management).

3.1.3. Information Sharing for Supply Chain Integration

Information sharing is one of the critical aspects of coordination between parties in a supply chain. According to (Wang and Ran 2018), information sharing is a crucial component of a supply chain engineering that commits to better collaboration and integration (Prajogo and Olhage 2012; Sahin and Robinson 2005; Gunasekaran and Ngai 2004). Efficient and effective information exchange should be structured so that the whole supply chain can share important market and operational information, improve productivity, and reduce transaction costs, time-to-market, and response-time.

Information sharing has become an essential feature of organizations as value-adding factors shift from physical and financial assets to intangible assets (Kocoglu et al. 2011). As SCM focuses on effective and efficient flows of physical and non-physical assets in both directions, from the primary source of raw material supply to the consumption of the product or the use of the service by the end customer, the orientation of the information is a “two-way shared” asset that does not reduce how it is used, but instead gets depth as it is used and shared in a value network. This is the crucial feature of integrated supply chains (Zhou and Benton 2007). The exchange of information between supply chain partners and within the organization has a significant impact on the effectiveness of supply chains. Companies can make better orders, capacity allocations, and production and material planning decisions by sharing information. Thus, the demand, the supply, and the inventory are more visible. Many studies show that sharing information is vital in achieving a seamless supply chain and points to its benefits.

According to (Lee et al. 2000), sharing of information is most favourable when lead times are long, demand fluctuations are high, and demand has a high autocorrelation coefficient. Longer lead times mean that the supplier must place an order after placing the order, right from the first attempt, because if it does not come as agreed, reorders will be very expensive. Of course, demand variability presents suppliers with difficulties if they do not have access to real-time data. Buffer stocks are typically used to counter demand fluctuations, but this increases inventory costs. Finally, (Yusuf et al. 2004) found that a high degree of cooperation and information-based integration is nuclear for agile supply chain capability. An essential element of agility in supply chains is visibility.

According to authors (McCullen and Towill 2002; Loughman et al. 2000; O´donnell et al. 2006; Datta and Christopher 2011) the reluctance to share common information is an example of inherent uncertainty.

As information sharing implies information integration, sharing and synchronization (Jaekel 2017), platforms are commonly used to provide a suitable digital environment. On a platform for information sharing, supply chain partners will continuously update the operational data required by the decision-making body, monitor the critical situation against the updated data, and coordinate the daily operating schedule based on the information on the platform. There is a share of information but also of knowledge. It enables supply chain partners to optimize day-to-day operations and increase the revenue they are involved in, thereby consolidating further partnerships, and shifting the supply chain in a positive direction. Such an information sharing mechanisms also dynamically monitors critical information or critical indicators in the supply chain dynamically and, if necessary, triggers appropriate responses to resolve possible crisis. In other words, information sharing platforms codify the knowledge gained from cooperative supply chain management, share knowledge of the network and drive learning to increase the ability of the system to manage disruptions.

Challenges to information sharing

Information can be delivered in many ways, IT advances have enabled companies to structure a process of sharing information with different levels of customized reporting, real-time access, data access frequencies, access levels, and software integration. However, these adaptation measures could increase the complexity of the information sharing process. A complicated information sharing process requires the creation of dedicated IT infrastructure, including IT staff, to maintain these features. Also, managers must cope with other cognitive burdens to handle the complexity of additional tasks. The complexity of functions affects the user´s behaviour in the search of information. The complexity of the information-sharing process also leads to delays that may affect performance.

(Roberts et al. 2004) have shown that complexity has influenced user interaction in groups – communication, participation and group integration have been found to be lower in more complex tasks. Also, complexity has been shown to disrupt assimilation of information and lead to more significant mistakes in decision-making. This complexity of managing, understanding, and using the information-sharing process is the second dimension of information-sharing in the supply chain. It is expected that the complexity of sharing information will hurt supply chain performance as more complexity will cause managers to have incremental burdens to gain and understand shared information. The complexity of the information-sharing process may also delay access to information by channel partners, affecting the of the supply chain´s performance.

3.1.4. Tracking and Tracing Systems

Tracking and Tracing systems make it possible to trace objects through a flow. The systems focus collecting and administering information on an entity along the supply chain and makes possible their traceability by verifying information about history, location, and status. The Norm ISO 9000:2015 defines traceability as "the ability to identify and trace the history, distribution, location, and application of products, parts, materials, and services. A traceability system records and follows the trail as products, parts, materials, and services come from suppliers and are processed and ultimately distributed as final products and services." (ISO 2015). Thus, the traceability notion implies the action of "Tracking" (following an item through it course) as well as "Tracing" (verifying backwards the course followed).

Two types of Tracking and Tracing networks can be identified depending on their usage location. They can be classified either as an internal system for inbound processes performed by one company or as an external system for outbound operations where various stakeholders of the supply chain interact (Shamsuzzoha et al. 2015). For example, extrapolating this classification to a port, an inbound system would consist of all operations performed inside a port, such as loading and unloading containers or bulk material to/from the vessels, storage of containers, transhipment of cargo, utilization of movable cranes, etc. On the other hand, and outbound system would encompass all activities where the port must interact with the other collaborators of the supply chain, e.g., vessels, hinterland transportation, suppliers, or end-customers.

By implementing a Tracking and Tracing systems, companies can benefit from several advantages:

1. Secure differentiation against competitors thanks increased quality of customer service,
2. Increase and improvement of manageability through an exchange of on-time complex information or system notifications,

3. Optimization of space for inventories, as sub-optimal stock levels are reduced with better exchange of information between planning and logistics departments as well as suppliers,
4. Better planning of processes in production, shipment, and delivery with increased satisfaction due to notification of real delivery times,
5. Support of Just in Time delivery programs thanks to flow visibility,
6. Reduction of back orders due to reliable system information,
7. Reduction of overall loses waste, frauds, and thefts. Real-time stock levels help to reduce housing of materials parts and reduce carrying costs of inventory,
8. Increase the efficiency and quality of information exchange between different actors across the supply chain,
9. Better assessment of risks along the supply chain due to early notification of delays, incomplete or wrong deliveries, and
10. Supports shifting from reactive to pro-active measures to recover from or timely react to disruptions on the supply chain.

Furthermore, in a legal context, Tracking and Tracing information helps to clarify liability issues; complete clarification on questions of origin; provide rapid consumer information; secure correct backorders reclaim; and limits possible further damages (GS1 Germany GmbH 2013).

The traceability of products has, for many companies, a high priority as it is required by law for several products. Initially it was used to monitor the logistical flow of goods; but today traceability of products is a control instrument for consumer protection and a prerequisite for high product quality. In case of crisis, such as Printing chemical ITX in food first detected by Italy in September 2005 (Fuegel et al. 2007), Dioxin in eggs as reported in year 2016 in Poland (Piskorska-Pliszczynska et al. 2016) or even terror attacks, traceability contributes to security.

Nevertheless, implementing Tracking and Tracing systems to assure traceability, assumes that everyone involved systematically checks the physical flow of goods link with the associated flow of information. Reaching complete traceability is challenging with technical challenges such data, standards, and protocols harmonization.

Tracking and Tracing technologies

According to the Tracking and Tracing system type and the application level, different mechanisms and technologies for identifying objects and storing information are preferred. The most used Tracking and Tracing instrument is the barcode. Two types are linear or two-dimensional (data matrix) bar coding. The first one is represented by a series of vertical lines with different width representing the EAN number assigned to the product. This is a unique number that helps to distinguish one product from another. A matrix represents the two-dimensional codes constituted of tiny white and black squares. This second type can store more information besides the EAN number (De Cindio et al. 2011).

Another widespread mechanism employed for Tracking and Tracing is the Radio Frequency Identification tags (RFID) that employ a transponder attached to the object to be identified. The transponder comprises a tag, an antenna and support that wraps the system. The tag’s function is to store the information, while the antenna is employed as a communication transmitter mean (Steltemeier and Bioly 2014). Twofold variations of RFID can be distinguished, either passive or active. The difference lies in using an internal energy source to transmit the information. Since passive RFID tags don’t possess such battery power, they can be applied as bar code.

On the other hand, active RFID tags, depending on their power range, can be utilized to track and trace different size objects (Probst et al. 2015). Whereas RFID systems of 866 MHz – 915 MHz are suitable for tracking and tracking of pallets, higher frequencies such as 2,45 GHz and 5,8 GHz are relevant for pallets and containers. High frequencies enable better communication with the exterior since they are less crowded and signals can fluently pass-through metallic barriers and narrow areas, which is indispensable for the containers. Furthermore, the higher the frequency is, the shorter the wavelength is and the shorter the antennas are. As a result, the elements of the RFID device are smaller (Steltemeier and Bioly 2014; Desa et al. 2009).

Linear barcode Two-dimentional code RFID Tag

Figure 3-3 : Examples of linear barcode, two-dimentional code and RFID tag (Pixabay 2019)

It is expected, nevertheless, that barcodes and RFIDs will be displaced by more interactive contactless communications forms such as Near-field communication (NFC) and Bluetooth Low Energy (LE). Contactless communication allows a user to wave information between devices without needing to touch the devices together or go through multiple steps setting up a connection. NFC devices may be active or passive. Passive devices such as NFC tags contain information that other devices can read, but it does not read any information itself. Active devices such as smartphones can not only read the information from NFC tags, but exchange information with other compatible devices or even change it if authorized. Well stablished example of NFC use is the contactless payment cards utilized in stores or train ticketing applications. While NFC devices utilize electromagnetic radio fields, LE focus on radio transmissions instead. This allows longer distances of almost 10 meters between devices. Nevertheless, they should go through a connection process “pairing”. A typical example of Bluetooth applications is the communications between smartphones and wireless headsets.

Figure 3-4 : Logos for labelling NFC and Bluetooth licensed devices (Pixabay 2019)

Regarding load carriers such as ships, trucks, trains and airplanes, Global Positioning System (GPS), and Global System for Mobile Communication (GSM) applications play a crucial role. In case of a GPS, a location is determined through the signals sent from all the GPS satellites to the GPS receiver. This information includes the time the signal was emitted and the orbit position of all GPS satellites. The GPS receiver calculates the time it takes to receive the information from each satellite. The satellites´ transmission time and the position are the base for estimating a freight transport’s location. A GSM follows the same principle as the previous one. The difference resides in the usage of telecommunications antennas to determine their location. Throughout a satellite communication or a GSM communication, the receiver´s position can be forwarded to a tracking server that is later displayed on a digital platform or an ERP system (Darekar et al. 2012; Probst et al. 2015; Steltemeier and Bioly 2014).

Tracking and Tracking can work as an individual technology and function along with smart technologies that automatically retrieve the position of an entity. Therefore, the recovery of information must be allowed by the company that owns the Tracking and Tracing system and all the supply chain collaborators. In consequence, Tracking and Tracing systems must be harmonized so that they can be operated by all the stakeholders (Probst et al. 2015).

3.2. Theory selection

For the selection of the theories that tailor to the needs of this work, several approaches proposed by different authors will be compared and critically evaluate to set the frame of this research, defining the foundations that will support the analysis and securing the adequate interpretation of results to contribute with new knowledge. This section is of notable importance for the rigor of research of this dissertation as the correct selection of models and theories guarantees a comprehensive answer to the research questions and robust results.

As information sharing among the parties is necessary to trace objects through a flow, models and theories related to information sharing were selected as the adequate mean to interpret and understand the process. Searching for theoretical models for setting a reference for this work, the author run into studies that presented models either for “information sharing” or “knowledge sharing”.

It could be observed that the term “information sharing” is preferred used on computer sciences and “knowledge sharing” in management science. Under this context, knowledge sharing should be understood as one of the processes of Knowledge Management (KM) that evolved in the late 1980s. KM evolved from two factors: recognition of the importance of knowledge as company´s asset and the recognition of the utility of the Internet for sharing it (Koenig and Neveroski 2008). Information sharing and knowledge sharing are closely related and often used interchangeably. Nevertheless, both constructs are analytically different but, in practice, are intertwined and interrelated. Trying to clarify interrelations and differences between information and knowledge (van der Spek and Spijkervet 1997) defined information as data (symbols) with meaning and knowledge as the ability to assign meaning (van der Spek and Spijkervet 1997). To a similar conclusion arrived (Quigley and Debons 1999) when defining **data** as a text that can answer the questions *who*, *when*, *what* or *where* and **knowledge** as an element that enables to answer the questions of *why* and *how* (Quigley and Debons 1999). These notions imply the tangible and passive dimension of information while knowledge denotes an active dimension where information is used to create more knowledge. At the same time, data and information require knowledge to be interpretable (Stenmark 2001). While (Stenmark 2001) analysed the relationship between information and knowledge as entities, (Savolainen 2017) analysed information sharing and knowledge sharing both as constructs. (Savolainen 2017) concluded that the activities performed under information sharing and knowledge sharing are largely similar, the concepts could be used interchangeably (Savolainen 2017). Further, in knowledge sharing, “the sharing activity focuses on information (documents, messages, databases) regarding what one knows, not the knowledge per se.” (Wilson 2010). Thus, for the purpose of this research, models for information sharing and knowledge sharing are both adequate.

3.2.1. Setting a conceptual framework

A review of existing theoretical models on Information and Knowledge Sharing was conducted to set a reference model for this work. As the research focus and central question of this dissertation are unique, adequation and/or complementation of these exiting theoretical models is mandatory to address the research questions properly. The key variables that enable the analysis and discussion of the data findings on the reference model will be defined and justified.

3.2.1.1. Overview of DeLone and McLean Information Sharing Success Model

(DeLone and McLean 1992) proposed a taxonomy and an interactive casual model for conceptualizing and operationalizing information sharing success, the “D&M IS Success” Model. The model attempt to provide a framework to understand the value and efficacy of information-sharing management actions and investments (DeLone and McLean 2002).

The D&M IS Success model consisted of his first version of six interrelated dimensions of success with causality flows in the same direction as the information flows. The authors proposed interrelations between these dimensions without testing them empirically.

After an extensive review of 180 concepts and empirical studies, (DeLone and McLean 1992) found myriad of measures to evaluate information systems´ success. Nevertheless, all these measures could be assigned to one of three levels defined by (Shannon and Weaver 1949): technical level where the accuracy and efficiency of the system are evaluated. The semantic level where is evaluated if the produced information serves the intended task, and effectiveness level where the effect of the information on the receiver is evaluated (Shannon and Weaver 1949). Within these three levels, six categories of information system success were defined: System Quality, Information Quality, Use, User Satisfaction, Individual Impact and Organizational Impact (DeLone and Mclean 1992).

Measures focused on the desired characteristics of the information system itself falling into the System Quality category; measures about the characteristics of the information as a product into Information Quality; measures for the interaction of information with its users were assigned to the categories Use and User Satisfaction. Finally, measures to estimate influence of Information on management decisions or organizational performance will fall into the categories Individual Impact or Organizational Impact, respectively. On Appendix D a summary of information system success measures into these categories is provided.

The D&M IS Success model suggest an interdependency between these six dimensions. The characteristics of the information system itself (System Quality) as well as the information produced

(Information Quality), affect the interaction of information with its recipient/users (Use and User Satisfaction). At the same time, the amount of Use can affect User Satisfaction and vice versa. Finally, the Use and User Satisfaction experience will have an influence over management decisions taken based on this information (Individual Impact), and consecutive management decisions (Individual Impact) will affect the organizational performance (Organizational Impact).

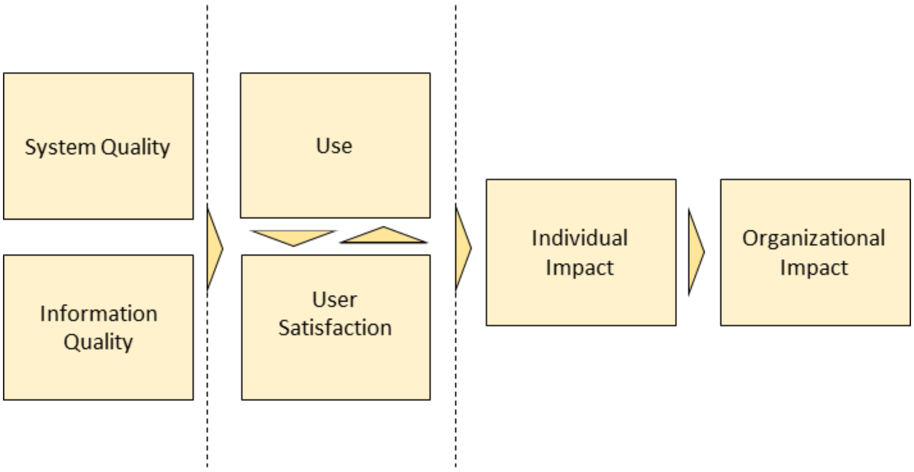

Figure 3-5 : D&M IS Success Model (DeLone and McLean 1992)

Later, the model was over 150 times cited and empirical investigations of the multidimensional relationships between these dimensions were undertaken (DeLone and McLean 2002). This led the authors to the revision of the model in 2002. On their reformulated model the dimension of Service Quality was added, and the dimensions of Individual Impacts and Organizational Impact were merged into the new dimension Net Benefits.

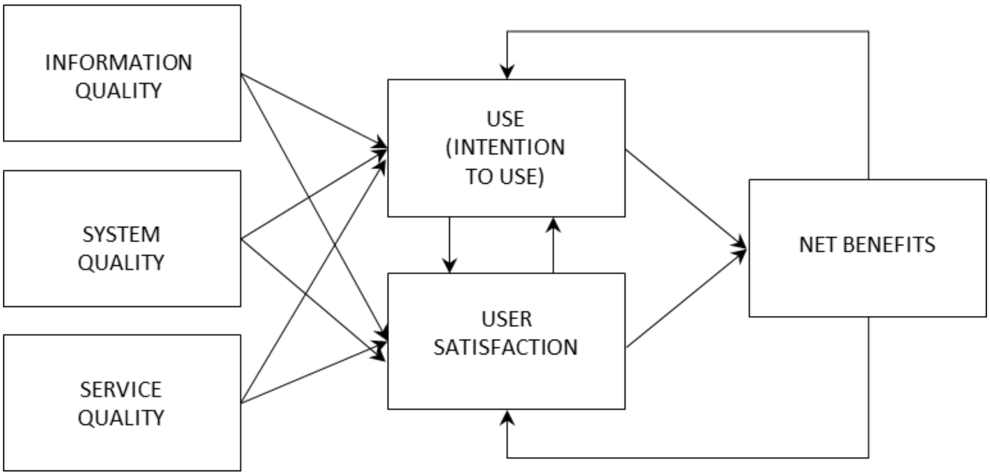

Figure 3-6 : Reformulated D&M IS Success Model (DeLone and McLean 2002)

3.2.1.2. Overview of the Model of Knowledge Sharing of Ipe

Based on a literature review of publications that referred to the management of knowledge within organizations, (Ipe 2003) formulate a model that identifies the factors that strongly influence knowledge sharing among individuals in organizations and formulates relationships between these factors. The model states that these variables are the nature of knowledge, the motivation to share, the opportunities to share, and the culture of the work environment (Ipe 2003).

The dynamics of main positive and negative effects within the different factors across its findings could be summarized (Ipe 2003):

1. Unlike tacit knowledge, explicit knowledge simplifies the transfer of knowledge (nature of knowledge),
2. Unlike embedded knowledge, rationalized knowledge is more suitable for knowledge sharing (nature of knowledge),
3. When knowledge is perceived as highly valued, individuals might not be ready to share it (nature of knowledge),
4. When knowledge can be used to control or defend, entitling owner power, it is unlikely to be shared (motivation to share),
5. If the process of sharing information is reciprocal, meaning in both directions giving and taking, information sharing would be stimulated (motivation to share).
6. Nevertheless, when the flow in both directions giving and taking are perceived as unbalanced, knowledge sharing will be slowed down (motivation to share),
7. Individuals preferred to share information with individuals holding higher status and power in organizations than with the ones in lower levels (motivation to share),
8. The probability of sharing information is positively related to rewards for sharing and negatively to penalties for not sharing (motivation to share),
9. Although formal opportunities for sharing, such as training programs and IT systems, allows bigger information receptors groups and speedy dissemination of shared knowledge, informal channels in personal or social spheres are preferred by individuals to share their knowledge (opportunities to share), and
10. The culture of the work environment can positive or negatively influence all four factors.

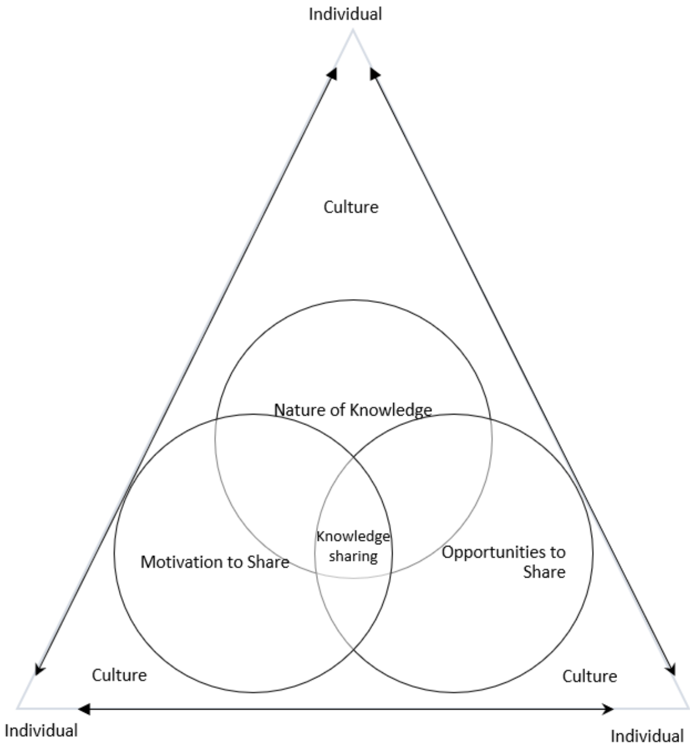

Figure 3-7 : Model of knowledge sharing between individuals in organizations (Ipe 2003)

3.2.1.3. Overview of the Conceptual Framework of Kembro, Selviaridis and Näslund

For the development of their conceptual framework (Kembro et al. 2014) conducted a structured literature review of more than 100 papers to identify the predominant theories applied to analyse different aspects of information sharing. Once identified, they complement the theories to develop a conceptual framework that could be used as an outline to understand information sharing between companies. On their conceptual framework, four aspects within six steps were identified, which characterize any path for companies to share information.

Information sharing aspects	Steps of the conceptual framework
Why share or not to share information	1. Identify reasons for sharing
	2. Consider reasons for not sharing
What information to share with whom	3. Determine what to share with which SC partner
How to share information	4. Decide upon the means for sharing information
Pre-requisites, barriers and drivers	5. Identify and address barriers and drivers
	6. Select appropriate governance mechanism

Table 3-1 : Steps of the conceptual framework of Kembro, Selviaridis and Näslund with corresponding information-sharing aspects with information from (Kembro et al. 2014)

In section 3.1.3 and 3.2.1.2 the information sharing aspects mentioned above were extensive introduced, and further inputs about the aspects of information sharing are largely similar as described for the models in section 3.2.1.1 and 3.2.1.2.

3.2.1.4. Overview of the Conceptual Framework of Gharawi and Dawes

None of the above introduced models and conceptual frameworks explore the influence of contextual factors, such as legal or political aspects on information sharing. Therefore, for the formulation of the reference model for this dissertation, further models and conceptual frameworks including these factors were analysed. One of these references is the conceptual framework of (Gharawi and Dawes 2010) conceptualizing knowledge and information sharing in Transnational Knowledge Networks (TKNs). TKNs could be conceived as an art of international digital government that aims to help countries around the world to comply with global rules and policies in critical areas such as security, global economy, and environmental protection (Gharawi and Dawes 2010). Given these networks´ interorganizational and international nature, the conceptual framework provides valuable insights about aspects influencing knowledge and information sharing across national and cultural boundaries. On the framework, knowledge and information sharing is a process (and not a transaction) between governmental sub-units located in different countries. Table 3-2 summarizes the factors that, according to this conceptual framework, influences knowledge and information sharing in this scene.

Layer	**Knowledge and Information Content**	**Organizational Context**	**External Environment**
Factors	Type of information Lacking data standards and definitions of sharing process Value, Sensitivity, and confidentiality of data Codifiability of data Embeddedness of data	Goals and interest of participating organizations Trust and past relationships Executive support and organizational commitment Perception of risk, costs, and benefits Organizational culture Leadership Authority and hierarchical structures Organizational rules, procedures, and regulation Resources	Culture Laws and policies Political support Language Geographic location

Table 3-2 : Factors influencing knowledge and information sharing (Gharawi and Dawes 2010)

3.2.2. Selection of supporting theories

Together with the proposed reference model formulated for this study, appropriate theories are fundamental to guide this research and organize the thesis´s ideas. With these theories, a body of principles is analysed that help critically explain and predict the relationship between variables that influenced how enhanced Tracking and Tracing systems can support more sustainable operations in the IWT. Further, understanding these theories a framework for how the gathered data should be used to explain the benefits and impediments of this newly enhanced T&T system. Finally, the proposed reference model and selected theories, will allow us to theorize and model the phenomenon traceability for sustainability to arrive at robust conclusions.

The evaluation of all potential theories would be extremely extensive and go beyond the focus of this thesis. Thus, the selection of a suitable theoretical framework was based on a pre-selection of theories based on (Chang et al. 2017). For the following discourse, the theories of Corporate Social Responsibility, Stakeholder Theory, Corporate Sustainability, and Green Economics are selected as theoretical framework for this thesis and form the basis for the following work. The reasons for this decision, as well as a general overview of the main components of the theories mentioned, are provided in the following sections.

3.2.2.1. Corporate Responsibility and Corporate Social Responsibility

The concept Corporate Responsibility (CR) stands for responsible, entrepreneurial action and can be classified as a management task and strategy due to its own target definition. In recent years, CR has become increasingly important for companies. The frame of reference encompasses the entire value chain, from operational to strategic processes, and, as part of corporate management, covers the three dimensions of responsibility for society, the environment, and the economy. CR, therefore, also includes the issues of organizational structure, development, implementation and monitoring of measures and communication in the company. CR has another influence in dealing with stakeholders who are interested in a sustainable corporate strategy. By adapting the CR strategy to the corporate strategy, a modern value system is created, which corresponds to a good reputation, and therefore contributes to the continued existence and success of the company. Integrating the elaborated CR measures into the value chain is an essential part of the success of the activities (Bertelsmann 2013).

As part of CR, Corporate Social Responsibility (CSR) is becoming increasingly important. The concept deals with the effects of economic activity on society and is, therefore, different from CR. CSR summarizes the principles of social responsibility and deals with processes of social responsiveness. In addition, guidelines and programs related to the company’s social relationships are part of CSR. Finally, the CSR strategy as part of CR is anchored in the corporate strategy (Mahon 2002).

3.2.2.2. Stakeholder Theory

There are numerous relationships of various kinds between a company and its environment. Individual relationships mean that a wide variety of expectations and goals of the people, companies, and organizations involved are brought to a company and influence it. Stakeholder groups influence the entrepreneurial activities of a group or are influenced by the company´s economic activity (Breuer 2018). In the following, in addition to the definition of the term, the connection between the stakeholder concept and the company´s sustainability strategy is shown.

The term stakeholder dates to 1963 and was first used at the Stanford Research Institute. The basic idea was to define those groups without whose, support their support, a company would cease to exist. The list of stakeholders initially included employees, customers, suppliers, lenders (Freeman 2010), and shareholders (Thommen et al. 2017). In addition, this first classification was expanded to include individuals and groups who were influenced by the activities of a company or influenced the achievement of corporate goals (Freeman 2010). Within this framework, a first distinction between the types of stakeholders and a basic distinction between internal and external stakeholders could be made.

Figure 3-8 shows a typical stakeholder universe of a large automotive group. In such a company, internal or primary stakeholders consist of customers and the Original Equipment Manufacturer (OEM) workforce. Internal stakeholders are characterized by their official and contractual relationship with the company and, due to their direct relationship, have a significant economic impact on the company (Savage et al. 1991). Thanks to their direct connection to the company’s value chains and business processes, the workforce also has in-depth and far-reaching know-how. For this reason, this internal stakeholder group is particularly importance for the company´s management since the workforce, with their knowledge, contributes substantially to the added value.

External stakeholders, on the other hand, come from the environment of the company and its activities. They are defined as stakeholder groups that are indirectly secondarily influenced by the company’s economic activities and are not integrated into the company’s direct activities. Nevertheless, external stakeholders can influence the corporate strategy, the business areas, and the processes of the automobile manufacturers (Savage et al. 1991). The group of external stakeholders includes representatives, organizations, or authorities from the fields of society, politics, business, science, and the media. The environment and the climate also act as external stakeholders. In these cases, there is either a political representative or a civil society organization representative (Rhein 2017; Freeman et al. 2010).

In contrast to the internal stakeholders, the external stakeholders are not directly involved in the company's value creation processes and, accordingly have little or no know-how regarding the company processes.

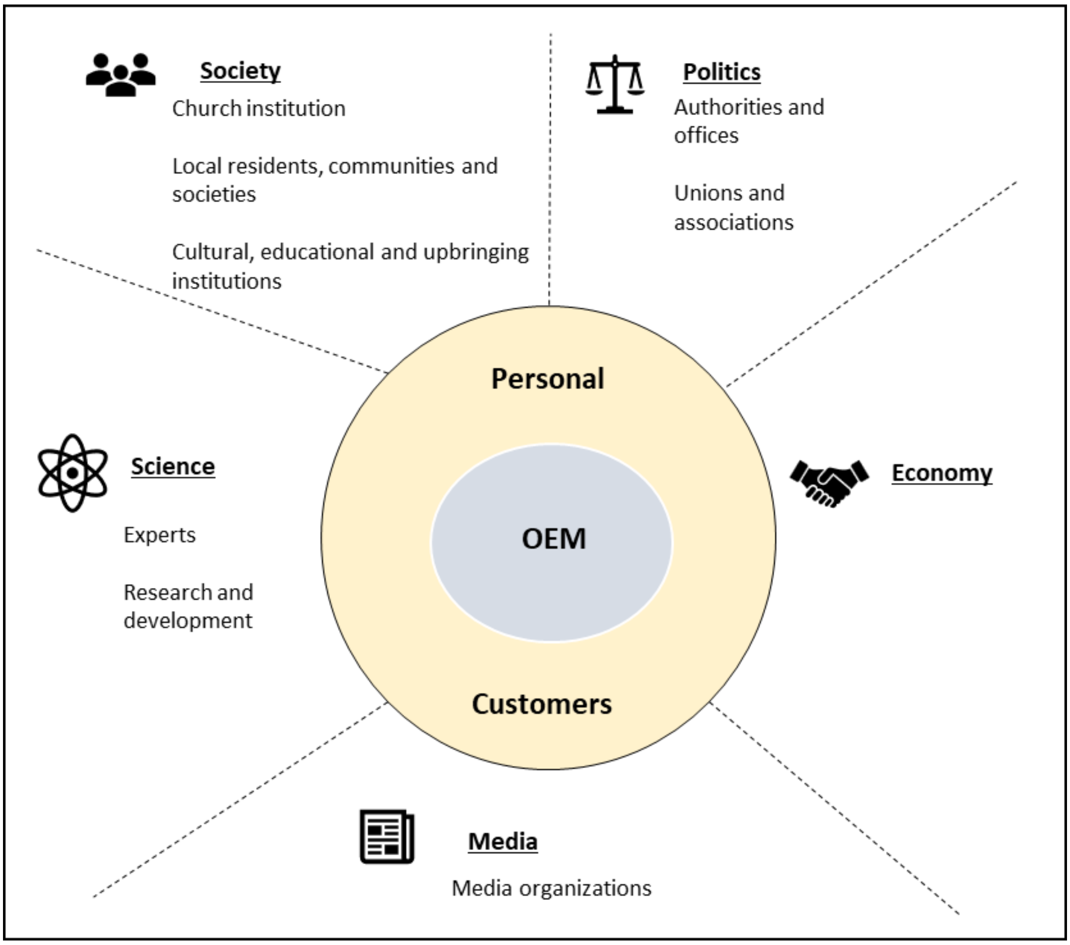

Figure 3-8 : Overview of internal and external stakeholders from automobile manufacturers based on the (Volkswagen Sustainability Report 2018)

In order to ensure an additional classification of the terms, the various stakeholders are assigned thematic headings to. For example, business partners, investors (shareholders), and competitors are assigned to the subject area of business. In addition, the classification of the stakeholders can be seen from the arrangement in the Figure 3-8. The internal stakeholders (circle) are located near the OEM and directly influence the OEM. The external stakeholders (square), on the other hand, are in the extended environment of the OEM.

3.2.2.3. Corporate Sustainability

Working up the theory selection, Corporate Social Responsibility and Stakeholder theories were introduced. It is, indeed, necessary to move forward to more complex notions. Corporate sustainability (CS) is one of them. With Corporate Sustainability a new management paradigm is settled that greatly differs from the traditional growth and profit-maximization models that companies followed for decades. The term Corporate Sustainability hat its origins during the mid-1990s when authorities were almost the sole actors responsible for sustainable development. The evolution of this way of thinking made clear that not only authorities but all individuals, society, companies, and systems are responsible for achieving sustainability. Getting this clear, firms began to rethink how they were consuming earth resources (paper, water, fuels, energy) and they were impacting the environment (emissions, waste, unsustainable production strategies). These considerations are nevertheless not enough for the overall sustainability of a corporation. This fact gave the foundation for a new theory. In Corporate Sustainability companies are required not only to pursue economic but as well societal goals, specifically those relating to sustainable development like environmental protection, social justice and equity, and economic development (Wilson 2003).

There is no universal definition of Corporate Sustainability (CS), but different authors who contribute to this notion all agree on the multidimensionality of its action field. In the year 2002, (Dyllick and Hockerts 2002) stipulated that Corporate Sustainability takes place when companies meet the needs of direct and indirect stakeholders without compromising their ability to meet the needs of future stakeholders as well. Three key elements can be identified by their definition: economic, environmental, and social sustainability over a long term. These dimensions were described based on the Triple Bottom Line introduced in section 3.1.2 of this thesis. Furthermore, (Dyllick and Hockerts 2002) extended the framework of Corporate Sustainability by defining six indicators for companies to employ in their strategies towards Corporate Sustainability: Eco-Efficiency, Eco-Effectiveness, Socio Efficiency, Socio Effectiveness, Ecological Equity and Sufficiency.

After the first introduction of CS, clarifying the interrelation between Corporate Sustainability and Corporate Social Responsibility (CSR) is mandatory. CSR claim an ethical obligation of companies to consider and address the needs of society, not just to act solely in the interests of the shareholders or their own self-interest (Wilson 2003). Thus, CSR should be considered as a tool to achieve CS (van Marrewijk 2002), which is itself the target.

Most contributions done for developing Corporate Sustainability frameworks present single models to be applied as a panacea for all companies. (van Marrewijk and Were 2003) remarks that one-solution-fits-all concept of corporate sustainability is not reasonable and proposed a new holistic, multi-disciplinary, multi-dimensional approach to develop customized corporate sustainability plan.

(Van Marrewijk and Werre 2003) based its work on the fact that each company owns a proper and, therefore, unique set of values due to the specific environmental conditions they operate in. This value system defines the guidelines to survive and sets the ambition levels of Corporate Sustainability for the specific company. As a result, there will be companies with basically no ambition for CS, which only motivation for implementing CS is the possibility to improve company reputation (Pre-CS-Red Level), and companies with a high motivation toward CS integrating it in every aspect of the organization with the single motivation to achieve sustainability on a worldwide scale as a responsibility toward present and future generations (van Marrewijk and Werre 2003). Further levels of CS between these two extremes are presented in the Table 3-3.

	MULTIPLE LEVELS OF CORPORATE SUSTAINBILITY					
PRINCIPLES	Pre-CS	Compliance-driven CS	Profit-driven CS	Caring CS	Synergistic CS	Holistic
CS ambition level / definition	At this level there is basically no ambition for CS. However, some steps labelled as CS might be initiated if forced from outside (e.g. through legalisation or a buyers' strike).	CS at this level consist of providing welfare to society, within the limits of regulations from the rightful authorities. In addition, organizations might respond to charity and stewardship considerations.	CS at this level consist of the integration of social, ethical and ecological aspects into operations and decision-making, provided it contributes to the financial bottom line.	CS consist of balancing, economic, social and ecological concerns, which are all important in themselves. CS initiatives go beyond profit considerations.	CS Consist of a search for well balanced, functional solutions creating value in the economic, social and ecological realms of corporate perfomance, in a synergistic, win-together approach with all relevant stakeholders.	CS is fully integarted and embedded in every aspect of the organization, aimed at contributing to the quality and continuation of life of every being and entity, now and in the time.
Internal drivers / motivation behind CS	The awareness that CS could increase personal power (e.g. through reputation improvement)	A sense of moral duty (e.g. regarding charity or stewardship): CS is preceived as a duty or correct behavior	Awareness of the business case for CS. CS is promoted when it is thought to contribute to personal success and the financial bottom line *Relevant issues e.g.: reputation in various markets, or a perceived profit risk in not installing a CS policy (e.g. possibility of scandals)	Personal values and beliefs of top-management and all participants that social and environmental care important as such	Personal values and beliefs of all stakeholders as well as top-management that sustainbility, social and environmental aspects are important as such and inevitable given long-term trends	Conviction that sustainability on a worldwide scale is the only alternative, since all beings and phenomena are mutually interdependent. Each person or organization therefore has a universal responsibility towards all other beings, both in present and future generations.
Criteria for decision making	The impact of the decision on personal power	The decision should be taken by the correct authority according to the proper procedures and in line with the basic purpose	Financial criterium: Shortest 'pay out period', highest expected profit, return on investment or shareholder value	People, Planet, and maybe Profit. Taken after consensus or at least with consent of all relevant stakeholders	Balanced functional decision, taking into account all available expertise and considerations with long term view perspective	In line with and in favour of holistic interests for survival of life on planet

Table 3-3 : Different levels of Corporate Sustainability as a result of unique value set companies (van Marrewijk and Werre 2003)

Finally, CS implies collaboration with external groups to achieve sustainability goals. For this purpose, fundamentals of the stakeholder theory are useful for corporations to strengthen relationships with all stakeholder groups because the stronger the relationships a company has with its external parties, the easier it will be to meet its corporate business objectives (Wilson 2003) on CR. This collaboration for achieving CS is fundamental as corporation´s sustainable way of doing business is becoming a pre-condition to operate.

3.2.2.4. Green Economy

"Green Economy" is a novel concept that has been defined in terms of emerging sectors, topics, principles, and concepts. It was first coined in year 1989 when Pearce (Pearce et al. 1989) presented, for the first time, policy measures for "greening" modern economies to align their actions toward sustainable development. The introduction of this concept to government policy and decision-making by global, national, and regional organizations over the last years proved its undisputable importance. "Green Economy" surged to parallel achieve environmental protection while stimulating the global economy. The fundamental proposition of a "Green Economy" is that sustainability can only be achieved by adjusting the economy and making investment decisions (OECD 2011).

As a concept still on definition, there is no officially accepted definition of green economy, and its scope and available definitions tend to vary in their emphasis and interpretation, leading to what some authors named as "shades of green". Several other terms, such as "green growth", "greening the economy" and "inclusive growth" are used related and interchangeably with "green economy". Nevertheless, each one is focused on different economic sectors, topics, and concepts all in the "green economy" dimension.

According to the United Nations Environmental Programme (UNEP) a green economy is one that "results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP 2011). On their way to define the concept of green economy, the UNEP identified nine sectors for public and private investment on green economies: renewable energy, low-carbon transport, energy-efficient buildings, clean technologies, improved waste management, improved freshwater provision, sustainable agriculture, forestry, and fisheries (UNEP 2010). The investments for greening these sectors should contribute to economic growth, the creation of decent jobs, social equity, and poverty reduction while climate and ecological challenges are also addressed. This concept implies a low carbon, resource efficient and socially inclusive economy in the final stage.

The Organization for Economic Co-operation and Development (OECD) stressed the importance of regulatory policies to achieve green growth by asserting that green growth should not replace sustainable development but as a pathway to sustainability. Through green growth, it should be possible to operationalized sustainability while working on an agenda with concrete measures "ranging from economic instruments such as taxes, subsidies and trading schemes, through regulatory policies including the setting of standards to non-economic measures such as voluntary approaches and information provision" (Horton and Speck 2011).

According to the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), green growth is "a pre-requisite for building a green economy in the context of sustainable development and poverty reduction" (ESCAP 2013), while the World Bank simple concept defines green growth as the economic growth that is environmentally sustainable (World Bank 2012).

All these reports agree that complex solutions rather than superficial changes to the current system are mandatory to coordinate global, regional, national, and even city agendas toward a more sustainable future are necessary. This will require a shift from current market systems to more accurate representation of nature´s economic value in the market, including the value of the ecosystem services, natural capital, and costs of their degradation (Borel-Saladin and Turok 2013). In this new value system, traditional progress measures such as GDP are inadequate to evaluate growth as they promote economic growth that largely ignore social and environmental externalities. Therefore, a new generation of taxes, tradable permits, and subsidies should be implemented to encourage a resource-efficient development. These price-based instruments include the feed-in tariffs for renewable electricity in Germany, Sweden´s carbon dioxide taxation scheme and the European Emissions Trading System. Such pricing mechanisms can incentive efficiency and innovation -mostly part of private investment-, while generating funds for poverty alleviation and development -mostly part of public agenda- (Borel-Saladin and Turok 2013).

Although green economy provides a more tangible framework to protect environment while stimulating global economic, remains the key concern the vague delimitation and prioritization of topics and sectors related to a green economy. This is proven by the multiplicity of definitions presented above. While this flexibility in interpretation allows a broader acceptance of the green economy, it permits countries to pursue and justify fragmented policymaking according to their own national interest, risking uncoordinated and, therefore, ineffective actions (Horton and Speck 2011).

3.2.2.5. Underlying conditions for adoption of IT

This sub-section begins with a review of theories for adoption models used in IT literature and selects a framework to identify measures to overcome the brakes to be identified.

There are several theories in IT research about technology adoption. The most salient ones are the technology acceptance model (TAM) (Davis 1989), theory of planned behaviour (TPB) (Ajzen 1991), unified theory of acceptance and use of technology (UTAUT) (Venkatesch et al. 2003), diffusion of innovation (DOI) (Rogers 1995) and the technology, organization, and environment framework (TOE) (Tornatzky and Fleischer 1990). After the revision of literature review contributions from (Oliveira and Fraga 2011) and (Han and Park 2017), the TOE framework was selected as a reference to identify the aspects that determinate the process to adopt and implement enhanced T&T systems in the IWT.

The TOE framework stipulates that three specific determinants influence how companies adopt and implement technological innovations, as in Figure 3-9. These are technological context, organizational context, and environmental context (Tornatzky and Fleischer 1990). Under the technology context are considered the characteristics of the IT practices and equipment with which a company works and the currently available technologies on the market. The organizational context encompasses specific aspects of the company, such as size, communication processes, and organization structure. A third element, the environmental context, groups all external forces influencing the company´s business, such as market, government, and IT suppliers. This framework is the most adequate for this study as it keeps deep relationship with the stakeholder theory, recognizing the numerous relationships between a company and its environment so that a wide variety of expectations of these groups dictates the entrepreneurial activities, which in turn built a base for sustainable business.

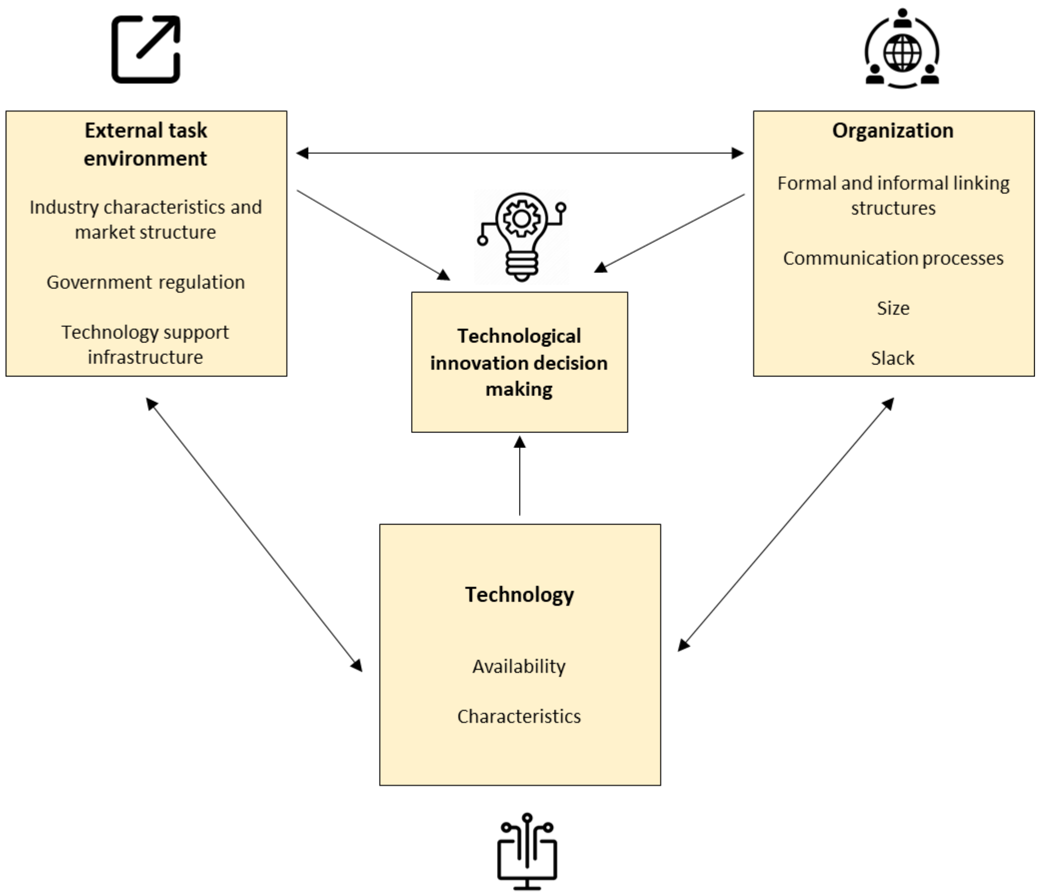

Figure 3-9: Technology, organization, and environment framework (TOE) (Tornatzky and Fleischer 1990)

Out of the literature review, it could be appreciated that some authors used the TOE framework with other theories, such as institutional theory (Scott and Christensen 1995), DOI theory (Rogers

1995), and (Iacovou et al. 1995), to better understand IT adoption decisions. Out of these three theories, (Iacovou et al. 1995) was identified as the most appropriate for this study.

The (Iacovou et al. 1995) theory explains companies´ adoption of IT innovations based on three factors: perceived benefits, organizational readiness, and external pressure, as in Figure 3-10. The (Iacovou et. al 1995) theory assess the perceived benefits of innovation as a decision factor for the adoption of new IT systems such as enhanced T&T systems (innovation), with the possibility to incorporate variables such as level of corporate sustainability, work culture, type of information to share, means of information sharing and governance mechanism in the organizational readiness context and trends in the external pressure context.

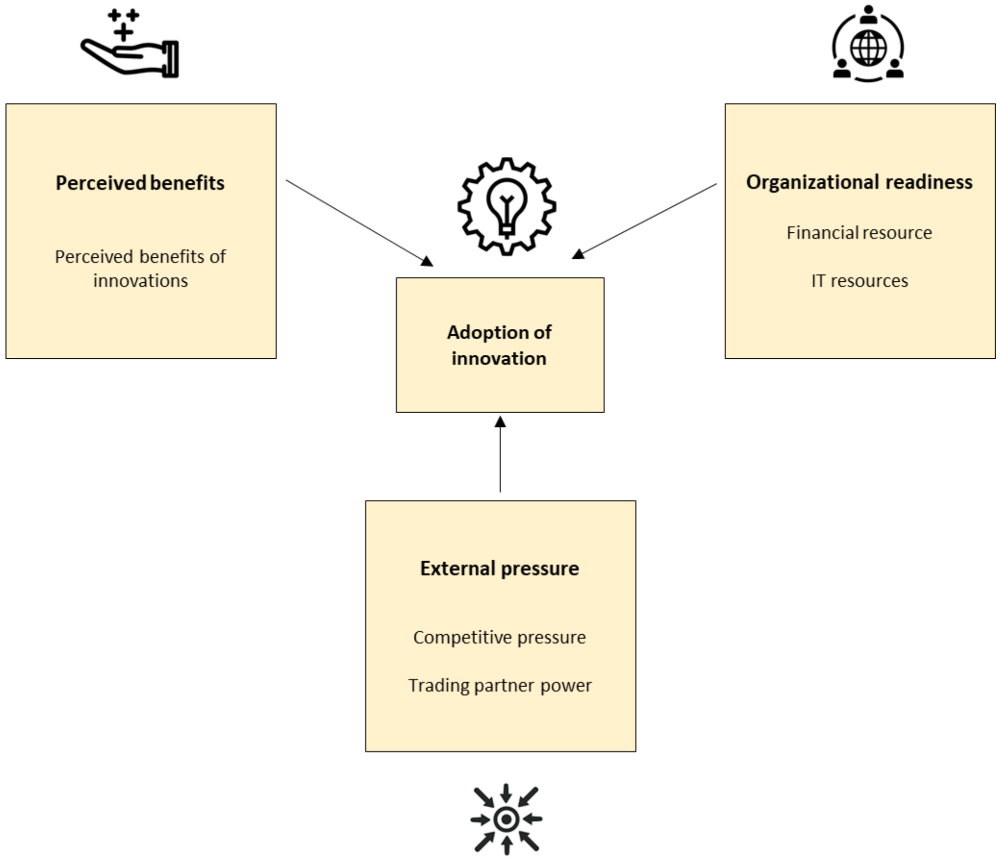

Figure 3-10 : (Iacovou et al. 1995) theory

For author´s understanding, innovation in core activities could lead to success and innovation in the services provided around this core business. This can be achieved through changes in the "way" the transport service is executed, or the "logic" how is this organized. Therefore, even though enhanced T&T systems do not imply a new fashion to carry goods over rivers and channels, it provides new innovative services around these movements.

Further, implementing an innovation could bring correlated benefits to other company activities. For example, intelligent data provided by enhanced T&T systems could allow the emergence of new intelligent analytics units/activities within the company to ensure continuous improvement. Specifically, T&T information can be used by operations to immediately adjust processes after disturbances are detected before new transports might be affected. Marketing could provide better, and more accurate service offers based on last developments, and management could use the information to develop adequate response plans and/or change strategies.

Nevertheless, fear to innovate is legitimate, as unsuccessful attempt to adopt and implement innovative technologies causes direct loss. To avoid these risks, many companies follow the dominant or leading companies´ technologies (Han and Park 2017). To mitigate risk of failure and minimize development costs, companies' options include technology development supported by government and/or small development of scale prototype to prove technology before implementation on important/sensitive services.

Innovation as a process over the time

The models and theories introduced above depict the decision process to incorporate innovative technologies as a discrete event. For this study, we enrich this premise and understand this process as a continuous over the time. The study of (Karahanna et al. 1999) proves distinctions between the behaviours of initial adopting and the subsequent continued usage of an IT innovation. This means there will be criteria that are relevant for companies when deciding to or not adopt eT&T that will be different from the criteria when deciding to continue using it. For example, costs of development vs savings will be the first decision criteria for the adoption. System user-friendliness is a criterion to continue use.

This happens because perception of a new technology varies across the time. Determinants at the stage of knowing the technology are not the same as when beginning to use it and again totally different after some time of usage. To explain this phenomenon, the decision process to buy a smartphone is a good example. The first expectation of buying a smartphone could be getting some status recognition. After this is the ease of use (intuitive navigation) relevant. After a time, it could be that none of the abovementioned determinants is relevant as the product is already known and represents no novelty. At this point, other determinants become more relevant such as compatibility an easy use of handy related services such as cloud services, battery life, other services such as virtual assistant, security features (face recognition), and similar. It could be appreciated that factors relevant to decide if the buyer would buy or not again the same smartphone brand changed over the time.

In their theoretical model to analyse the intention to adopt and the resolution to continue using an IT innovation (Karahanna et al. 1999) argue both stages are determined by two basic factors: the personal reflecting interest and the social influence. Personal factors could be passed similar experiences, such as the perceived usefulness, the perceived enhanced of image, and the possibility of testing the innovation or observing a user operating it. Social factors describe accepting opinions about the innovation from experts, already users, and supervisors. In their study, they conclude that social environment will be more important for the question of adopting or not. Nevertheless, user attitude will be stronger for the question "continue using or not". The set of decision criteria when evaluating adopting or using an IT innovation will also differ. While potential users tend to focus on a wider set of technology characteristics to reduce the uncertainty of their decisions to adopt or not, users might focus on more rational and fewer considerations when deciding whether to use it (Karahanna et al. 1999).

3.2.3. Proposition of an analytical model

After the review of existing theoretical models on information and knowledge sharing presented in section 3.2.1 it can be pointed out that a broad range of possible models discussed in the literature. Since these models are very general without considering the interfaces of the information and knowledge sharing with other issues such as sustainability, a new model, based on these general ones but adequate for the target of this research, will be defined. Attempts to measure information sharing on sustainability are not often undertaken because of the difficulty of isolating the contribution of the information systems function from other contributors. As this study does not attain to operationalize these contributions, this does not pose a barrier for the introduction of the sustainability dimension.

The new reference model will provide the foundation for the in-depth investigation of the main research question as it defines and justifies the key variables to be used in the analysis and discussion of the data to be collected in Chapters 5 and 7. The first proposition of this model to be presented in this section will be then refined with the research results in Chapter 8.

It should meet some characteristics to elaborate a reference model that properly address the research question with well- grounded results and the possibility to apply for future research. First, the model must be complete but, at the same time, general. It must incorporate all previous research, while, at the same time being not too specific (general) so that it could be used even in more complex schemas. Further, the model should make possible to explain the studied phenomenon (explanatory value) and allow the researcher to do some predictions about it (predictive value). Therefore, the reference model proposed here does not attain to address the data exchange itself. This would demand the command of data structures specific to each company, losing its general applicability and predictive value. Rather than that, the model provided in this research can be used as an instrument to analyse the implementation of new technologies for information and knowledge exchange with an impact on more sustainable operations. The model is developed in the case of the inland waterway transport sector, it could be nevertheless used as a reference model for other studies.

The purpose of the model is twofold:

1. To map a procedure to analyse the implementation of new information and knowledge-sharing technologies for more sustainable operations, and
2. To guide future empirical research and theoretical building about developing these innovative technologies to address new legal, societal, environmental and market requirements.

Description of the model

The developed model denoted in this work as “enhanced Tracking and Tracing Implementation for Sustainable IWT Operations” (eT&T-SusInWa) analytical model illustrates how the variables of study might be related to each other as in Figure 3-11. The model will lead this research when investigating the implementation of enhanced Tracking and Tracing systems to achieve more sustainable operations in inland waterway transport. The core part of the model is the cause-effect relationship between the variables *level of implementation of enhanced Tracking and Tracing systems* (independent variable) and achieving *more sustainable IWT operations* (dependent variable). According to (van Marrewijk and Werre 2003), each company owns a proper and unique set of values due to the specific environmental conditions they operate (section 3.2.2.3). These values set the ambition levels of corporate sustainability that define the level of commitment of the company to more sustainable operations. In the model, this variable *level of Corporate Sustainability* (moderator variable) is represented as a variable that moderates the effect that enhanced T&T systems have over sustainable IWT operations. The highest the level of CS of the company, the highest the effect of enhanced T&T systems over sustainability in the IWT.

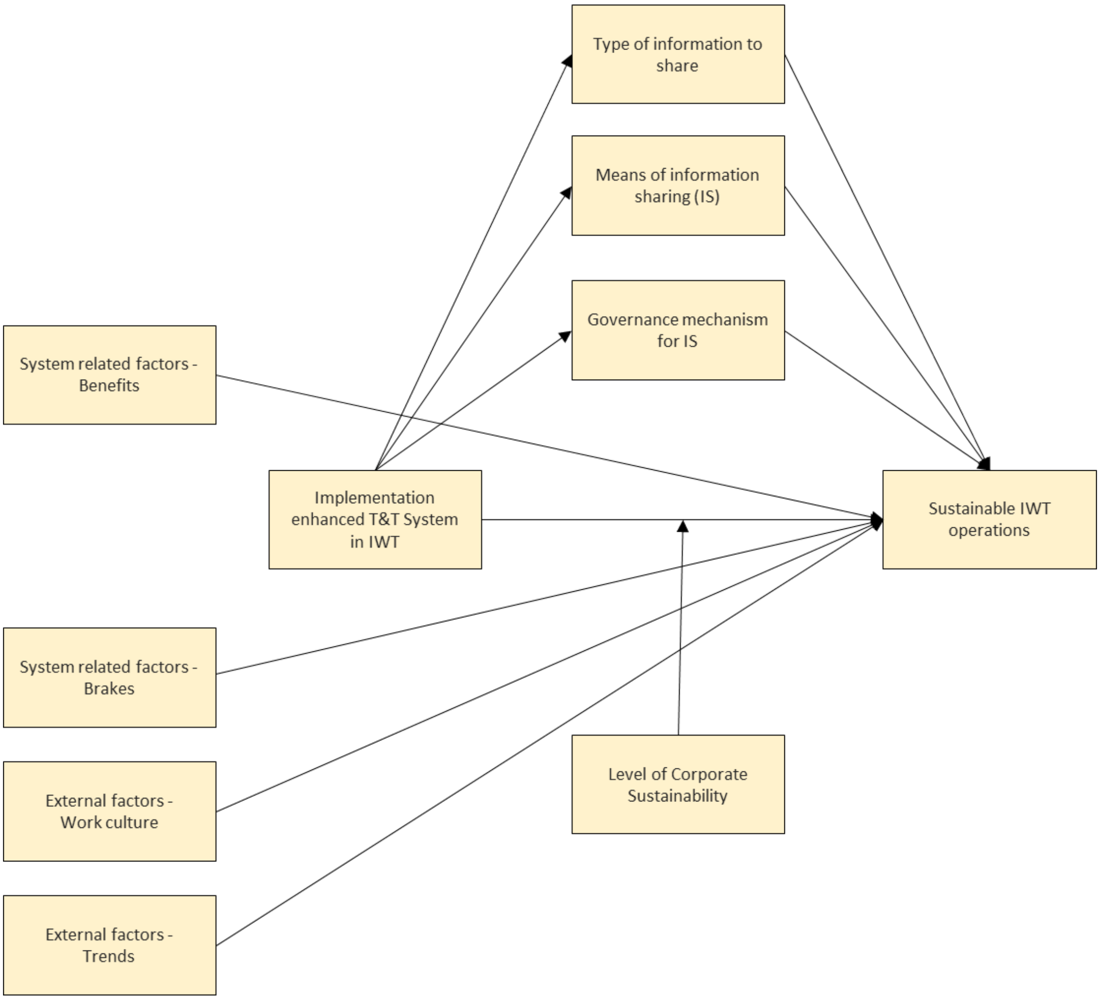

Figure 3-11 : enhanced Tracking and Tracing Implementation for Sustainable IWT Operations (eT&T-SusInWa) analytical model

Other variables are incorporated into the model to understand how these factors govern the relationship between the independent and dependent variables. As introduced by (Ipe 2003), the *type of information to share* affects how knowledge is shared. Further variables have the same effect, such as the selected *means* and *information-sharing governance mechanisms* (Kembro et al. 2014). These three variables: *type information to share*, *means for IS* and *governance mechanisms for IS* (mediator variables), come between the independent and dependent variables and strengthen the cause-effect relationship between them. The greater the level of implementation of enhanced T&T, the broader the means to share this information and the stronger the governance mechanism for coordinating and controlling the exchange of T&T information in a contractual (contracts) or discretionary (trust) way. Here it is possible to explain the model´s differences between the moderator and mediator variables. The *level of implementation of enhanced T&T systems* does not affect the *level of CS of a company*. Regardless, the company decides on this ambition based on its set of values and culture. On the other hand, the *type of information to share*, *means for IS* and *governance mechanisms for IS* are integral to explaining the cause-effect relationship. Adding more variables to the model will improve its predictive value and reduce bias in the findings.

Other factors related to the enhanced tracking and tracing system are external factors and are expected to influence the sustainability of IWT operations by implementation of enhanced T&T systems. The *benefits* (DeLone and McLean 2002; Gharawi and Dawes 2010; Ipe 2003; Kembro et al. 2014) and *brakes* (DeLone and McLean 2002; Gharawi and Dawes 2010; Ipe 2003; Kembro et al. 2014) linked to the implementation of an enhanced Tracking and Tracing systems from the point of view of different stakeholders in the IWT, and current or potential customers are certainly a decision criterion for companies in the IWT to implement or not enhanced T&T systems. These two control variables are related to the T&T system itself. If the related *benefits* are worth it, the *level of implementation of enhanced T&T systems* will increase, and so on, *sustainable operations*. In the same fashion, if related *brakes* are not mitigated, the *level of implementation of enhanced T&T systems* will decrease and, thereby, the *sustainability of IWT operations*. Further other control variables are external to the T&T system itself but are expected to influence the relationship between the independent and dependent variable, such as: *work culture* (Ipe 2003) and *trends*. Information sharing demands interaction between players and the work culture in the IWT sector and companies operating in the sector can be a facilitator or an impediment for more sustainable operations through enhanced T&T systems. Finally, as explained in section 2.3 evolutions in the IWT sector are driven by technological and organizational *trends*, so they are important drivers with power to accelerate the adaptation of enhanced T&T systems.

4. Research Methods

In the natural and engineering sciences, the classic quantitative methods are considered to be the dominant empirical research methods. Quantitative methods focus on measurability and quantifiability as well as objectivity and isolability (Bortz and Döring 2006).

However, a qualitative instrument regarding qualitative social research was selected for this work. The reasons for this lie in the thematic focus of the primarily qualitative aspects of information exchange and sustainability. The inductive approach to qualitative methods is the most apparent mean of dealing with the key questions formulated since the open form of these research elements is not editable in numbers but only in text form. In addition, the large sample size required for reliable results of quantitative methods cannot be guaranteed within the framework of the thesis and the research question formulated. The following sections explain the qualitative methods chosen for the methodology of this thesis.

4.1. Method Interviews

An expert interview is an oral interview in the form of a conversation with asymmetrical roles: the interviewer asks questions about a specific topic, and the interview partner who is knowledgeable in this field, answers with their experience and perspective. The product of an expert interview is text data in transcript or protocol form (Skibar 2018; Baur and Blasius 2014).

Although literature sources agree that the expert interview is one of the more qualitative approaches in empirical research, its expression has precise gradations. Supporters of the qualitative approaches are often criticized for pre-structured interviews being opposed to the qualitative ideal of openness and non-influencing (Bogner et al. 2014). As a result of this discussion, different forms of interviews have emerged. An approach to categorization characteristics according to (Bortz and Döring 2006) can be found in Table 4-1. The table depicts the features of different formats (structured, half-structured, non-structured) for expert interviews. The type of structure will allow the interviewer a degree of freedom (hard, neutral, soft) to adjust the questions during the interview. As a result of this freedom-degree, the possible or best canal of communication can be determined (written, telephone, face to face). The election of an interview type with a related authoritarianism level and type of contact is the base to determine the optimal number of interviews (single, group, survey) and interviewer (single, tandem, audio), mostly obeying to the available resources (timing, financial). It could be appreciated that a structured interview is suitable for verifying factors already identified and measure then. Half-structured and non-structured interviews, however, allow the identification of new factors and deep into their contexts.

Extent of Standardization	Authoritarianism of the interviewer	Type of contact	Number of Interviewees	Number of Interviewer	Function
structured	hard	written	single interview	single interviewer	detecting
half-structured	neutral	telephone	group interview	tandem	mediatory
non-structured	soft	personal	survey	audio	

Table 4-1 : Characteristics and manifestations of expert interviews based on (Bortz and Döring 2006)

The expert interviews based on guidelines used in this work are regarded as partially standardized forms of interview. The eponymous guideline has a double function: on the one hand it serves as a structuring framework for the interview process and on the other hand as a comparable and “concrete aid in the survey situation” (Bogner et al. 2014). The duration of the interview, the topic complexes involved and especially the questions dealt with are determined in advance, only the level of detail of the pre-formulation varies with the examination situation (Bogner et al. 2014).

To obtain as much information as possible from the interview, there are recognized basic rules for the structure of an interview guide, the formulation of the questions and the design and implementation of the interview.

Macro and micro planning

(Bortz and Döring 2006) structured the guideline planning at the macro and micro levels. The macro level determines the sequence of the individual thematic sub-areas and thus give a general structure to the interview. The following macro structuring is mentioned as an example:

1. General questions about the person,
2. Questions on subject area I,
3. Open discussion,
4. Questions about subject area II, and
5. Final discussion

(Skibar 2018) supplements the macro level of the guideline with an area for ad hoc questions and a formal cover sheet as well as a supplementary sheet for framework conditions and interview notes that go beyond the obligatory audio recording of the conversation (Skibar 2018).

In the following micro planning stage, the content within the individual subject complexes is specified and the questions are formulated. The aim of the design is, on the one hand, to gain the highest possible information (what questions are asked). On the other hand, the interviewee’s willingness to talk should be activated or supported (how are the questions asked). The most sensitive section of the conversation is the interview opening. In this part, the interviewer must generate interest in the interview, and thus, readiness to talk, removing existing inhibitions. Introductory, contact or “icebreaker” questions are particularly useful here (Bortz and Döring 2006).

A common approach for organizing a subject area is to order the questions from easy to difficult and from evaluative to descriptive. Answering simple questions at the beginning is usually easy for the interviewees and enables a gentle introduction to the following subject area (Skibar 2018).

The main questions should primarily be open. These are formulations, which in contrast to decision questions (e.g., yes, or no), entail detailed answers. This gives the interview a character of conversation and supports the experts’ flow of speech (Skibar 2018).

The interviewer can control the conversation dynamically using so-called filter questions. Subsequent questions on complexes of topics can be made dependent on the answer to the respective filter questions. Similarly, so-called buffer questions facilitate the transition between different subject areas (Bortz and Döring 2006).

Conducting interviews and surveying techniques

The quality of the empirical survey largely depends on the appropriate interview situation and behaviour. Influencing or indirect control of the interviewee by the interviewer and thus falsifying the test results should be avoided. It is important to select a suitable so-called setting, i.e., the entirety of the framework parameters that shape the interview. Psychological aspects are particularly relevant, such as the assignment of roles to the interviewees. Such interview effects must be reflected in the run-up and considered to obtain a possible neutral research result. The overall goal of the interview should be to build a positive atmosphere in which all interviewees feel comfortable without being influenced by exaggerated euphoria.

4.2. Method Content Analysis

Content analysis is a standard method of qualitative research. Processing large (text) data volumes such as transcripts or protocols promises a structured approach in otherwise difficult-to-grasp qualitative research areas. Defined communication characteristics can thus be recorded and classified intersubjectively comprehensibly (Hoffmeyer-Zlotnik 1992). In addition to a straightforward analytical procedure, content analysis is characterized by a firm compression (reduction) of content and results (Blatter et al. 2018). (Gläser and Laudel 2010) Therefore, describe the qualitative content analysis is a "quantifying method" of text analysis.

One of the most popular methods is the qualitative content analysis according to Philipp Mayring. Mayring presents a comprehensive, systematic concept for the analysis of qualitative data. His approach, which initially came from the social sciences, is now regarded as a reference standard in many disciplines and is taken up across the board in relevant specialist literature (Bogner et al. 2014; Misoch 2015; Mayer 2013). Based on Mayring's content analytical process model, the structure for content analysis is presented in Figure 4-1.

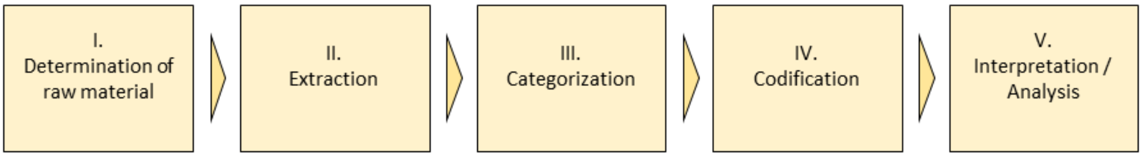

Figure 4-1 : Structure of the qualitative content analysis of the thesis (Mayring 2015)

Determination of the raw material

The content analysis as an evaluation method is based on ready-made linguistic material. Before the designated material, usually in text form, can be compressed and extracted, it must be determined and classified. Mayring names three analysis steps that can be differentiated when dealing with the starting material (Mayring, 2015):

1. Definition of the material: In the first step, the text material to be analysed, known as the "corpus", is precisely defined. This text structure should remain the same in the further course of editing. Ensuring the correct and representative selection of cases in extensive surveys is also necessary.
2. Analysis of the development situation: A detailed description of the conditions under which the material was created is essential for clean processing. Points to be recorded in this step are the people present (“interacting agents”), the author's cognitive background, the target group, and background of the interviewees.
3. Formal characteristics of the material: On the last step, transcripts of spoken material should be written that will be the raw data.

Extraction - paraphrasing, generalization, and reduction

After the original material is defined, it is compressed using paraphrasing, generalization, and reduction techniques, this is the extraction. For this stage, the four steps of Mayring´s process model will be implemented to bundle the material in form and content, as in Figure 4-2.

Step 1: Paraphrasing
S1.1: Deletion of all parts of the text that are not or little relevant, such as decorating, repeating, or clarifying phrases S1.2: Translation of the text-based passages to a uniform language level S1.3: Transformation to a short grammatical form
Step 2: Generalization to the level of abstraction
S2.1: Generalization of the objects of the paraphrases to the defined level of abstraction, so that the old objects are implied in the newly formulated ones S2.2: Generalization of propositions in the same way S2.3: Paraphrases that are above the level of abstraction are retained S2.4: In case of doubt, use theoretical assumptions
Step 3: First reduction
S3.1: Deletion of paraphrases with the same meaning within an evaluation unit S3.2: Deletion of paraphrases that do not have substantial content S3.3: Selection of the paraphrases that are still considered to be central to the content S3.4: In case of doubt, use theoretical assumptions
Step 4: Second reduction
S4.1: Bundling of paraphrases with the same or similar statement or object S4.2: Summary of paraphrases with several statements on an object (construction / integration) S4.3: Summary of paraphrases with the same or similar object and different statements on a paraphrase S4.4: In case of doubt, use theoretical assumptions

Table 4-2 : The four steps of extraction according to (Mayring 2015)

The result of paraphrasing, generalization and reduction is a protocol-like document that is the basis for coding and category formation on the subsequent analysis.

Categorization

To systematically analyse the material, its statements must be assigned to individual categories. The next step is to set up appropriate categories with an inductive or a deductive approach. A deductive approach forms the categories from the theoretical knowledge or previous knowledge before the survey. It is an inductive approach if the category is only formed during or after the survey (Mayring 2015). To obtain the most meaningful categories, the two methods are often combined in practical implementation (Meier 2014).

Codification

Codification means the assignment of the categories previously created to the corresponding text passages. In addition, coding rules can be defined that should enable clear assignment in critical cases.

Interpretation and evaluation

Various techniques are used to interpret qualitative material. A selection of the most important ones for this work is presented in Table 4-3.

Description	Explanation	Analysis Category
Frequency analysis	Filtering out text components using a category system; statement about the relative weight of these components by frequency	Structuring; summary
Valence and intensity analyse	Filtering out text components using a category system; assessment based on context; summary of assessments	Structuring; summary
Objective hermeneutics	Explication of individual interactions (context, intention, objective motives and consequences, function); filter out consistent communication figures, generalization	Explication; structuring
Context theories	Micro and macro context	Explication

Table 4-3 : Basic forms of interpretation according to (Mayring 2015)

4.3. Method Participatory-Creative Workshops

Different strategies will be followed to validate the accuracy of the information collected during this thesis and to guarantee study acceptance among readers. One of these strategies is the implementation of Triangulation by using more than one method to collect data on the same topic. In section 4.1, expert interview was introduced as one these methods to collect data on the research topic of this thesis. The second method to collect data is based on a participatory research focus founded by the interactive inquiry orientation of Action Research founded by (Lewin 1946). Kurt Lewin, a German American psychologist, is considered one of the modern pioneers of social, organizational, and applied psychology in the United States. Lewin was particularly concerned about the independence, equality, and co-operation of minority groups. With his revolutionary approach (Lewin 1946), he sought to implement social science to help solve the social conflicts that arose in the early modern era, such as social and industrial exploitation issues. His approach made it possible to bring change to a system under the motto “bringing research into action”. This was exemplified by problem owners´ and the researcher´s active participation in exploring the problem, making decisions, monitoring, and keeping watch on the consequences (Adelman 1993).

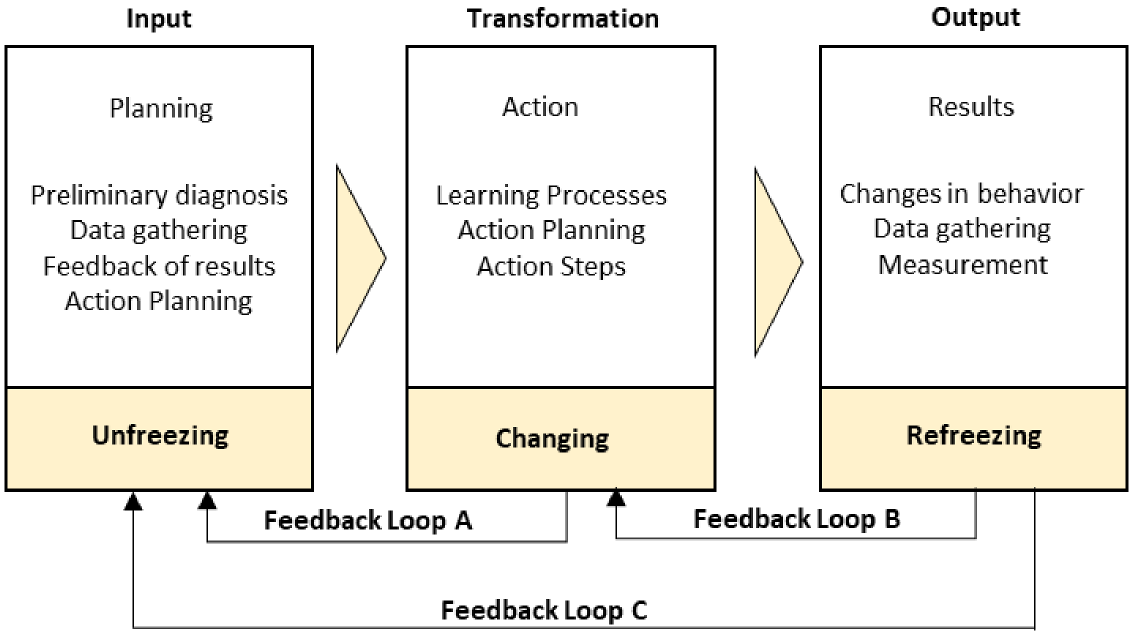

Figure 4-2 : Systems model of the Action Research process (Lewin 1958)

Lewin descripted this process of change as a cyclical one with three steps. The first step, "Unfreezing", encompasses a preliminary problem diagnosis, data gathering, feedback results, and joint action planning. The second step, "Changing", encompasses learning processes and formulating an action plan. The third step, "Refreezing", represents the output of this exercise with changes in behaviour and measurement of consequences. Feedback loops between each step complete the cyclical process. Figure 4-2 provide a graphical representation of this model.

Action Research enables researchers to spouse contributions of sciences with contributions to practice by bringing together knowledge and action through a pragmatical philosophy. Although Action Research was conducted initially on phycological sciences, this orientation has been successfully implemented in organizational sciences, for example, in (Molineux 2018) contribution, which presented Action Research as a systemic approach to designing and implementing change in organisations. This notion was introduced by (Wendell and Cecil 1973) when they defined *Organization Development* as "organization improvement through Action Research".

In the context of Action Research, there is an increase in the awareness of new forms of collaboration, such as Open Innovation, to increase research productivity. Open Innovation is a policy priority of the European Commission in its strategy 2020-2024. It is the practice that "assumes that firms can and should use external as well as internal ideas, an internal as well as external paths to market, as they look to advance their innovations" (Bogers et al. 2017). As a result, a new era in the research and innovation ecosystem has become increasingly important to build a link between academia, business, users, policymakers, and non-profit organizations to co-create all together collaboratively, openly, and globally. This new paradigm for organizing innovation is expected, on the one hand, to improve quality, efficiency, and responsiveness of research and, on the other hand, to increase the creativity and trust in the results while reducing levels of uncertainties, namely technological, business model, regulatory and user acceptance (Moedas 2016; European Commission 2019). The participatory-creative workshop method selected for this study matches indeed with Open Innovation. Thus, the study will benefit from the abovementioned advantages by implementing such a method.

Workshop as a participatory-creative research method

Pioneers in using participatory-creative workshops in medicine (Heron and Reason 1985) demonstrate the use of workshops for reflection and theory building in the surgery. Further examples are (Blennerhassett 1988), who suggested workshops or interviews to formulate learning methods for senior civil service managers with scare experience in IT, and (Molineux 2018), who ran workshops to design new systems obtaining a vast range of creative ideas.

Typically, the word *workshop* denotates “a room or building where things are made or repaired using machines and /or tools” (Cambridge Dictionary 2019). Nevertheless, the word got another meaning to designate an event of limited duration “whereby a group of people learn, acquire new knowledge, perform creative problem-solving, or innovate in relation to a domain-specific issue” (Ørngreen and Levinsen 2017). Their findings about the opportunities and risks related to workshops as a research method are summarized in Table 4-4. The representation of “opportunities” beside “risks” should not be interpreted as a direct relationship between each opportunity to a specific risk per line. Moreover, the two columns intend to denote a counterpoise.

Opportunities	Risks
A helpful approach for emerging and unpredictable studies themes	The quality of workshop results relies on the moderator´s ability to create good, creative, and participative atmosphere while keeping focus on interested questions/topic
Can be designed to produce reliable and valid data about the research topic	The benefit for the participants should be clear for them as they are investing time and resources to attend the workshop
Participatory character supports validation of research findings making them more reliable	Participant come with expectations (new insights, suggestions, process, innovations) that differ depending on their interests
Boost the identification of factors affecting the study that are not obvious before the workshop	Background, interests, or the mood of participants and the group-mix can influence workshop direction
Provide an obstruction for participants from their routines that stimulates reflection and new recognition	Active participation is fundamental to reaching workshop objectives
Through the group work, discussions are provoked, the grade of detail of the information is higher, and knowledge is explicated	Participants could react in differently to the immersive and collaborative activities planned for the workshop
Group work inspire new insight into the research topic in ways other methods cannot	All participants should be given personal attention and chance to be heard
A high degree of combination possibilities with other methods for mixed method approaches	

Table 4-4 : Synopsis opportunities and risks of workshops as research method according to (Ørngreen and Levinsen 2017)

Chapter 7 introduces the strategies followed to boost opportunities and mitigate risks of implementing workshops as research method for this study.

Types of Workshops

To identify the best workshop for the research objectives of this study, a scrutiny of the different types of workshops was performed. The number of types of workshops is considerable. There are strategy-workshops, team-building-workshops, conflict-management-workshops, leaders-workshop, change-management-workshops, organizational-development-workshops, process-optimization-workshops, and others. The most useful types for this study were selected and introduced below.

<u>Knowledge/World Café</u>

On a Knowledge Café, World Café, the participants gather around tables and discuss the table-question. After about 25 minutes, the participants change tables and come together in new constellations. The work results of the tables are finally exhibited in a “vernissage” for all participants. By repeating the same questions at several café tables, the participants gain knowledge from a wide range of knowledge resources. Due to the diversity of the participants, many different perspectives are discussed, and a better-shared understanding of the facts and challenges within a very short time can be achieved. This format is valid when large groups´ knowledge and collective intelligence should be used for a complex topic to find extraordinary solutions.

Open Space Technology

Open Space Technology is an interactive conference method in which the moderator sets a thematic framework and the participants themselves bring in the questions and concerns that interest them the most. Based on the collected questions and concerns, the content and the agenda of the conference is agreed. The questions and concerns are then discussed on small groups and the results written over forms. The results of all work groups are open to be read by all. Finally, depending on the target of the workshop action prioritization, action planning and further initiatives are planned jointly.

Barcamp

Such as the Open Space Technology, and Barcamps are events where the content and sequence of the event need to be stipulated on advance. These will be done by the participants at the beginning of the event. Thus, they are often referred as unconferences or ad-hoc-conferences. During the Barcamps participants become presenters as they can suggest a theme they would like to discuss. Invitations to Barcamps are open, and participants are not chosen. Everyone can suggest a theme to be presented/discussed in a session using three hashtags. Participants interested in the suggested theme raise their hands to show curiosity. If a suggested theme receives enough attention, it will be introduced in the agenda and receive a place and time to discuss it. Theme presenters can decide if giving a presentation, perform an open discussion, employ a workshop method, or use other format to discuss its theme with attendances to their sessions. Presenters are encouraged to share presentation on social medias. Commonly, no presentation about the results of each session is shared, but a get-together follows a summary to stimulate networking. The use of social media during Barcamps is widespread to share thoughts/results among participants and make them accessible for people who could not attend the Barcamp.

Road mapping

Road mapping is an approach to support innovation processes and strategy execution very used in companies such as Motorola and Phillips and public organizations. The main objective of a Road mapping workshop is to deliver a strategic plan in a simple graphic or table that answer the following questions: Where are we now? Where are we going? How can we get there? Through Road mapping can the strategic plan be formulated to implement new research and development programmes to develop new technologies that could support the design of new products to reach new markets while identifying what resources (capital, supply chain, staff) are needed to reach these goals (Phaal et al. 2007). As Roadmaps define the path to follow by organization, the team is mainly conformed of relatives (company stakeholders). This composition is vital as well as Roadmaps have a strategic importance for the company, and usually, their results are confidential in the case of profitable firms. From the company site, the nature of group-work for building a common vision improve the strategic plan´s success as it is a collective contribution of involved workers.

5. Mapping the needs for enhanced Tracking and Tracing Systems

Mapping the needs for enhanced T&T systems for more sustainable operations on the IW was a substantial part of this research regarding time and design. Once the research preparation phases described in Chapters 1 to 4 were completed, Chapter 5 denotes the beginning of data collection in the field. Contacting companies and getting interviews, clarifying their doubts, organizing meetings, and visiting them on their premises was very time-consuming. Nevertheless, as the proverb states, "The Greater the Effort, the Sweeter the Reward". The data collection was a very gratifying and enriching experience for this dissertation, as fruitful interviews were conducted with several experts in the field.

The sampling technique for interviews and the several strategies to reach the desired target group are presented in section 5.1. Further, several issues are addressed to optimize interview time, boost data collection, and increase the comfort of interviewees, based on lines from section 4.1 and the consideration of ethical principles. Section 5.1 ends with the analysing the final constellation of interviewees and implications for the study out of this participant mix.

In section 5.2 the design of interviews as a research instrument is fully explained, such as characteristics and manifestations of expert interviews, thematic blocks of the questionnaire-guidelines, and customized versions. Chapter 5 ends with section 5.3, where information about the reports of expert interviews and study visit is introduced. The findings are structured on the customized questionnaire-guideline´s thematic blocks (theme complex) of the respective. It allows the aggrupation of findings addressing the same issues and makes possible comparisons throughout interviews.

5.1. Selection and structure of interviews

A nonprobability sample technique was used for the expert's interview, whose exceptional knowledge and experience in the study theme were essential for gathering relevant data. A twofold strategy was followed to reach practitioners in the inland waterway sector with expertise in key notions of Tracking and Tracing systems and sustainability. First, two leading associations in the Rhine region were contacted to present the study objectives and motivate their members to participate in the interview process. Second, inland ports were directly addressed to recruit future participants among their acquaintance in a chain-referral sampling fashion. The sample was built up until it was confirmed that interviewing more participants were not providing any additional perspective or information (saturation).

The Association of Forwarding and Logistics North Rhine-Westphalia e.V. (VSL-NRW) was the first body reached. The VSL-NRW represents the interests of approximately 500 North Rhine-Westphalian freight forwarders members in municipalities and all authorities at the land level concerned with relevant national laws and other country regulations regarding road transport, ports, environmental law, regional customs regulations, taxes, local charges, and police regulations. In addition, the office is available to the authorities as an advisory body. The VSL-NRW cooperates closely with the chambers of industry and commerce and vocational schools in all aspects of vocational training and plays a significant role in review matters. The Committee for Inland Navigation and Maritime Forwarding / Port Management was the unit cooperating with the study.

The Association for European Inland Navigation and Waterways e.V. (VBW) was the second body reached. The VBW is an organization that promotes the multimodal transport system through waterways. The association supports its 125 corporative members spread over ten countries clarifying scientific, technical, legal, and practical questions related to waterways and ports´ construction, operation, and use.

In total around 750 practitioners received an invitation to participate in the interviews, and approximately forty-five (45) first interested were engaged in the sessions.

Once potential experts were identified, the corresponding interview guideline was sent before the interview. This procedure leads to three advantages:

1. The potential interviewee could prove timely if the company was able to provide insights for the questions,
2. The potential interviewees could judge if they were the right person for conducting the interview or if other colleges should be as well invited, and
3. The potential interviewees could better prepare for the interview and collect or prove information for the questions before the day of the interview.

All these contributed for a better utilization of the interview-time, collection of more profound insights, and less anxiety or confusion from the interviewees during the interview process.

At times, potential experts recognized, after inspection of the interview guideline, that they could not contribute appropriately to the study. In many of these cases, they suggested a better-suited new potential expert.

Ethical principles introduced in section 1.8 by (Orb et al. 2000) and (Bell and Bryman 2007) were considered as follows:

1. The goals of the study, procedure of the interview (duration, place), and intended utilization of the interview results were fully communicated prior the interview to the experts,
2. Special requests from interviewees were respected, such as the protection of sensitive company data,
3. The right of anonymity of individuals were respected. Thus, no names are given,
4. Author’s affiliations were communicated and in the case of questions about background, interest, further information was given in the aim of transparency,
5. Interviewees were allowed to check interview transcripts and add, delete, or edit them, and
6. The author tried to be fair, providing mutual benefit for the researcher and the participant.

Principles of *beneficence* and *justice* were observed, and mutual benefit for researcher and participant was secured through several initiatives:

1. Results from all interviews were shared with all participants in form of a presentation and a report,
2. Interested participants were added to the network of IW projects where the author was working, and access to all project publications was given, as well as invitations for further activities on the Tracking and Tracing systems for IWT,
3. Participation in the interview was acknowledged highlighting the companies´ name, and
4. Possibilities for the exchange of the author´s experiences in other past or coming IWT projects were offered.

Only some participants were interested in all these benefits, but all at least in one. The author considers that this cooperative posture provided a trustable and valuable co-work for both parts. It is expected to contribute to more enriching inputs and trustworthy research.

A total of eleven expert interviews operating in the Lower Rhine region were conducted from April to August 2018 until saturation was achieved. Additional meetings were conducted from June to September 2019. Additional meetings proved to be valuable to further expand the first findings and close gaps from expert interviews. During the additional meetings, it was possible to focus better on specific issues as insights were already obtained after expert interviews concluded. It allowed verification of the information gathered. A list of the interviews conducted, and the additional meetings can be found in Appendix E.

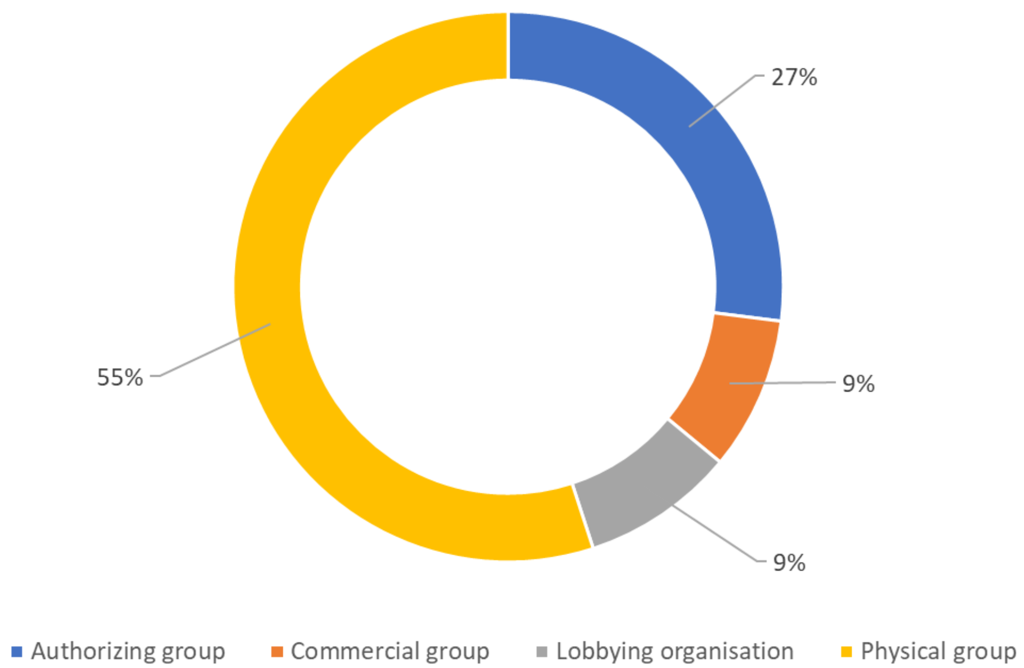

Figure 5-1 : Mix of interviewees

Figure 5-1 depicts the mix of interviewees using the player classification approach introduced in section 2.1.2. As previously mentioned, this classification approach does not include waterway infrastructure operators such as locks, district vessel traffic service centres, and regulatory bodies. Other institutions interested in the inland waterway, such as relevant associations, interest groups, river commissions, and consultation bodies, are also included in the (Wagennaar 1992) classification either.

These last ones are in figure 5-1 under the category “Lobbying organizations” classified. Neither research nor innovation institutes are dedicated to developing innovations for the inland waterway systems on the (Wagenaar 1992) classification considered. This type of player is under “Research Institution” ordered for this statistic.

The involvement of these three other groups should allow a broader overview. Lobbying organizations are in regular contact with multiple IWT players to represent their members´ interests upon governmental, social, business, and scientific instruments. Through their participation, further dimensions than business, such as legal, social, and technical insights, are intended to enrich the interview findings from multiple perspectives. Research institutions plays an essential role in the modernization of the inland waterway systems through the development of innovative systems that go from the development of new vessel types, new navigation systems, traffic monitoring systems, innovative transport concepts, and solutions regarding traffic engineering, logistics, and transport economics issues. Through their participation, the forthcoming innovation framework in the IWT should be considered in the study. It facilitates realistic anticipation of future systems developments for the IW sector, revealing possible interfaces with this study.

Figure 5-1 shows that more than half of interviewees are part of the physical group, directly involved in the logistics processes and physical movement of goods through the inland waterways. It includes haulage contractors for the pre- and post-carriage and terminal operators, stevedores, and vessel operators. The insights provided by this group are of high importance for this study as they are directly involved in cargo movements. Thus, this is the group for which the most relevant benefits from such a new system are expected.

During the interviews, it was observed that the construction of the market on the focused region of Lower Rhine is characterized by holding companies with a service portfolio covering different stages of the cargo movement through several own subsidiaries. For example, it is not unusual in the focused region that a holding company sells transport services through the waterways when one subsidiary parallel organizes the transport as a carrier/forwarder, and another subsidiary assumes the pre- and post-carriage to and from the consignee and shippers to be transhipped in terminals operated by another subsidiary. Sometimes, the cargo is even transported by vessel belonging them. Nevertheless, this differs from the rule as vessel operators' market is mainly built up over one single-person independent businesses. Usually, such well-structured holding companies own other subsidiaries operating train lines to complete the services spectrum with several transport modalities. It also increases the resilience of their networks as disruptions in one transport leg can be absorbed by modal shifts. For example, cargo can be shifted from vessels to trains in low water levels to meet contractual obligations.

One out of five interviews was with experts exercising a supervisory function. One interview was conducted with waterway inspectors and the rest with port authorities. Even though the authorizing group is not directly involved at an operational level, they can provide essential insights from an administrative point of view and complement the operational insights from the physical group. Port authorities provide a logistic marketplace for the rest of the IWT players as they are landlords of the transhipment points, water to road, water to train, and water to water. Management strategies of port authorities directly impact the cluster operating in their premises. It begins with selecting the geographical locations, proximity to urban areas and industrial/transport hubs, and accessibility to waterways, sea, train lanes, and highways to boost multimodality and governance structures for complying with regulations such as security, taxation, and navigation. Finally, port authorities pursing a customer-oriented strategy rather than a merely supervisory function could yield important advantages for the settled companies by facilitating the instruments for a healthy and, therefore, profitable relationship between the port cluster and the city where they operate or even with other partner port authorities along the waterway.

The administration of port cities of the future is a concrete example of how port clusters can go beyond their controlling role to a business partner role. (Szymiczek et al. 2019), in their exploratory study with the Duisburg ports, in Germany, Valencia in Spain, Gdynia in Poland, Panama and Colon in Panama, Guayaquil and Posorja in Ecuador, and Buenos Aires in Argentina, discussed how port clusters could boost healthier and more profitable environments. This consortium highlighted the concept of Port Cities of the Future to redefine transport and logistics for a successful symbiose between ports and their surrounding cities. This new concept aims to achieve new forms of collaboration in port clusters to change from a transport management (Port to Port Corridor) to a network management perspective (City-Port-City). This practice aims to master the challenges of port cities environments, such as uncoordinated maritime and hinterland traffic systems, inefficient road flows to and from ports, the unexploded potential of synchromodal transport, slow climate change action in the port sector, lack of methods and instruments for the dialogue between ports and cities for the planning, execution and controlling of flows. Figure 5-2 summarizes the findings of this study. The first dimensions in which these six ports were interested to stand out were defined: efficiency, intermodal integration, compliance/responsibility, security, and sustainability. For each dimension, one to three action lines were identified as essential for this future port city. Finally, an innovative system/concept/solution based on disruptive technologies was conceived to meet each action line´s objectives fully.

The participation of the commercial group in the interview process was less representative than the ones from the physical and authorizing groups. The interviewees were reluctant to provide further contacts due to the data protection requirements implicit on the commercial relationship with their customers from whose cargo is transported. Nevertheless, examining Sustainability Reports made identifying some companies moving their cargos through IW possible. Only one of the companies contacted was willing to participate in the interview. The requirements of this single representative of the commercial group were significantly more stringent than the other participants regarding how information should be shared and the selected questions willing to be answered as information was categorized as confidential due to its competitive advantage over market competitors. The exchange was appreciated as it provided more understanding of the role of shippers and consignees using the IW. This company provided insights from both perspective as shipper and consignee, as it also organizes the transport of final products and raw material through IW.

Nevertheless, from the interview, it was realized that the commercial group would mostly be producers or merchant companies whose core business is trade. Thus, to concentrate on their main activities, they outsource transport services to the organizing group (forwarders) under agreed service levels and rely on the entire organization, execution, and control of the transport to them. Thus, it is not expected that the commercial group will be an actual beneficiary of the eT&T system in operational terms. Therefore, the low representation of this group in the interview is sufficient for the study.

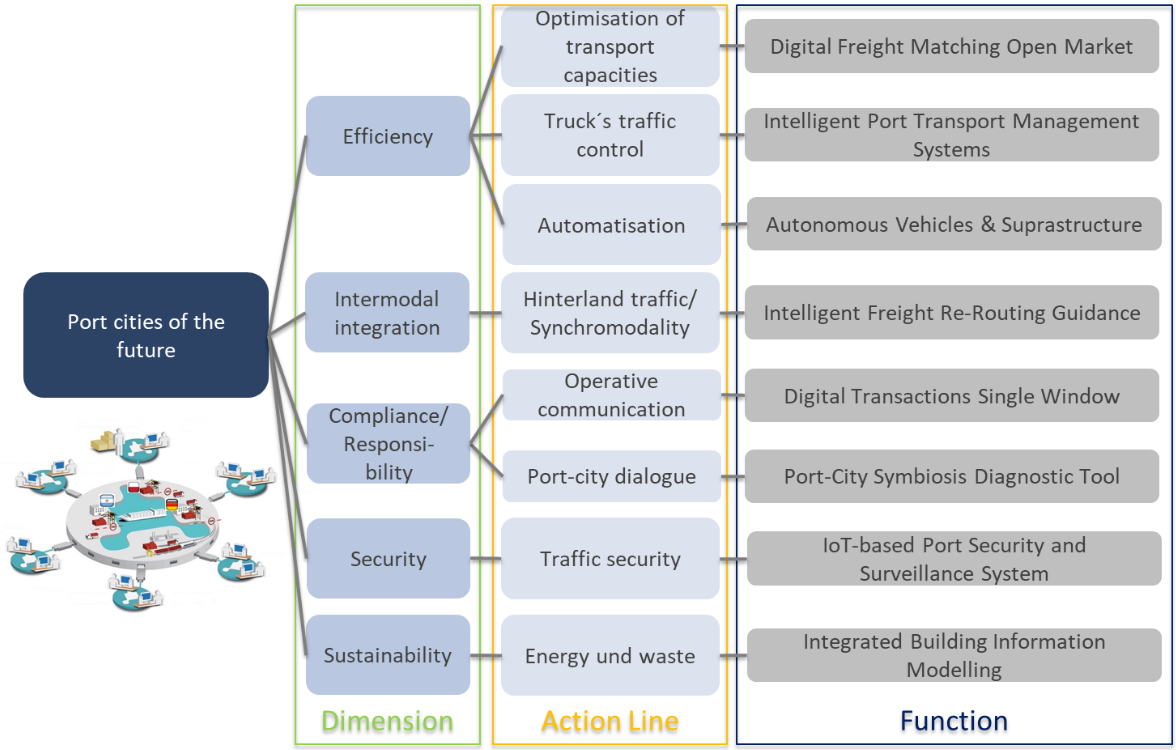

Figure 5-2 : Transport and logistics in the symbiosis of port city of the future (Szymiczek et al. 2019)

Finally, one lobbying organization complete the expert group, providing a strong data source with legal, social, technical, and scientific insights. The resulting final composition of the expert group allowed the study a better understanding at all levels: operative, administrative, commercial, political, and societal, as in Table 5-1. In the additional interviews, one more lobbying organization and one research institution participated in complementing with more insights on the political, societal, and scientific level.

Interview group	Level of insights
Commercial group	Business level
Physical group	Operative level
Authorizing group	Administration level
Lobbying organization	Political and societal level

Table 5-1 : Level of insights won through experts in each player group

5.2. Design of interview instruments

For the interview instrument´s design, the analysis unit is determinant. As defined in section 1.3, the unit of analysis was identified as the perceived benefits and impediments linked to the implementation of eT&T. Given the exploratory nature of this study, the information gained through interviews should be maximized. An open structure level in the questionnaire would allow the interviewees to share all their experience, knowledge, and opinions. Nevertheless, the interview should be done in a limited time, and data should be compared to formulate new propositions based on consistent findings. For the triangulation process, this comparison is also essential. Therefore, considerable control of the response flow is imperative, "clear questions, open answers". Thus, a *level 7* for half-structured questions was selected as the most adequate for the abovementioned purposes.

Figure 5-3 explain the structure-level selected for this study. On this scale, level "0" correspond to full open questions such as questions about personal opinions and level "10" correspond to high structured questions such as yes/no questions. The selected level "7" allow questions to address specific issues but a significance freedom to gain new insights.

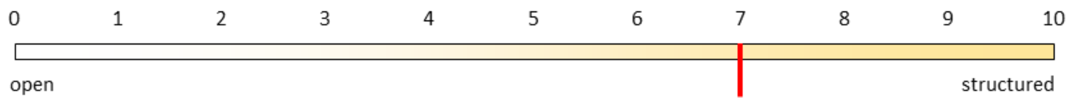

Figure 5-3 : Structure level of the questions formulated for the interviews

Once the structure level for the questions is defined, further factors should be specified. Table 5-2 describes these factors named *characteristics and manifestations* of expert interviews according to (Bortz and Döring 2006). Fields colored highlight the selection for this study. As explained, the questions will be formulated with a half degree of standardization and the interviewer takes a soft authority being open to new inputs from experts. Finally, the interviews are characterized by a classic setting as a single in-person interview.

Question structure-level	**Authoritarianism of the interviewer**	**Type of contact**	**Number of Interviewees**	**Number of Interviewer**	**Function**
structured	hard	written	single interview	single interviewer	detecting
half-structured (level 7)	neutral	telephone	group interview	tandem	mediatory
non-structured	soft	personal	survey	audio	

Table 5-2 : Characteristics and manifestations of expert interviews using (Bortz and Döring 2006) reference

Thematic blocks

The interviews are based on a tripartite guideline consisting of an introduction, the main part and closing remarks.

The main part is broken down into three individual subject areas. The selection, sequence and design of the thematic complexes and key questions were made in accordance with the recommendations of macro and micro planning from section 4.1.

The introduction begins with greetings and the presentation of meeting participants. In this way, it should originate a friendly atmosphere where both interviewer and interview better know each other´s backgrounds and functions. The clarification of interview´s objectives should help to refresh interview´s targets and keep the focus as it helps the interviewee to understand the interviewer interest while increasing process´s transparency. The introduction is then followed by the main part with the key questions catalogue.

The key questions catalogue is articulated on theme complexes. Under each theme complex the questions related to a specific thematic are clustered. The company or organization should be introduced on theme complex 1: *Business/Tasks*. For this purpose, core business and companies' products, authorities tasks, and services of lobbying and research organizations, respectively, are inquired. Further questions about the location of offices and clients should give an idea about the geographical action radio of the organization. Last question on this theme complex should give a smooth transition into second theme complex.

The second theme complex: *Logistics processes / Challenges,* has as its primary objective to get insights about the logistics and transport processes of the company and their challenges. Questions about the planning, organization, execution and control of logistics and transport processes should allow a deep understanding of the characteristics of the complete chain of each company. Further questions related to the transport unit reveal the smallest unit that could be traceable by the company. Once information about processes and products is clear, questions about the different partners in the chain are addressed by inquiring matters about data exchange. The second theme complex for physical, commercial, and authorizing groups finished with an open question "What are the problems related to the processes recently discussed?" This is a question where the experts are asked about their opinion. It makes it possible to wrap all information collected before the interview moves forward to the following thematic complex. In the case of lobbying and research organizations, questions in this thematic complex are limited to their opinion about known problems from their members or clients in the IW sector related to transport and logistics processes as they are not involved in any cargo movement.

After the company portrait and general logistics and transport processes are discussed, the third thematic complex, *Tracking and Tracing,* gets into the details of the cargo traceability. It begins with an open question about the interviewee's perception of the grade of visibility of their chain. Then the smallest transport unit that could be traceable is defined, and what transport-related data is shared with partners. Technical questions about IT-Systems, data formats, and exchange channels used to exchange related T&T data are requested. Answers to next question should provide a picture of the level of automatization of the administration of this T&T data. Last thematic complex finalizes by seeking the expert´s perception about challenges related to the acquisition, administration, and sharing T&T data.

Introduction
Greetings and participant´s introduction Clarification of interview´s objectives

Key questions catalogue		
Thematic complex	**Nr.**	**Key questions**
Theme complex 1: Business / Tasks		
Theme complex 2: Logistics processes / Challenges		
Theme complex 3: Tracking and Tracing		

Closing part
Declaration of consent for the public acknowledgement of participation and interview data treatment and use Authorization to send the protocol or the transcription of the interview Closedown

Figure 5-4 : Structure of questionnaire guidelines for interview with experts

The interview concludes with a closing part where the interviewee is recalled about the intended use of the data collected. After consent, approval to send the protocol or transcript is agreed upon. In the end, the closedown of the interview takes place. Figure 5-4 depicts the structure of the questionnaire guidelines explained above.

Several variations of the questionnaire guidelines were developed. As experts in companies from different player groups were intended to be interviewed, a customization of the questions was mandatory to improve acceptance and understanding of the questions. For example, the question “Describe your typical waterway transportation process from point A to point B.” posed to carriers is inappropriate in this textual form for terminal operators as they do not carry cargo but tranship it on their terminals. Thus, this customization process of the questionnaire guidelines yields five (5) customized versions for carrier and freight forwarders, terminal operators, shippers and consignees, port authorities and inspectors, and lobbying and research organizations. All five customized questionnaire guidelines versions can be found in Appendix F. The number of questions per questionnaire guideline varies between 17 to 19 for the groups of carrier and freight forwarders, terminal operators, port authorities, and inspectors. The most extensive questionnaire guideline is for the shippers and consignee group. Additional questions, such as client location, product, order frequency was formulated for this group to foster market and last mile delivery conditions. The shortest questionnaire guideline is for lobbying and research organizations, with only seven (7) questions. This last group is not directly involved in the transport operations and has technical issues outside its core domain.

As a discovery-oriented interview, open-ended questions allow enough space for interviewees to contribute with their insider perspectives. None pilot studies were performed, such as a test run, as the interviews were addressed to experts. It would not be practical to lose limited research participants and their valuable information and time with test questions. Better than this, work colleagues from different backgrounds in the project Smart Track 4 Waterway checked and commented on questionnaire drafts.

5.3. Expert interviews and technical study visit

Before the interviews, different sources of information about the company and its activities on the interview themes were collected and examined, such as company websites, corporative annual and corporate responsibility reports, published articles, media interviews, and other official publications. These data sources were complemented with company documentation and systematically organized on a database. Undoubtedly, the interviews served as the primary source of information. Indeed, the multiplicity and variety of information sources described above aim to comply with the research´s validation strategies to increase plausibility, credibility, and coherence of results explained in section 1.5.

Almost all interviews took place in the interviewee´s offices, offering access to company resources, a view to operational field, and access to additional interviewees participants in a comfortable environment for the participants. In addition to the interviews, a study visit consisting of a tour around the terminal facilities on foot into an inland port terminal led to a comprehensive insight into the daily operations and implementation degree of systems such as T&T to provide cargo visibility in IW systems. Appendix G presents all reports of the expert interviews (11) and the study visit (1). Reports of additional interviews do not need to be added as they did not follow such structured guidelines as expert interviews. Their reports are, nevertheless, part of the study database, and inputs considered in the analysis.

6. Proposition of benefits and brakes out of expert interviews

Chapter 6 introduces the first results of this research study by presenting the first proposition of benefits and brakes gained from the expert interviews to implement enhanced T&T systems for more sustainable operations in the IW. The chapter begins with the characteristics of the content analysis performed to achieve these findings in section 6.1. Section 6.2 introduces the benefits of eT&T and section 6.3 the brakes on implementing such systems. Each benefit and brake are fully described, and both sections finalize with Tables 6-1 and 6-2, summarizing the findings. Benefits were assigned to categories to build additional layers for the analysis. Chapter 6 ends with section 6.4. Critiques and quality criteria of selected method. This section evaluates the trustworthiness of the content analysis results. This reflective exercise intends to promote criticism and evaluation of the work done.

6.1. Content analysis to expert interviews data

As explained in section 1.3, the unit of analysis is the perception of benefits and brakes linked to implementing an enhanced tracking and tracing system from the point of view of different stakeholders in the IWT and current or potential customers.

The content analytical process model introduced in section 4.2 was followed for the content-analysis, and steps were repeated several times to maintain the quality and trustworthiness of the analysis. The analysis schedule began by reading through interviews and study case reports to obtain a sense of the whole before breaking information into smaller meaning units containing the insights being searched. Each meaning unit was then labelled with a code, getting at the end a coding list. As we allowed the topics to emerge from the raw data, the coding list was revised, extended, and modified several times until a final list was achieved. A process of distancing during the analysis was also conducted to filter unnecessary information from valuable one. Further, relationships between topics were proofed to interpretate and get new findings.

Several categories and sets were identified during the analysis to enrich the interpretation process by identifying relationships. Some categories are set up on a deductive approach, others in an inductive way. During the analysis, a list was developed with the meaning of each category to minimize cognitive change during the content-analysis process.

Findings were then analysed for each interview/case study and across different interviews to shape a general description.

Finally, data were coded into spreadsheets to get a database and verify if experts expressed the same ideas in similar or different ways. This practice made the process transparent, from raw data to results, while ensuring analysis´s quality. After a list of benefits was achieved, relationships between topics were proofed to group them together to summarize findings.

Through the exercise, we identified topics that were expected from the theoretical framework, other that were surprising and not anticipated, and unusual topics that turned our attention to unique perspectives and expand the understanding of the research theme to other dimensions. Ethical principles to report multiple perspectives were followed, even contrary findings introduced in section 1.8 were maintained.

6.2. Benefits of enhanced Tracking and Tracing Systems

This section presents and thoroughly explains the benefits of enhanced Tracking and Tracing Systems from the analysis of expert interviews. Benefits are coded as "BE" followed by a natural number to create a unique reference throughout the document. Numbers given to benefits do not express any weighing measure but a singular reference on the list.

BE-1 Increased resilience of IWT through the system´s availability with the implementation of a mobile network for enhanced T&T

In several interviews, the use of websites offering Tracking and Tracing data for vessels like MarineTraffic and Vesseltracker were mentioned. Their services are based on the information broadcasted by AIS devices on board vessels. AIS integrates a standardized VHF transceiver with a positioning system such as a Global Positioning System receiver for tracing vessels. However, information about a vessel is only available when the AIS device is on, and an AIS receiving station is located nearby to transmit the data. When these conditions are not met, broadcasted T&T data has gaps. Introducing an enhanced Tracking and Tracing system for the cargo would demand a second technology. Then mobile network and intelligent mobile devices (smart phones) connected to cloud applications offer a highly suitable solution. Implementing Mobile Cloud Computing (MCC) for cargo tracking operating parallel to AIS would increase system availability without redundancies. If information from one technology is not available, the second technology can offer complementary information to minimize the adverse effects of information gaps.

BE-2 Improved reaction upon transport alterations through automatic notification of ETA deviations

Without a doubt, the value of the enhanced Tracking and Tracing systems for terminals operators is not the availability of continuous information about where the cargo is; but the possibility of obtaining reliable Estimated Time of Arrival (ETA) (Beplat in personal communication on 09 September 2019). It is essential for terminal operators to better plan resources at the terminal and for forwarders to better synchronize follow-up processes such as on-carriage transport. Terminals such as DCH require vessel operators to pre-notify their arrival to the terminal 24 hours ahead. In the case of deviations from this pre-notified arrival time, terminal operators rely on the vessel operator, who should communicate this. Unfortunately, it was several times expressed that it is common that the terminal workforce expects the vessel to arrive at the communicated time but then realizes ETA will not be met. This delay or missing information poses challenges for terminals as resources for serving calling vessels should be re-located and downstream processes re-planned.

BE-3 New automatically triggered reservation for vessels and cargo-customized services when arriving to terminals

In a study of the University of Rostock it was found out that real-time traffic information about arrival status of ferries in the Baltic Sea could improve not only operations related to vessel services (staff mooring and berths allocation) but as well already planned services for the cargo being transported by these ferries to be loaded/unloaded on the ports. Such information can be shared with affected parties to reduce the chances of a situation-based rescheduling (Vojdani 2019). Nowadays, this information is transmitted via e-mail or telephones. An enhanced Tracking and Tracing system could support the deployment for new automatic triggered reservation system of services for vessels and cargo based on real arrival-times. This will from one side, release vessel operators from registration processes by automatically communicating structured digitalized data that can be right-away shared with downstream actors. On the other side, pre-scheduled capacities for e.g., the further transport of transhipped cargo or container repair services, could be better deployed.

BE-4 Cost savings due to unnecessary reserved capacities

Access to real-time arriving data could facilitate the implementation of digital freight matching open markets for the better utilization of transport capacities on the port surroundings. A digital freight matching open market (DFMOM) is an open transport planning and sharing platform for real-time sharing of available transport capacity as well as a collaborative environment matching offer and demand on real-time to better allocate transport capacity both for short-haul/hinterland and longhaul/ cross-border freight delivery (Szymiczek et al. 2019). The use of such open collaborative environments (or marketplaces) for sharing and matching available transport capacities with transport needs is not yet depleted. The reasons for this situation are multiple and range from the lack of flexibility and dynamism of past experiences in this area up to missing such systems services to provide DFMOM tools with the necessary real-time input data about cargo arriving or leaving an inland port. Enhanced Tracking and Tracing system can provide such a data and makes possible an “Uberization” of the sector.

BE-5 New services of automatically triggered reservation for lock passage

Nowadays, information from arriving vessels to locks is transmitted by the vessel operator himself, who contact the lock operator to communicate via e.g., radio or telephone, his passing intention. Due to the divergent dimensions of the vessels, different locks configurations (e.g., one chamber or two) and the different times of vessel-arrival at the locks, it is difficult for the lock operator to provide an optimal passing-schedule. This leads to waiting times for all vessels when considering a single lock. When talking about complete routes, it is difficult to estimate the travel times of the vessels on canals and rivers with locks, especially over river segments with several ones. The fluctuating volume of ships on the one hand, but also the prioritization of passenger ships and ferries at the locks on the other hand makes it difficult to predict the duration of lock throughput disturbing the planification of arrival times to destination ports. This last phenomenon causes waiting times that limits and increase the cost of handling (Klassen on personal communication on 01 January 2019). For example, the route of transport of the ships downstream from France and Luxembourg shows considerable fluctuations since there are 28 locks on the Moselle and a maximum of 48 long ships could go through one lock in 24 hours. Though any cargo transhipment takes place on locks, as complete vessels are going through, push notifications of an enhanced Tracking and Tracing system could support the automatically data sharing of vessels approaching and alleviate this situation. Further, by confirming check-in times at locks, the speeds of the vessels can be adjusted what offers possibilities for reduction in fuel consumption.

BE-6 Savings in terminal operations through optimized cargo movements and better yard occupancies

Real-time information about exact ETAs to terminals at cargo level have as potential benefit the better arrangement of terminal procedures, leading to important lead time reductions and improved cargo safety and security. Thus, close surveillance of cargo movements and status throughout terminal facilities is improved thanks to information about time of arrival, clearance status and expected departure time for each cargo unit. Further, enhanced Tracking and Tracing data can support the implementation of geo-fencing features to push alerts in the system when cargo is entering or leaving specific geographical locations pre-defined by the organizing group. Such a functionality allows the identification in real-time of the actual responsible player based on the location of the container (Boile and Sdoukopoulos 2014). Further, it is expected that cranes movements, onshore cargo handling means, and yard occupancies could be improved with the management of cargo tracking data to reduce restowages. Nowadays, vessel operators decide on technical requirements, experience and route plan the stowage plan of cargo in the vessel. This stowage plan is maintained by the vessel operator and can be changed from terminal to terminal over the planned route. Unfortunately, there is no synchronization between stowage plan and the planned container handling at terminals, which reduces the terminal productivity in approximately 30 % (Stolte on personal communication on 12 May 2018).

BE-7 Improved coordination of multimodal chains, especially vessel-train transshipments

As expressed on the expert interviews, coordination challenges arise when cargo from multiple modes of transportation needs to be consolidated (Selbach on personal communication on 4 June 2018). Problems emerge when one mode of transport arrives faster than the other one. If a ship must wait for a train, demurrage charges must be paid. Vice versa, when a vessel is delayed and a train is waiting for cargo in this vessel, the train will block a track during this time. Enhanced Tracking and Tracing systems could reduce the negative effects in both situations, allowing players to re-arrange travel based on real-time data of cargo location. This could, support decision making to adjust the speeds of the vessels or trains and reduce fuel consumption and keeping, if possible, places free for productive operations instead of idle times.

BE-8 Performance metrics for the evaluation of port terminals

For port authorities and terminal operators, one of the most efficient tools to analyse and improve performance is the implementation of metrics to evaluate operations and business. Quantitative measuring of port activities is of great importance for the continuously improving terminals. The results of such evaluation could provide quantitatively measurable and comparable performance metrics that creates seamless advantages for terminals as a unit, port authorities where they are settled, and regions as follows:

1. It allows an objective evaluation of each terminal´s efficiency and, therefore, the comparison between terminals. Just from the economic perspective, e.g., carriers and shipping companies will re-configurate their lines to visit terminals with high handling speed as time is money,

2. It makes possible for port authorities to compare terminals settled on their premises and evaluate the productivity of the concession infrastructure, and
3. It promotes the transparent comparison of ports among regions, which could be used for the identification of strengths and weakness of each one in terms of cargo handling, connectivity, and season performance, among others.

The United Nations (UNCTAD 1976) and the World Bank (Chung 1993) were the first organizations to define a set of performance indicators for port management. Nevertheless, due to the absence of industry performance measurement standards (Esmer 2008), different data and methods are often used to produce their estimations making a systematic comparison difficult. To tackle this challenge, (Chen et al. 2016) developed a port performance analysis framework to derive port performance indicators based on vessel location traces (GPS, AIS) and ports open data (Marine Cadastre Project, MarineTraffic API). This approach relies on the fact that key performance indicators of ports are directly related to the handling events at terminals, especially the number of ships that arrived at terminals and the quantity of cargo handled by terminal facilities in a period (Chen et al. 2016). Nevertheless, for calculation of handling quantities of cargo, estimations were compulsory as no directly available data from AIS or open data sources are available for this purpose. Thus, an enhanced Tracking and Tracing system that makes possible to trace cargo movements would definitively provide systematic data for the objective calculation of performance metrics based on cargo real data.

Examples of performance indicators that would be possible to calculate and widely evaluate port efficiency are according to terminal operating systems developer (Octopi 2016):

- Voyage productivity: measures the speed for loading and unloading in moves per hour. Indicator about how fast the terminal handling cargo is,
- Cargo dwell time: measures how long a cargo unit stays at the terminal. Indicator about the utilization of port terminal yards, and
- Cargo traffic: measures the amount of cargo unit going through the terminal at a given time (day, month, or year).

Further, measurement of port performance from user´s perspective could enhance this framework allowing the evaluation of following aspects, according to (Vaggelas 2019):

- The efficiency of rail services,
- The efficiency of road services,
- Availability of online information,
- Availability of real-time information,
- Level of accuracy of information provided to customers, and
- Port security level

Enhanced Tracking and Tracing could also be used on a singular line basis to generate target-performance comparisons of routes (Möller on personal communication on 20 August 2018), mode of transport, carrier, or facility with verifiable audit trails.

BE-9 Increased automatization level of data exchange through format-standardized transport data

The mark of combined transport that characterizes supply chains with participation of the IWT is a complex system due to the multiple interfaces between different infrastructures, handling methods, legal frameworks, and a plethora of players with different interests that lead to multiple own definitions of their requirements for data exchange. To make it competitive and profitable, "the provision and exchange of necessary information for transports in combined transport, based on a standardized data basis, are the foundation for secure, efficient and cost-saving transport" (DIN SPEC 91073). Nevertheless, a standard for this purpose did not exist bevor year 2018 when the German Institute for Standardization (DIN) published the Norm DIN SPEC 91073 *DIGIT – Standardization of data exchange between all stakeholders of the intermodal transport for efficient communication in digital future*.

The DIN SPEC 91073 stipulates a modular data structure that presents all information generated in combined traffic in a standardized manner. For this purpose, uniform formats, semantics, and syntax for data exchange in combined transport are defined. The norm specifies what data fields should be completely available at the respective transport stages.

The lowest level visualizes the cargo unit process status. In principle, this status can be displayed neutrally and independently of the status of the respective mean of transport. The cargo unit status describes the unit condition at a particular time. This information should be known to all involved and is an ideal way to exchange information at a specific time. For example, the data field for the registration and information exchange of the estimated time of arrival of the transport mean to the transhipment point, commonly known as ETA, should be standard codified as "VM.Avisiert" (TM.notified). Another example is at the cargo unit level, when the cargo unit is secured and has been loaded into the transport mean, commonly known as ready for transport, this data should be standard codified as "StatusLE.Ausgangskontrolle" (StatusCU.Exitcontrol) when registering and exchanging this information along the complete chain (DIN SPEC 91073).

Across different expert interviews could be observed that the need for digitalized channels for the exchange of data concerning cargo status makes it impossible to implement automatic notification mechanisms. Furthermore, if they were possible, the missing standardized formats make it difficult to achieve a wide sharing. Port terminals are contacted via fax or telephone with information about the products to be unloaded, the vessel, and ETA. This information is then register manually on stand-alone company's information system and not shared with other parties. It happens at each terminal over the route, and this means analogue communication leads to manual data introduction each time.

Similarly, it could be identified across several expert interviews that the vessel operator is contacted via radio or telephone when it is necessary to prove the transport status. It also means the manual introduction of this information on stand-alone systems and possible communication to other chain players (e.g., cargo shipper) through unstandardized ways. The experts then perceive an enhanced Tracking and Tracing system as a valuable tool for tackling this challenge, and simultaneously, open opportunities to implement less complicated than EDIFACT messages formats for the data exchange on the IW scene (Hanke on personal communication on 06 June 2018).

BE-10 Shift from a pull to a push communication method

Selecting how the data transfer system should operate, with a pull or a push communication method, will have important effects on the system design and the performance of activities triggered by this information. Out of the interviews, most companies share information about the transport status using a pull communication method. So, when one party needs information about the status of the transport, it requests it from its TMS or another party and, in turn, gets the desired data. If a consignment is not arriving when expected, then enquiries are made to know why. It implies: 1. a player should first notice this situation what could mean it is already too late to react, and 2. The information reaches only the party who enquired, but no other parties, as the request action is the deciding factor for the data transfer leading mostly to multiple bilateral communications. Shifting to a push communication method where data is transferred without a prior request, information can quickly reach a large pool of parties. Pull and push methods have disadvantages for Tracking and Tracing services. On a pull communication method, the limited amount of data, only available when demanded, makes it challenging to have a complete and timely picture of the transport status. On a push communication method, instead, the amount of pushed data could overload the recipients and their systems with excessive data traffic. A published/subscription mechanism could be adopted to prevent such an effect, where one party transfers the transport status data to a data pool or repository, which pushes the data to other parties who have previously subscribed to receive this data (GS1 2017). Furthermore, filters could be utilized to receive only the data needed by the interested party.

BE-11 Time and costs savings when tracking substantial amounts of small consignments from multiple cargo owners

It can be concluded from the expert interviews that players in the organizing and physical groups need exact information about status, arrival times, delays, or other events that require a reaction. Thus, they rely on information about the transport (vessel´s ETA, ATA, ETD, ATD at terminals) and cargo (gate in and gate out at terminals) status that is usually gathered manually from several sources (websites, telephone, etc.). Not having access to reliable, complete, up-to-date, valuable, and understandable information makes a good planning difficult leading to costly mistakes.

In October 2019, the Port of Rotterdam launched the application *Boxinsider* that allows shippers and freight forwarders to see where their containers are located at any given moment from a single source, eliminating the manually search and retype of container event data. According to the Port of Rotterdam, *Boxinsider* can reduce time for tracking containers by 20 to 50 % (Port of Rotterdam 2019).

Nevertheless, such costs savings could be negligible in the case of bulk cargo. In this cargo sector, full shipload is common, and forwarders could have up to 98% of their transports from one consignor to one customer on this basis.

Thus, time and costs savings can be tangible for multiple consignors' owners of a shipload. It is the case, for example, of the new delivery concepts for city logistics using inland waterways presented in section 2.3 like Beer Boat of Utrecht, traveling six times per week, to supply more than 60 catering businesses on the city centre with beer and beverages.

BE-12 Competitive advantage for each player resulting from new customer-oriented services through enhanced T&T

From a technical point of view, the transport through inland waterways as a product does not offer a high marge for product innovation. A vessel will always travel from terminal A to terminal B through nearly current stages and processes on IW transport modality Therefore, inland waterway companies should invest in service differentiation to gain competitive advantage (Berger on personal communication on 20 August 2018). Consequently, instead of services being add-ons to the transport product, they should become the centre of the total offering, with products as add-ons to the services (Gebauer et al. 2011).

Organizing and physical group players working together with customers of the commercial group to develop a tailored solution of enhanced Tracking and Tracing promotes the creation of services challenging to imitate. The collaboration increases the probability of keeping the customer-service provider relationship longer as resources (time and knowledge) from both sides strengthen the relationship and makes the customer to think twice before beginning from cero with a new provider.

It was concluded through a study, that customers integrating with the tracking systems of the logistics service providers potentially tie the customers to the providers (Janah and Wilder 1997).

For the customer, accessing real-time status data about their cargo being transported could also positively affect inventory reduction strategies. It can be explained similarly to the bullwhip effect, as information can significantly reduce process variability by reducing uncertainty (Chen et al. 2000).

Another competitive advantage for users of such an enhanced Tracking and Tracing systems is the possibility to manage the following information about cargo transport processes such as: duration in terminal, duration in transport, duration in stevedore companies, and duration in intermediate stages (re-working, consolidation, among other). This information makes it possible to trace and accumulate costs to each transport process in a process costing fashion. This information can be valuable for the economic performance evaluation of running service contracts and for the more accurate price calculation and services definition of new ones (e.g., transport offers).

Further, administration of transport data from enhanced Tracking and Tracing systems provides business with big data for the implementing advance analytics and artificial intelligence technologies for decision-making. For example, by tracking location together with weather conditions, and historical traffic patterns, the physical group could evaluate through IoT sensors if a shipment of refrigerated goods is at risk for equipment failure and then automatically reroute delivery to a closer distribution centre or proactively dispatch a repair crew to prevent spoilage (Stackpole 2020).

BE-13 Improved conditions for shippers with smaller cargo volumes to use IWT

IWT is traditionally related to transporting large shipments with one (full shipload) to few cargo owners per vessel. This assumption makes IWT unattractive for shippers with smaller cargo volumes. Many conditions discourage this new market from shifting its cargo into IW:

1. It is difficult to find carriers in the IW willing to handle Less-than-Load (LTL) shipments as the workload for the organization, execution, control, and accounting significantly increases with the number of customers.
2. It is more difficult to consolidate shipments with several types of commodities on a vessel and optimize capacity utilization while respecting technical and security constraints.
3. Transport services pricing becomes challenging as the transport costs should be allocated to several customers with different cargo and contractual relationship characteristics.
4. Less-than-shipload customers fear their shipment will be prioritized than full-shipload shipments.

Generally, companies performing full-shipload shipments celebrate contracts for regular service, winning a position upon the carriers. This prioritization could be reflected not only on the prices per volume but as well on the transit times.

Carriers aiming to explore and succeed in business in the Less-than-Load market segment could mitigate the abovementioned discouraging issues by offering enhanced Tracking and Tracing services to these customers. From one side, the communication costs of possible transport deviation of multiple customers can be reduced with this automatic traceability system that allows tracking up to the packaging unit level, such as pallets and big bags. Second, this could increase the number of customers interested and facilitate the task of getting enough volumes for consolidating cargo with different commodities on vessels. As transport services pricing becomes challenging for LTL, allocation of enhanced Tracking and Tracing technology becomes more accessible among several parties. Forth, the impression that LTL shipments will be handled as low priority can be mitigated by sharing transparent transport status data through enhanced Tracking and Tracing systems.

BE-14 Prompt identification and location of points where cargo volume discrepancies occur

The risk of cargo theft has increased in recent years (Szymiczek et al. 2017). Even though the risks of theft over rivers and canals in the focus region are low (Chief Police Officer Holler on e-mail communication on 22 Mar 2020), according to the German Federal Office for Freight Transport (BAG), border regions and the surrounding area of large ports are particularly affected by cargo crime. The Transported Asset Protection Association (TAPA) reported an increase of 114,7 % in cargo crimes in 2019 with losses exceeding 137 million EUR (TAPA 2020). Most stolen products have a significant market value and a large target group and are available in portable formats and weights. Generally, trucks are the biggest target for cargo thieves as professional bands take advantage of insecure parking areas visited by truckers to assault drivers. The number of losses has pushed ambitious plans for equipping truck parking areas with surveillance equipment and process to counteract this tendency on the roads.

An enhanced Tracking and Tracing system could, in large dimensions, help to avoid cargo theft in the IW, especially in the mentioned transhipment points, in a proactive way, discouraging criminals and, reactively, providing historical data about the cargo status for investigations. Further, the implementing eT&T in the IW creates favourable conditions for the rise of high-priced and sensitive cargo over canals and rivers. It demands instruments such as eT&T for a more secure handling.

Several technologies are being deployed to monitor assets such as RFID, video surveillance, GPS, and mobile computing solutions. Nevertheless, each carries a disadvantage. GPS, for example:

1. Trace the vehicle but not the product,
2. Full chain coverage of multimodal chains with multiple transport providers is problematic from a technical as well administrative point of view, and
3. Cargo from LTL shipments cannot be tracked. Containers might be tracked, but there is no way to confirm whether a specific pallet/box is in the container.

By tracking the cargo and not the vehicle with an enhanced T&T system, tracking through multimodal chains can be boosted, avoiding cargo theft, pilferage, adulteration, or the infusion of counterfeit products in shipments.

BE-15 Increased transparency in the demonstration of compliance with dangerous goods transit times

Dangerous goods can damage people´s health, cause fires or explosions and/or damage the environment. Therefore, handling dangerous goods is subject to stringent norms ruled through the European Convention Concerning the International Carriage of Hazardous Goods by Inland Waterway (ADN) mentioned in section 2.2. According to this convention, transit of dangerous goods in terminals should be less than 24 hours. Enhanced Tracking and Tracing systems could support the compliance of this rule and the automatic generation of protocols for certification of processes.

At the end of section 6.2, out of expert interviews a total of 15 benefits of enhanced tracking and tracing systems for more sustainable IW were identified and assigned to categories and set of categories as in Table 6-1.

A first category set should allow us to assign the meaning unit (perception of benefits) to one or more of the sustainability dimensions (economic, social, and environmental) introduced in section 3.1.2. This is, to which sustainability dimension(s) does the identified benefit contribute for. A second category sets the player group (commercial, organizing, physical and authorizing according to section 2.1.2) that profits the greatest from this benefit. These two first categories emerged in a deductive way from the theoretical framework. A third category and sub-category should stablish at which level do each benefit has an impact (business, administration, operative, political, societal, and scientific) and an additional sub-category explaining how (transparency, security, reliability, timeliness, and efficiency). This third category and sub-categories emerged out of the interview analysis in an inductive way. The last set of category and sub-category introduced in section 3.1.2, should identify the opportunities for value creation opened thanks to this benefit.

Benefit Nr.	Benefit	Sustainability Dimension	Player group relevance	Impact level	Impact dimension	Areas for value creation	Opportunities for value creation
B-1	Increased resilience of IWT through the system´s availability with the implementation of a mobile network for enhanced T&T	Economic and environmental dimension	All	Operative	Reliability	Risk management	Operational risk management
B-2	Improved reaction upon transport alterations through automatic notification of ETA deviations	Economic dimension	Commercial and physical group	Operative	Timeliness	Risk management	Operational risk management
B-3	New automatically triggered reservation for vessels and cargo-customized services when arriving to terminals	Economic and environmental dimension	Physical and authorizing group	Operative	Efficiency	Growth	Innovation and new products/services
B-4	Cost savings due to unnecessary reserved capacities	Economic and environmental dimension	Physical group	Administration	Efficiency	Return on capital	Sustainable processes
B-5	New services of automatically triggered reservation for lock passage	Economic and environmental dimension	Physical group	Operative	Efficiency	Growth	Innovation and new products/services
B-6	Savings in terminal operations through optimized cargo movements and better yard occupancies	Economic and environmental dimension	Physical group	Operative	Efficiency	Return on capital	Sustainable processes
B-7	Improved coordination of multimodal chains, especially vessel-train transshipments	Economic and environmental dimension	Physical group	Operative	Efficiency	Return on capital	Sustainable processes
B-8	Performance metrics for the evaluation of port terminals	Economic and environmental dimension	Physical group	Operative	Transparency	Risk management	Regulatory management
B-9	Increased automatization level of data exchange through format-standardized transport data	Economic and social dimension	All	Administration	Efficiency	Return on capital	Sustainable processes
B-10	Shift from a pull to a push communication method	Economic and social dimension	All	Administration	Efficiency	Return on capital	Sustainable processes
B-11	Time and costs savings when tracking substantial amounts of small consignments from multiple cargo owners	Economic and social dimension	Organizing and physical group	Administration	Efficiency	Return on capital	Sustainable processes
B-12	Competitive advantage for each player resulting from new customer-oriented services through enhance T&T	Economic dimension	All	Business	Efficiency	Growth	Innovation and new products/services
B-13	Improved conditions for shippers with smaller cargo volumes to use IWT	Economic dimension	All	Business	Efficiency	Growth	New markets
B-14	Prompt identification and location of points where cargo volume discrepancies occur	Economic dimension	Commercial group	Operative	Security	Risk management	Operational risk management
B-15	Increased transparency in the demonstration of compliance with dangerous goods transit times	Environmental dimension	Physical and authorizing group	Administration	Transparency	Risk management	Regulatory management

Table 6-1 : Summary of benefits of enhanced Tracking and Tracing systems out of expert interviews in categories and set of categories

6.3. *Brakes to implement enhanced Tracking and Tracing Systems*

This section presents and thoroughly explains the brakes to implement enhanced Tracking and Tracing Systems from the analysis of expert interviews. Brakes are coded as “BR” followed by a natural number to create a unique reference throughout the document. As for benefits, numbers given to brakes do not express any ranking but a singular reference on the list.

BR-1 Multiple sources of disruptions in IWT (congestions, low water levels)

Even though the free capacities of the IW network are nowadays far away from the congestion levels of roads, the IWT is affected by events that cause disruptions. These events could be manmade such as delayed trains with cargo to be unloaded on vessels or natural events, such as low water levels affecting offered capacities and waterway network conditions. Other events that lead to disruptions on the IW are congested seaports at which inland vessels are due to call or missing of customs documents. The diversity of disruptions shifts decision-makers´ attention to other issues, as the relationships between eT&T and these events need to be more noticeably clear for them.

BR-2 Potential users would rather prefer single tools with information for multiple transport modes

Interoperable and interconnected solutions for managing multimodal transport are vital for improving the performance of the complete chain. Several traffic management and information systems has been developed for freight transport which could be classified according to (TAP) classification into freight resource management systems and applications, terminal and port information and communication systems and applications, freight and fleet tracking management systems and applications, and integrated operational/information exchange platform/portal/marketplace (TAP 2000). Each of the operators in each transport modality may have different ICT systems or applications in the abovementioned categories, focusing on companies' particular individual needs, what makes interconnections between them difficult. Each new application implies more costs (acquisition, training, maintenance, personal costs to operate) and elevates the complexity of the processes. Thus, integrated end-to-end systems have a significant advantage compared to stand-alone ones.

BR-3 Uncertainty about responsibilities (who will pay e.g., demurrage charges) when eT&T information is wrong

Wrong data negative impacts go far away from time to correct the error. Bad data hurts companies' reputation, wasting time, adding considerable expenses, compromising resources based on wrong decisions, and making all downstream process more difficult (Redman 2017).

In the present age, a data-driven culture is very present and is fundamental for successfully implementation of analytics, artificial intelligence, and smart ecosystems. This monetizing phenomenon of data poses opportunities as well treats for users. Thus, many of uncertainties arise when evaluating the risk of wrong information. To assess the costs related to it, the "rule of ten" is widely applied. This rule states that "it costs ten times as much to complete a unit of work when the data are flawed in any way as it does when they are perfect" (Redman 2008). The IW sector is not free from such a risk. Thus, it is a barrier to implementing eT&T the fear of getting possible wrong information from the system and making wrong decisions based on it. Further, responsibilities about who will pay for the error increase mistrust.

BR-4 Complexity of information exchange formats

As introduced in section 2.1.6, the transport through IW is characterized by a continuous and large amount of information exchange among several actors. Operators in the IW sector manages several information streamlines for specific purposes such as wetter conditions, water levels, locks and bridges status, hazards, traffic information, vessel position, course and speed, cargo type, and cargo stowage plan (de Blic et al. 2018). In the last years, a significant number of services and systems were developed to manage the transport over IW. These services and systems still need interoperability and integration that is needed so that their applications offer a considerable level of consistency and synergy between them (CCNR 2004). Nowadays, the standards EDIFACT or XML are the most important references to exchange information electronically in form of messages in the IWT.

Nevertheless, as explained in section 6.2 (BE-9), the need for digitalized channels for exchanging cargo data in standardized formats is remarkable. It happens because many players see available exchange formats as challenging to understand, a barrier to implementing T&T due to the multiplicity of exchange formats.

BR-5 Fear of IWT operators to lose contact with customers and jeopardize loyalty as a result of "impersonal" digitalized processes

To success in business, shifting the focus from a purely economic, operational, and environmental point of view to the human element is mandatory. Without customers, there is no business and then no profit for IW players. Any organization aiming to operate and gain value over a long term must be guided primarily by customer care (Chaudhuiri and Holbrook 2001). However, identifying service-experience expectations of IW customers could be difficult as they are currently three generations of workers in the customer group (Baby boomers, Gen X, Millennials) among IW users, namely shipper and consignee in the commercial group and forwarder in the organizing group. Customers from each generation have different mindsets and therefore expectations. At this point it, satisfied customers are essential but loyal ones are even more important. Customer loyalty is defined by customer perceived value, brand trust, customer satisfaction, repeat purchase behaviour, and commitment (Punniyamoorthy and Mohan Raj Prasanna 2007). A service industry study revealed that getting a new customer cost at least five to nine times the cost of maintaining an old one (Cheng et al. 2011) It means business with loyal customers are more profitable than with new ones.

Nevertheless, offering a customer care digital service through real-time eT&T information is a complex task. Just as for e-shops, users of such a system are no longer willing to accept less from their experience with digital processes than they are accustomed to getting from personal experiences (McKinsey 2020). The convenience of using the digital instrument, customer autonomy, sense of relationship with the company or the community, and customer confidence in digital instrument determine loyalty (Skurpel 2020). Therefore, following the premise "getting it right" from the beginning is fundamental for digitalizing processes.

BR-6 Actual lack of standardized and modularized data structure for the data exchange

The theme lack of standardized and modular data structure for the data exchange in the IW was fully explained in the main legal provisions at the international level on the theoretical framework in section 2.2.2. Discussions about benefit BE-1 and brake BR-4 presented pages above, addressed this theme.

BR-7 EDIFACT messages with pre-notifications of departing times already exists for IW cargo coming from seaports

EDIFACT "comprises a set of internationally agreed standards, directories, and guidelines for the electronic interchange of structured data, among independent computerized information systems" (UNECE 2020). EDIFACT standard was mainly used on the maritime sector. Due to the interfaces between this transport mode and IW, the last one adopted the same standards. The pre-notification process could be as follows. In the case of export activities through IW, the sea terminal receives a container pre-notification via COPINO message. After the container is loaded onto the inland vessel the sea terminal receives a CODECO message that includes the time and date of the loading process.

Shipping orders are received as IFTMIN messages. The confirmation of receipt is then sent as an APERAK message. The status of the shipping order is sent as an IFTSTA message.

Regarding depot management, daily depot registrations are sent as COEDOR messages to inform customers about the number of available containers. Nowadays, EDIFACT messages are offered as an online service by seaports´ Port Community Systems (PCS) through platforms. Due to the international transport nature of seaports, this type of services is oriented to the container transport. The requirement for the subscription of this service is the integration of ERP systems e.g., TMS for the EDI exchange. Some PCSs can get this information through a particular internet version.

BR-8 Positioning of vessels already possible

The Positioning of vessels is nowadays possible through the Automatic Identification System AIS. AIS is a ship-borne radio data system that exchange static, dynamic, and voyage-related vessel data between AIS-equipped vessels and between these vessels and shore stations in both directions. The vessels can be located with this information, and their information can be displayed on a chart (position and movements) or tables (vessel´s static data). AIS is not intended to replace navigation services or radar, nor VTS, but to support them. The information transmitted by inland AIS can be divided into the following categories:

1. Static information sent every six minutes: vessel number, call sign, vessel name, vessel type;
2. Dynamic information sent every three minutes when “at anchor” and speed below three knots or between ten to two seconds “in rote”: position of vessel, ETA at locks, bridges, terminals, borders; and
3. Voyage-related information sent every six minutes: length and type of cargo.

Inland AIS aim to support onboard navigation, shore-based traffic monitoring, and calamity abatement for more safer operations in the sector. Initially, AIS had a terrestrial coverage of around 32 Km, but with Satellite-AIS satellites collect AIS signals from vessels and complete the Positioning. Further, AIS data can be complemented with earth observation data and advanced analytics algorithms to derive more value from AIS data. Nevertheless, the technology has several limitations. The most relevant for this work are incorrect information can be transmitted, and not all ships are equipped with AIS.

BR-9 Lack of a culture for visibility on the IWT

Supply chain visibility is one of the significant challenges for companies. As much as 84% of Chief Supply Chain Officers reported on a survey that lack of visibility on their supply chains is the biggest challenge (IBM 2019). Thus, transport service providers experience the increasing pressure to provide customers with this visibility to meet these expectations. However, persistent traditional ways to execute supply chains, lack of operator´s system interoperability, low adoption of digitalization, and lack of real-time insights across the supply chain are some factors that must be considered to achieve visibility in the IWT.

Table 6-2 summarizes the brakes explained above and assigns them to a category (type) as technological, legal, ethical, or organizational-related brake.

Brake Nr.	Brakes	Type
BR-1	Multiple sources of disruptions in IWT (congestions, low water levels)	Technological
BR-2	Potential users would rather prefer single tools with information for multiple transport modes	Technological
BR-3	Uncertainty about responsibilities (who will pay e.g., demurrage charges) when eT&T information is wrong	Legal
BR-4	Complexity of information exchange formats	Technological
BR-5	Fear of IWT operators to lose contact with customers and jeopardize loyalty as a result of "impersonal" digitalized processes	Ethical
BR-6	Actual lack of standardized and modularized data structure for the data exchange	Technological
BR-7	EDIFACT messages with pre-notifications of departing times already exists for IW cargo coming from seaports	Technological
BR-8	Positioning of vessels already possible	Technological
BR-9	Lack of a culture for visibility on the IWT	Organizational

Table 6-2 : Summary of brakes to implement enhanced Tracking and Tracing systems out of expert interviews

6.4. *Critiques and quality criteria of selected method*

After conducting a content analysis to the expert interviews to formulate potential benefits and brakes, this work will be submitted to criticism and evaluation in this section. This reflective process allows the readers to evaluate the trustworthiness and look for possible alternative interpretations. Thus, target of this section is to determine the most adequate concepts to evaluate the quality of the selected method. Traditionally, quality in quantitative research is evaluated based on the concepts of reliability (consistency of the means of data collection), validity (accuracy of the findings) and objectivity (independence of research findings from the researcher as a person) (Lincoln and Guba 1985; Steinke 2004; Mayring 2014). One can say, accuracy of the findings relays on consistency of the means of data collection, in other words, validity relies on reliability. Thus, without reliable research procedure, accuracy of the findings is difficult to reach.

However, qualitative researchers argue that qualitative research demands a set of criteria for quality evaluation different from the one of quantitative research (Lincoln and Guba 1985; Steinke 2004; Finlay 2006). For this purpose, (Lincoln and Guba 1985) suggested the utilization of the concepts of confirmability, dependability, credibility, and transferability. After examination of the meaning of these concepts it could be concluded that confirmability refers to objectivity, dependability to reliability and credibility to validity. The fourth concept, transferability, added a new dimension as it refers to the degree that the results may be applicable to other settings.

It can be then observed that authors, more than defining a totally new set of criteria for quality assurance in quality research, it is the target to adequate the focus of the evaluation with this criterion. (Bengtsson 2016) argue that not important are the criteria itself but how they are used in relation to "truth" and "trustworthiness" as qualitative studies are not looking for a definite "truth" that can be generalize; but for depth understanding of a specific concern to explore it from different perspectives (Patton 2002; Rolfe 2006).

A review of different authors´ point of views yields several concepts they suggested for quality evaluation of qualitative methods and how these concepts are interrelated as in Table 6-3.

	Objectivity / Confirmability	**Reliability / Dependability**	**Validity / Credibility / Internal Validity**	**Transferability / Generalization / External Validity**
Lincoln and Guba (1985)	•	•	•	•
Steinke (2004)	•	•	•	•
Creswell (2014)		•	•	•
Krippendorff (1980)		•	•	
Mayring (2014)	•	•	•	

Table 6-3 : Concepts for quality evaluation of qualitative methods according to different authors based on (Lincoln and Guba 1985; Steinke 2004; Creswell 2004; Krippendorff 1980; Mayring 2014)

All authors agree that consistency of the means of data collection (reliability / dependability) and the accuracy of the findings (validity / credibility / internal validity) are adequate criterion for quality evaluation of qualitative methods. Thus, this criterion will be used for this study. Once quality criteria-set is defined, methods that ensure quality for this criterion were collected from literature and listed in Table 6-4. Selected techniques for this study are orange highlighted. The evaluation itself is performed using the Mean Opinion Score (MOS) – Excellent, Good, Fair, Poor or Bad – grade system.

Qualitative quality criteria	Traditional quantitative concept related	Techniques to ensure quality
Dependability	Reliability	Audit: researcher´s documentation, methods and decisions
		External comparison
		Predictability check
		Construct validity check
		Transcripts checks
		Codification track
		Cross-check codes
Credibility	Validity	Member checks
		Prolonged engagement in the field
		Data triangulation
		Re-test
		Parallel-test
		Consistency check
		Detailed description of setting and mulitple perspective
		Peer-debriefing

Table 6-4 : Techniques to ensure quality of selected methods in pre-defined criteria-set based on (Finlay 2006; Lincoln and Guba 1985; Ballinger 2006; Mayring 2014; Creswell 2014; Bengtsson 2016)

Four techniques were selected to evaluate the dependability of the results from the content analysis of expert interviews: audit trail, construct validity check, transcripts checks, and track of codification.

A comprehensive audit trail (Finnlay 2006) is provided throughout the complete study to explain the several steps of the content analysis and why each decision was taken, as discussed in sections 4.1, 4.2, 5.1, 5.2, and 5.3. Thus, a subjective rate of “Good” was given to the results of this technique.

For the construct validity check (Mayring 2014), the findings were tested for plausibility confronting them to knowledge won in the introduction to inland waterway transport systems (Chapter 2), theoretical framework (Chapter 3) as well as background provided by the field immersion (section 1.4). As a result, a subjective rate of “Good” was given to the results of this technique.

For the transcript check (Creswell 2014), interview reports were verified to identify possible mistakes during transcription and were shared with all interviewees to validate and achieve better results. Feedback from experts helped to guarantee messages were clearly understood. Consequently, the results of this technique were rated as “Excellent”.

When tracking the codification (Bengtsson 2016), the coding list was several times revised, extended and modified until a final list was compiled, and all changes were appropriately tracked.

Further explanations for each code were protocolized to avoid researcher´s cognitive change during the analysis. Therefore, the results of this last technique could be subjectively rated as “Excellent”.

Three techniques are selected to evaluate the credibility of the results from the content analysis of expert interviews: member checks, re-test, and detailed description of setting and multiple perspective.

Member checking (Creswell 2014) was used to determine the accuracy of the qualitative findings by taking the results of the content analysis back to the participants so that they could determine if they were accurate. It was performed through a presentation during the participatory-creative workshop (section 7.2). Participants agreed with the results of the content analysis. Nevertheless, the subjective evaluation was rated as “Fair”. It was necessary to present interview results compactly, due to the time constraints of the experts.

Re-test (Mayring 2014) was done by repeating the content analysis a second time and testing if the same findings came out. A subjective evaluation of “Good” was rated as the results of this technique made it possible to reflect on the first content analysis and tune results by adjusting some findings.

Detailed descriptions of each benefit and consideration of multiple perspectives (business, administrative and operative as well as technical, legal, and economic) were reported. These descriptions allow readers to understand the setting and promote discussion while considering many perspectives and presenting the results to the reader more explained and realistically (Creswell 2014). A subjective rate of “Excellent” was given to the results of this technique as findings were validated and extended through further research to fully describe the benefits of T&T systems for more sustainable operations in the IWT from different perspectives.

Finally, an average for the techniques rating was then estimated to get an overall qualification for each quality criteria. As a result, the *credibility* and *dependability* of the results from the content analysis of expert interviews were rated as “Good”, confirming the results as trustworthy.

Table 6-5 summarizes the subjective rating for both selected qualitative quality criteria out of the performed techniques for this work.

Qualitative quality criteria	Techniques to ensure quality	Technique Rating	Criteria Rating
Credibility	Data triangulation	Fair	Good
	Re-test	Good	
	Detailed description of setting and multiple perspective	Excellent	
Dependability	Audit: researcher´s documentation, methods and decisions	Good	Good
	Construct validity check	Good	
	Transcripts checks	Excellent	
	Codification Track	Excellent	

Table 6-5 : Techniques and quality criteria rating for the results of the content analysis to expert interviews

7. Validation of benefits and brakes out of participatory-creative workshops

Chapter 6 presents a first proposition of benefits and brakes related to enhanced Tracking and Tracing systems for more sustainable operations in the IW. This first proposition resulted from the content analysis of the data collected during the expert interviews phase, fully introduced in Chapter 5. As explained in Chapter 4, using more than one method to collect data on the same topic (triangulation) is a strategy implemented in this study to validate the accuracy of the information collected. The expert interview is the first method, and in this chapter is, the second method explained: participatory-creative workshops. This method is fully introduced in section 4.3. According to (Oberholzer et al 2015) a workshop is the adequate method if:

1. There is a challenge for the participants to work together on a theme in development. If not, a meeting or presentation to present the content would be enough, and
2. Group work offers differential advantages that could not be reached through bilateral conversations.

After reflection on these two questions, the participatory-creative workshop continues to be considered an adequate method for the study purposes:

1. The theme of enhanced Tracking and Tracing systems in the IW is a novel issue in the sector where many discussions are demanded before such systems are implemented. This poses a challenge to participants to explore different perspectives on this theme. Many workshop participants as well expressed this, and
2. Bilateral conversations were already conducted in form of expert interviews. Another type of knowledge is expected to be generated through interactive group work. Through group work, knowledge is explicated, and the resulting discussions allows us the collection of more detailed information.

Chapter 7 explains how the method participatory-creative workshop was implemented in this study. The chapter begins with the discussion of criteria and workshop-participants selection process in section 7.1. Section 7.2 fully explained the design of workshop methodology such as organization (workshop venue, program and activities, time management, materials, space, equipment, catering), documentation strategies for collecting and recording workshop results, follow-up, contingency plans, and ethical issues for co-working. Section 7.3 provides a report of the workshop results. This is input for sections 7.4 and 7.5 were benefits and brakes related to implementing enhanced T&T systems in the IW are reviewed. The chapter ends with section 7.6, where the quality of the participatory-creative workshop is evaluated.

A workshop is an interactive activity that involves many persons and demands careful preparation for complex organizational and logistics arrangements. Thus, the resulting design of the workshop is crucial to achieve the objectives. This is a determinant of the success or failure of this event. For this purpose, several sources were revised to succeed in this task. The most relevant ones building the basis for the organization of the workshop are PRO-IDEAL PLUS project deliverable “D.3.2 – Concept and Methodology of Interactive Workshops”, Oberholzer publication “Workshop Baukasten” and the book “Participatory Workshops”.

7.1. Selection and structure of workshop participants

The purpose of the workshop is twofold. First to validate the findings of expert interviews and second, to better understand relationships between the implementation and operation of enhanced Tracking and Tracing systems and its interfaces with legal, commercial, governmental and, to some extent, technical issues. Thus, potential users of enhanced T&T systems were identified as the target group for workshop participants.

A micro group facilitation was selected and the adequate reference group size from 5-10 to 15-25 workshop participants. As participants came from different companies and organizations without knowing each other, larger groups could be intimidated and deteriorate the collaborative work with an overwhelming ambiance. On the other hand, small groups make it possible to care for each workshop participant. As workshop duration was planned for 3,5 hours, time was restricted. Thus, it was preferred to collect high-quality data with high-detail grade from a small group of participants, rather than a large amount of data risking missing descriptive nature from many sources to be addressed in a limited time.

The registration rate is a challenge for any event organizer. To estimate the number of invitations needed to be sent to achieve a critical minimum number of participants, the author recalls experiences from past projects. Further, exchange with work colleges about their experiences were conducted, and web check of forums was performed. There are neither official nor precise estimations about this quote. Nevertheless, from the abovementioned sources and experiences, the author estimated a possible registration rate of 2 %. Registration to an event does not guarantee attendance, especially if the event is free. It was estimated that 20 % of the registered participants would not show-up on the day due to other obligations, sickness, traffic disturbances or simply a change of mind. Unlike an interview, where dates could be easily rearranged bilaterally, events do not allow this flexibility. Thus, to achieve a minimum number of real-attending 15 people to the workshop, 18 registrations should be the target. For this, a minimum of 900 people should be invited. After contacts with several lobbying and research networks, the author got the support for sending the invitation to more than 750 members of the following associations: Lower Rhine Chamber of Commerce and Industry Duisburg - Wesel – Kleve, University Duisburg-Essen, Center for Logistics and Transport, Association for European Inland Navigation and Waterways, Association of Transport Economics and Logistics North Rhine-Westphalia e. V., Federal Association of Forwarding and Logistics e. V., Dialogistik Duisburg as well as German ST4W Project Network. Through these associations, players of all IW groups: commercial, physical, authorizing, lobbying organizations and research institutions were addressed. Personal invitations were also sent to all experts who participated in the interviews. Recruiting workshop participants with multiple backgrounds proved to be adequate to reduce the high-affinity number of participants that might lead to disturbances during the discussions. At the same time, this diversity allowed the author to gain knowledge from different perspectives. Although the 750 sent invitations were not the necessary 900; the fact that experts from interviews were personally invited and the vast majority were deeply interested on theme as well participating in further related activities, it was expected a high probability of their attendance that would help to achieve the minimum critical participant number.

In addition to the invited workshop participants, a support team of three persons participated: the coordinator and author of this thesis and two rapporteurs. As workshop organizer, the takes control of all the activities from the conception, organization, execution, and follow-up of the workshop. The two rapporteurs gave their support on the day of the event at the workstations to collect notes from the discussions to be used by the author to validate her protocols. Rapporteurs also help so that participants do not feel alone, and the thesis author do not need to interrupt each group in the middle of their discussion, taking synergy from the debate. The rapporteur also ensures that all participants can to participate in the forum. No dominant role would be taken that would affect the results or denigrate the collaborative environment. The author prepared guides for the information transfer phase to support the rapporteurs a discreet stimulation to the discussion regarding locks. Fortunately, they were unnecessary as participants´ ideas in each workstation were detailed enough.

Special attention was given to the invitation letters as it was the single opportunity to get the attention of potential participants for the workshop and thus was the first essential element for the success or failure of the event. The invitation heading is decisive for the recipient to read further or not. Thus, the header expressed, in a few keywords, the type of the event, innovative theme and addressed sector. The main text of the invitation communicates important information to the recipient such as: organizer, workshop theme and objectives, place, date, duration, event methodology, characteristics of expected participants, the exclusivity of opportunity, costs, contact person for questions and registration together with a program and information about catering for participants. A copy of the workshop program could be found in Appendix H.

Once registration was closed, backgrounds, motivations, and interests in workshop participation were investigated to know the participants better. This was in consideration for the further organization of the workshop to boost event success and reach objectives. Sixteen persons participated in the workshop, including the supporting team of three. A list of the attendees can be found in Appendix I. Figure 7-1 depicts the composition of workshop participants using the player classification introduced in section 2.1.2.

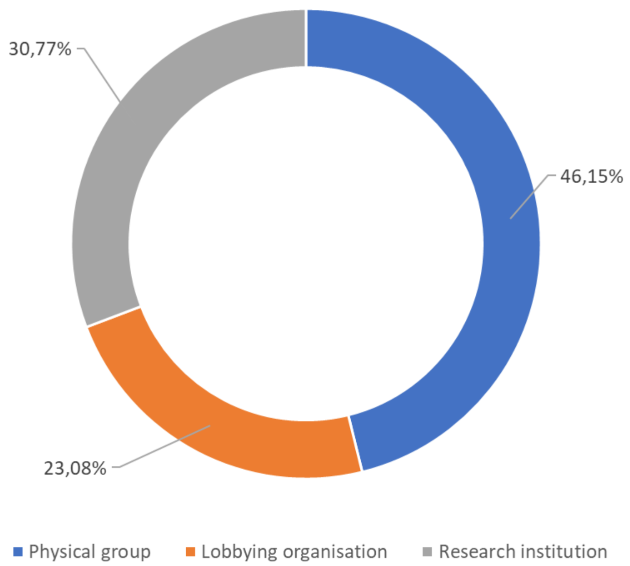

Figure 7-1 : Composition of workshops participants excluding supporting staff

Figure 7-1 shows that almost half of participants are part of the physical group, with various companies assuming tasks from haulage contractors for the pre- and on-carriage, terminal operators, stevedores, and vessel operators. As for the interviews, the insights provided by this group are from high importance for this study as they are directly involved on the cargo movements.

Research institutions are the second most representative group taking part in the workshop. Research institutions play an important role in modernising inland waterway systems by developing innovative strategies that go from the developing new vessel types, new navigation systems, traffic monitoring systems, and innovative transport concepts and solutions. Through their participation, the forthcoming innovation framework in the IWT should be considered in the study. This facilitates realistic anticipation of future developments of systems for the IW sector, revealing possible interfaces with this study.

Finally, a third group was well represented in the workshop: Lobbying organizations in the IWT. Almost 1 out of 5 participants were active in this player group. These organizations are in regular contact with multiple IWT players and represent the interest of their members upon governmental, social, business, and scientific instruments. It is intended that through their participation insights in further dimensions such as business, legal, social, and technical ones enrich the interview findings from multiple perspectives.

The resulting composition of workshop participants allowed us a better understanding at different levels: operative, political, societal, and scientific as in Table 7-1.

Interview group	Level of insights
Physical group	Operative level
Lobbying organisation	Political and societal level
Research institution	Scientific level

Table 7-1 : Level of insights won through workshop participants in each player group

7.2. Designing the workshop methodology

The following section will explain the different tasks involved in the organization of the participatory-creative workshops for this study.

Workshop conception

Designing a workshop is like preparing for an experiment. The researcher should be confident about the procedure and prepare the materials and equipment to be used to guarantee data integrity and the investigation´s repeatability. Rather than chemical and physical laws, human behaviour is the critical element. In a chemical experiment, for example, the researcher "uses" materials and equipment under a rigorous procedure to achieve results. On the day of a workshop, the workshop venue is the labour, and the "materials" are participants, who compared to reactive, have expectations and needs. Therefore, teamwork techniques (procedures) should be selected to boost creative work in a collaborative environment under consideration of organizer as well as the participants´ needs. Finally, since people are not machines, the organizer should anticipate some flexibility to react to ongoing developments during the day.

A workshop is a time-consuming but as well a time-saving event. From one side, great organization efforts are needed to manage the intended agenda and the attendants. On the other side, a significant number of people attending the workshop with different backgrounds is a mobilization of energy and intelligence, that could lead to incomparable results or frustrating experiences for both sides. Therefore, careful organization of workshop is imperative. All these factors were carefully examined, and the workshop was designed to maximize the opportunities and minimize the risks introduced in section 4.3.

The preparation task began by reviewing the workshop objectives. As introduced in section 7.1, the workshop´s purpose is twofold. First, to validate the findings of expert interviews and second, to better understand relationships between the implementation and operation of enhanced Tracking and Tracing systems and its interfaces with legal, commercial, governmental, societal, and to some extent, technical issues. To address the first objective, an impulse presentation was organized to present the results of the expert interviews. Even if the word presentation evokes a passive meaning, this activity was planned to be an open, active discussion between thesis´s author and participants. This should happen at the beginning of the workshop to present the foundations for further discussion on the following activities and immerse participants who are new in study processes into the theme. The second objective was more demanding as participant commitment was essential to share descriptive knowledge and not only information. Thus, a more participatory activity was planned to achieve this second objective. Therefore 2 phases of information transfer were then designed. The first is for "benefits", and the second is for "brakes". One of the workshop formats introduced in section 4.3 for these information transfer phases should be selected.

Open Space Technology and Barcamps formats could increase the probability of active participation and commitment of the attendants, as they are free to define the theme they would like to develop and the means. Nevertheless, this freedom implies a high risk of deviation from the thesis questions that could lead to poor results in adequately addressing the research question. Further, the traditional use of social media in Barcamps format to communicate event results or get feedback from non-present observers presents several disadvantages. First, participants might not be willing to share their contributions among unknown public as the company or sector-sensitive information could be spread without control. Second, inputs from non-present observers through social media do not allow for verification quality of the sources.

Other workshop format introduced in section 4.3 were Road mapping workshops. Even though enhanced T&T systems for the IWT demand a roll-up plan for technological development and acceptance, this study does not define this concrete path. Thus, a Road mapping workshop format suits better technology development projects than an exploratory study like this thesis.

The format of World Café, where the participants come together in groups around tables and discuss the table´s questions, suits the objectives of the two information transfer phases. This format allows the organizer to formulate good questions in advance and get detailed inputs from each table´s discussions. Nevertheless, the traditional methodology of all participants visiting all discussion tables could be an exhausting experience, drowning the participants energy and interest. Therefore, a variation to the conventional format was conceived where four questions-table, known as *workstations,* were going to be parallel discussed by small groups each, without participants taking turns for tables. Participants were invited to choose a table (single workstation) to work at. This allows the participants to select the workstation with the questions they feel is more related to their own interest and experiences. This makes possible, in turn, the collection of data with more quality and a higher descriptive possible by keeping participants´ motivation constant throughout the workshop. Each workstation should have no more than four participants. In this way, all participants will have the opportunity to interact. Groups of four, max. five persons per workstation allow a mixed constellation with different perspectives for each question. The group size allowed the giving time to participate in the discussion without being marginalized, losing participants´ contributions.

After several evaluations, it was expected that the chosen World Café format would allow the author and workshop participants to address the complexity of the topic to reach extraordinary findings quickly. Further, this participatory format is more likely to ensure a strong interaction and engagement of participants.

For the workstations, structured proceedings and visual techniques were evaluated to help workshop participants to communicate and illustrate ideas. These techniques should be easy so that participants could do it on their own in a short period but robust enough to allow a systematic representation of ideas to be explained and discussed in small groups at a workstation level and with the entire group in an open round discussion afterwards. A plethora of techniques are possible for this purpose. The author evaluated all 21 techniques presented in Part 5 in the Manual "Participatory workshops" from Chambers and selected the technique of *card writing, sorting and consensus.* Under this technique, participants working on a workstation are invited to work on the workstation by writing ideas on the cards with simple rules:

1. Everybody can write cards,
2. One topic per card,
3. Cards are writing under group consensus,
4. Cards should be stuck up using pins over the pin board,
5. For categories headings are written, and
6. Cards should be sorted according to categories and sequence

A workstation reporter will present the resulting pin board with sorted cards in an open round discussion. Participants of other workstations are invited to comment on each workstation´s findings.

Ethical considerations

As for expert interviews, ethical principles introduced in section 1.8 by (Orb et al. 2000) and (Bell and Bryman 2007) were considered for the participatory-creative workshop as follows:

1. The goals of the study, procedure of the workshop (duration, place, method) and intended utilization of the workshop results were fully communicated before the day the participants,
2. Special requests from participants were respected, such as protection of personal contact data,
3. The right of anonymity of individuals were respected. Thus, no names are given, and pictures with faces are not published,
4. Author's affiliations were communicated, and in the case of questions about background, and interest, further information was given with the aim of transparency, and
5. The author struggles to provide mutual benefit for the researcher and research workshop participants who gained knowledge on the thesis theme and set basics for possible future development of this new technology.

Principles of *beneficence* and *justice* were again observed, and mutual benefit for researcher and participants secured through several initiatives:

1. Impulse presentation with the results of expert interviews were shared with all participants,
2. Results from all workstations were share with all participants,
3. Interested participants were added to the project ST4W network, and access to all project publications was given, as well as invitations for further activities on the tracking and tracing systems for IWT, and
4. The possibility of exchanging the author´s experiences in other past or coming IWT projects were offered.

Further organizational aspects were carefully planned, such as logistics for the event, venue selection and workspace arrangement, catering, contingency plans and debriefing. These are shared in Appendix J.

7.3. Workshop´s report

In this section, a report of the workshop is presented.

Impulse presentation

As a first stimulation for the discussion and opportunity to validate the first results of this study, the author of this thesis presented the results of the interviews. The presentation allowed the participants a quick view of the data exchange´s status quo in inland navigation. The method of the interviews was presented. Following, the insights gained during the interviews were presented structurally, classifying main findings in:

1. Track and Trace for pallets,
2. Track and Trace for containers,
3. Track and Trace for vessels,
4. Data exchange formats, and
5. Main concerns about national IW.

Participants gave their opinions about the interview findings in an open discussion at the end of the impulse presentation.

I Phase of information transfer

In the first phase of information transfer, participants were asked to select a topic to work on using a pin board and a note card to write down their opinions and classify then on the board. On each workstation where between three to four participants.

On each workstation, participants should work on one of these questions:

1. Identify target groups (users), potential and application scenarios of new track and trace systems for bulk cargo in IW
2. Identify target groups (users), potential and application scenarios of new track and trace systems for dangerous goods cargo in IW
3. Identify target groups (users), potential and application scenarios of new central information systems for exchanging ETAs of cargo/ships in IW
4. Identify target groups (users), potential and application scenarios of new systems offering "predictive analytics" services for cargo/ship in IW

After the 30 minutes, all participants were called to an open round discussion. Each workstation presented its findings, and an open discussion on the big round helped to finalize each workstation.

II Phase of information transfer

On the second phase of information transfer, participants continued working on the selected topic (workstation) and they were asked to exchange their contributions on the questions mentioned above and identify:

1. Risk and requirements to develop new track and trace systems for bulk cargo in IW,
2. Risk and requirements to develop new track and trace systems for dangerous goods cargo in IW,
3. Risk and requirements to develop new central information systems for exchanging ETAs of cargo/ships in IW, and
4. Risk and requirements to develop new systems offering “predictive analytics” services for cargo/ship in IW.

Once again, the participants had 30 minutes to discuss in group on their workstation, write their ideas on the cards, and display them on a pin board. After the 30 minutes, all participants were called to a big round. Each workstation presented its findings, and an opened discussion on the big round helped to finalize each workstation.

Following, results of the discussions of each workstation are presented.

1. Tracking and Tracing System for Bulk Cargo in IW

Inland waterway transport is considered a fragmented industry, making establishing uniform systems difficult. This also applies to T&T systems, that have, so far, hardly been used at container and pallet levels. However, for the overall goal of improving efficiency, economy, and handling volumes of bulk cargo, Tracking and Tracing systems offer a wealth of potential:

- Improved information quality of the value chain,
- Improved scheduling, especially in time-critical and last-mile scenarios,
- Improved risk assessment for all downstream stakeholders,
- Basis for just-in-time (JIT) and just-in-sequence (JIS) processes and other new uses in the IW,
- Improved data consistency for future information systems,
- Prevention of system interruptions,
- T&T as part of a uniform data hub in the IW and adjacent logistics processes,
- Improved image and expression of the industry's intention to innovate, and
- Increasing the attractiveness and awareness of IW.

Out of the discussion, concrete application scenarios were identified:

- Monitoring of refrigerated containers and other temperature critical goods, and
- Establishment of a standard, web-based data platform for T&T data.

In principle, all actors of the IW logistics chains are considered target group. However, the significance for the individual depends on the respective process.

2. Tracking and Tracing System for Dangerous Goods in IW

Nowadays, the transport of dangerous goods through waterways is, to a large extent, performed in tank vessels. The transport of dangerous goods in more minor or even standardized units, such as pallets or boxes, is deemed a new market. Nevertheless, the development of new T&T systems for dangerous goods offers several potentials:

- T&T as part of a uniform data hub in the IW,
- Better monitoring of location, movement, and status of dangerous goods along rivers and canals for security purposes,
- Better collection of statistics for better planification of operations, investment, regulations, and national strategies/policies,
- Access to real and accurate data in real time,
- Give a new order to the things and begin to “follow the product, not the worker”,
- Better control and planification of usage of tanks/transport aid materials for a specific chemical. Alternative, for the planification of loading different chemicals,
- Better monitoring of autonomous vessels, and
- Better coordination of maintenance operations, e.g., tanks cleaning.

Several target groups were identified who could be interested in the T&T services and the related T&T data such as:

- Government for the control of minimal security fuel levels as well as taxes. Fuels taxes are a significant financial source for the government,
- Insurance companies would like to have access to statistics generated by the T&T to calculate risk better, develop adequate insurance products and identify tendencies,
- Chemical industry would benefit from improved visibility of dangerous goods inbound and outbound transports,
- Citizens could be better involved/informed about transporting dangerous goods on their surroundings. This can increase the acceptance of related industries, e.g., chemical parks, and
- Shipping companies, terminal operators and vessel operators would benefit from visibility.

Nevertheless, new T&T system for dangerous goods implies several risks, such as:

- Higher administrative efforts because of a higher level of complexity,
- Not all users would consider more visibility as good,
- Time-related developments in the sector of dangerous goods could lead to inappropriate conclusions and more robust regulations, and

- With the collection and management of T&T data for dangerous goods, is the responsibility higher, especially in avoiding terror activities.

Requirements and conditions to achieve are:

- A single European platform,
- Development should address all stakeholders, and
- Open questions such as tool test, hosting and maintenance of the system, business model should be cleared.

3. Central information systems for exchanging ETAs of cargo/ships in IW

Nowadays, exchanging ETAs in the IWT in Germany is performed mainly via radio or telephone. Successfully implemented systems to digitalize this process is the app iBarge from NPRC. Through this app, vessels members of this association can introduce their estimated time of arrival to next terminal through the app. This information will then automatically be shared with the terminal operator. Any changes could be immediately introduced in the system, and all parties manage the same information, which is actual.

The use of central information systems for exchanging ETAs of cargo/ships in IW implies several advantages:

- Uniform communication system,
- Increase of predictability of IW processes,
- Increase of efficiency and terminals occupation levels,
- Better planification of internal processes several supply chain actors with the consequent cost and time reduction,
- Reunification of transport data from sea, inland waterway, and road modes, and
- Electronical transmission of data to reduce the number of manual inputs and therefore decrease errors rates.

Possible supply chain actors who could benefit from a central information system for exchanging ETAs are shippers, skippers, transport and logistic service providers, and terminals.

It is expected that before the introduction of a central information systems for exchanging ETAs in the IW can be successfully implemented; following issues should be cleared:

- System complexity,
- Management of “sensible data” about each vessel transport (arrival times, location, etc.),
- System-acceptance in the skipper milieu,

- Critical user mass for achieving a standardized process,
- Technical availability of the system according to the technology (mobile networks),
- Standardized interfaces with ERP and TMS,
- User-friendly according to the average age and information systems capabilities of vessel operators,
- Not only technical but as well knowledge about change management to digitalization will be needed, and
- Disruptive business models.

4. Systems offering "predictive analytics" services for cargo/ship in IW

Predictive analytics-based Inland Waterways Voyage Planning tool are innovative solutions to help vessel traffic managers, towboat pilots, and river lock operators to maximize logistic transport resources. Implementing services promises tremendous changes for the IW to adopt a data-driven decision-making culture through intelligent systems.

The implementation of predictive analytics for the calculation of forecasts and estimation of supply chain events (arrival times, transport time, loading time, etc.) offers several advantages:

- Energy consumption of vessels could be optimized by adequation of vessel speed and terminal throughput,
- Planning of the terminal process could be optimized on the calling process,
- Coordination of transhipment of the cargo to further downstream transportation (boosting synchromodality) can be improved, and
- Consolidation of cargo coming/leaving with different transport modes (Road, Train) can be better synchronized.

Several target groups were identified that could be interested in estimations from systems with predictive analytics functionalities:

- Terminal operators,
- Shippers with high value or time-sensitive cargo, and
- Cargo consignee.

A system of this kind will demand extensive data for accurate and timely data sharing such as:

- Data from AIS,
- Data about the inbound and outbound transport,
- Data from waterways operators,

- Data about the status of the cargo,
- Data about the status of waterway network (water levels and events in river, canals, locks),
- Timetable of passenger vessels,
- Data from terminal occupation levels, and
- Planning board of dispatcher.

On the other side, such a system can make possible:

- Information sharing of more accurate ETAs,
- Re-thinking for the better utilization of infrastructure during idle times or proactive measures for peak times,
- Better communication in the case of disruptions, and
- Optimization of terminal processes.

Pictures of all ideas poster, where the results of the discussions are displayed for each workstation, can be found in Appendix K.

7.4. Review of benefits of enhanced Tracking and Tracing Systems

This section presents and thoroughly explains the benefits of enhanced Tracking and Tracing Systems from analysing the participatory-creative workshop. The codification is introduced in section 6.2. were the first 15 benefits were introduced keep their validity for the review. Thus, the listing in this section begins with the benefit number 16.

BE-16 Improved protocolization of unalterable historical cargo movement data, especially in the cases of discrepancies and certifications

Nowadays, traceability is a powerful mean companies use to prove their value chains´ sustainability and responsibility. Tracking and Tracing systems can provide historical data about transport and logistic activities with trustable and complete records of cargo movements.

Traceability of objects without gaps throughout their complete lifecycle is essential for sustainable circular supply chains because:

1. It makes difficult the introduction of counterfeit products. Besides the adverse economic effects, brand image damage, and customer security risks, social aspects are involved as counterfeit products are often manufactured in conditions with poor controls for safety and quality,

2. It makes possible for companies to adequately address and monitor their ecological (e.g., footprint) and social impact (e.g., human rights) across their supply chains,
3. It makes possible the continued trace of product´s aggregation and disaggregation processes (items into cartons, cartons into pallets, pallets into containers) and links them to assets (location, transportation aid, transportation means, etc.) over the value chain,
4. It supports the adequate recording of maintenance, repair, and operations as well as disposal, destruction, or recycling of products,
5. It allows companies to cope with market pressures and comply with emerging internal and external traceability requirements and regulations. More precise, the German Act on Corporate Due Diligence in Supply Chains, to come into force in 2023, requests companies registered in Germany to appropriately identify, address and report on human rights risks in their supply and value chains, and
6. It provides adequate data collection for attending information queries upstream and downstream of the value chain. For example, in this case, a retailer needs to find upstream information about the certifications and ethical practices of logistic service providers that transport the products they are selling. Or in the case, a manufacturer needs to recall a specific batch/lot of products and return then because of product defects and risks (legal, reputation) for the maker/seller.

BE-17 Consolidation of communication channels between supply chain players

Throughout expert interviews, it was confirmed that nowadays, the communication channels for sharing information about transport status are multiple and mostly use analogue technologies. On the one hand, vessel operators communicate through telephone, fax, or radio when they are approaching an inland port or registering their passage on waterways or canals parts to the responsible traffic centre. Vessel operators should even switch between different radio channels through different waterway sections. On the one hand, when the forwarders need to validate the location and status of the vessel, vessel operators are called by telephone. On the other hand, the analogue nature of this information exchange implies mandatory manual introduction of information on the respective system or the consecutive resending of this information in spoken or without format written forms. Implementing an enhanced Tracking and Tracing system could significantly contribute to consolidating these multiple not digitalized communication channels. This would directly impact the economic and environmental sustainability dimensions of operations in the IW. Utilizing fewer and digitalized communication channels yields savings on the operational costs as time for the exchange and administration of this information would be reduced. From an environmental perspective, fewer material resources for the related paperwork would be needed. Further, the workforce can better invest their time in the security of the operations to prevent accidents and their possible environmental effects. It is expected that all player groups profit from this benefit at an administration level turning it more efficient due to the reasons above mentioned. Opportunities for creating value for all players with sustainable initiatives to improve their business are related to this benefit as it directly contributes to more sustainable value chains improving resource management along the complete supply chain.

BE-18 Increase of IWT modal attractiveness by reducing black box image

Even though multiple experts expressed that the transport with inland waterways once the cargo is on the vessel loaded and leaves the port (especially the seaports) is relative reliable as forwarders are familiar with the usual navigation times for regional transport legs, IWT is considered as a "black box" by many shippers and logistics service providers (Punter and Hofman 2017). This perception is mainly because, during the execution of the shipment, there is usually no way for shippers to track the status of the cargo. This harms the competitiveness of IWT in comparison to other transport modalities. "Real-time tracking is necessary for process monitoring" (Stolte on personal communication on 12 May 2018). For Full-Shipload transports, where the total cargo transported by a vessel is from one consignor (one loading process) to one customer (one unloading process), the investment of an enhanced Tracking and Tracing system is not profitable. The highest added value is provided, such as a system in the case of the transport of cargo in a vessel from multiple consignors to multiple customers, as this increases the number of players with cargo tracking necessities. Increasing the visibility of the load along the complete IW transport leg would profoundly contribute to improving the image of this transport modality making it more attractive and boosting modal shift. More visibility on transport-related data in the IW positively influences the economic and environmental dimensions of operations in the IW. The expected modal change to IWT resulting from the increased visibility would positively impact the IW operating companies' profit due to gaining market for long term. This undoubtedly affects the business level as process are perceived as more reliable. Opportunities for creating value for all players to improve their business are related to acquiring new markets and resulting growth.

BE-19 Global optimization of complete supply chains through synchronized exchange of transport data

Integrating all players in the supply chain with synchronized data about transport status allows a global optimization. This global optimization means optimizing the entire supply chain rather than only a part based on each transport stage´s responsible single interest (Robles et al. 2013). This global optimization would be possible thanks to both instruments: improvement in the transport data management and optimization of own processes due to this enhanced visibility. These two instruments are expected to improve economic and environmental sustainability dimensions. The improvement in data management allows savings on the administrative processes, and the optimization of operation processes positively impacts overall performance through better navigation, waiting times reduction, and idle or unnecessary cargo movements decrease. The effect leads to efficient utilization of resources and thus minimizing environmental externalities. All player groups could gain from this activity. The operative level is expected to experience the most significant impact as efficiency of processes soars. For companies, opportunities for more sustainable value chains are opened with returns on capital due to the reduction of supply chain costs for the sake of savings in communication costs and enhanced operational efficiency.

BE-20 Enhanced of just-in-time (JIT) supply chains

An essential benefit of the just-in-time philosophy is the potential saving in inventory costs through smaller but continuous supply deliveries just as they are needed (Christensen 1996). This dynamic leads to a reduction in inventory levels and, therefore, in inventory holding costs. For JIT supply chains is not high velocity the deciding factor but the capacity to meet delivery time windows with a reliable cycle. This applies especially for IW as this transport network has free capacities. Further, the vessels are themselves floating storage. With more cargo being shifted to IW, the network become denser as more daily departures are needed to cope with the growing volume leading to more intermodal connections for faster throughputs (ECMT 2006).

eT&T systems could provide the necessary information about cargo status to estimate reliable arrival time. This allows the better planification of cargo handling, resource management for smooth operations with real-time information about shipments, pop-up alerts in case of delays, route deviations, unexpected stops, or any event that affects the delivery ETA. Traditionally, JIT supply chains are implemented in manufacturing environments with ample inbound supplies, primarily for bulk cargo. The incursion of inland navigation on the urban and interurban freight transport possesses significant advantages and opens new markets for small-scaled shipment (Durajczyk and Drop 2021). Further, city storage holding costs are typically high as they are coupled with land prices. Additionally, increasing traffic jams in cities with increased transport times and emissions make IW a suitable option for delivering to cities on a JIT basis.

BE-21 Better surveillance and control of high-priced and time-sensitive cargo

Due to vessel´s navigation speed, the inland waterway has traditionally been preferred for the transporting of no time-critical products. The transhipments represent many IW users´ disadvantage in handling high-priced goods due to the perceived risk of unauthorized access. Most of the cargo handled in the geographical area of study are bulk and low-cost goods, as explained in section 2.1.

High-priced and time-sensitive cargo impose high requirements for logistics. These products should be protected against the weather and, especially in the case of high-priced ones, be protected against unauthorized access. Further, handling of high-priced cargo carries significant cargo holding costs estimated as high as 42-45% of invoice value (Yang et al. 2015). This influences the election of a transportation mode as shippers and consignees struggle to ensure quick transport throughput times.

eT&T systems can be helpful to goods with these challenges and support better surveillance and control of high-priced and time-sensitive commodities through IW. Several issues were already discussed in pages above. Following is a synthesis with references on this theme throughout the document. In BE-20, it was explained how IW networks might become denser and thus faster to meet shippers´ and consignees' targets of quicker transport throughput times. In BE-2, the possibilities to react in case deviations or disruptions affect the transport over IW were introduced to make the transport modality more attractive for this kind of goods. In BE-12, this aspect is deeper addressed and introduces how eT&T could support the implementation of advance analytics, IoT and artificial intelligence to track these commodities better and make better transport decisions. BE-18 and BE-14 presents how eT&T improved cargo status visibility making the transport more secure against cargo theft, pilferage, adulteration, or the infusion of counterfeit and helping for a prompt identification and location of points with cargo volume discrepancies.

BE-22 Improved safety and security of transport units for dangerous goods and hazardous waste

Out of theoretical framework, expert-interviews, participative creative workshops, and additional meetings, it was appreciated that dangerous goods and hazardous waste are nowadays in IW almost exclusively as bulk and not in small-scaled transport units handled. Therefore, AIS systems that provides the information about vessels are enough to position dangerous goods and hazardous waste transported on this basis. Nevertheless, the promotion of IW for urban and interurban freight transport possesses significant advantages and opens new markets for small-scaled cargo, as explained in BE-20. These new flows of small-scaled cargo could include dangerous goods and hazardous waste. Product-specific and hazardous waste accounts for only 10% of all municipal waste. However, the disposal costs of these goods account for 70% of total municipal disposal costs (Umwelt Bundesamt 2018); making this sector an essential object for cost reduction through transportation modes such as IW. eT&T can support their safe and secure transport by collecting and exchanging real-time data about their location and status. This built the basis for the incursion of IW in this new transportation market, e.g., hospitals disposals in containers, construction waste in big bags, batteries and accumulators in collection containers, lighting products in box pallets or paint and lacquer in tanks.

BE-23 Mitigation of legal brakes concerning data privacy through shifting of data privacy issues from vessel owner to cargo owner

When tracking vehicles, the tracking data is the property of the vehicle owner, who is very often 3PL. The owner/producer owns the T&T data relevant to the product by tracking the development. This new approach to following the product and not only the transportation mean leads to multiple advantages for cargo owner (commercial group) and transport provider (organizing group).

For shippers and consignees, the prompt identification and location of points where cargo volume discrepancies occur can:

1. Allow them to increase the odds of recovering the cargo. The sooner information is available, the faster they could react,
2. Increase accuracy of transport bills and detection of costs that might be caused by inflated cargo loading/unloading times,
3. Ensure that preferred or in contract agreed routes, delivery timelines, shipping conditions and operating processes are met,

For carriers and forwarders, following benefits are expected:

1. Faster identification of route deviations, dwell time or disturbances at facilities, as well as bottlenecks,
2. Drop of insurance premiums thanks to reduced theft. This makes possible to offer the commercial group lower transport services prices, and
3. The best routes can be identified to speed transport and avoid unnecessary stops.

In the case of discrepancies, a good relationship customer-service provider could be secured thanks to accurate and unalterable protocols for objective operational transparency and mutual performance benchmarking.

BE-24 Performance metrics for the evaluation of safety in port terminal areas

Real-time information about cargo movements in terminals can benefit the better arrangement of terminal procedures improving cargo safety and security. Further, through the systematic data collection of cargo movements, metrics can be calculated to evaluate cargo security performance in port terminals. These metrics can support target performance comparisons for selecting the best routes with port terminals displaying the highest levels of cargo security.

In section 6.2, out of expert interviews, 15 benefits of enhanced Tracking and Tracing systems for more sustainable IW were identified and assigned to categories and sets of categories. At the end of this section 7.4, this list is extended as in Table 7-2. A description of the different categories was introduced in section 6.2.

Benefit Nr.	Benefit	Sustainability Dimension	Player group relevance	Impact level	Impact dimension	Areas for value creation	Opportunities for value creation
B-16	Improved protocolization of unalterable historical cargo movement data, especially in the case of discrepancies and certifications	Economic dimension	All	Administration	Transparency	Risk management	Regulatory management
B-17	Consolidation of communication channels between supply chain players	Economic and environmental dimension	All	Administration	Efficiency	Return on capital	Sustainable value chains
B-18	Increase of IWT modal attractiveness by reducing black box image	Economic and environmental dimension	All	Business	Reliability	Growth	New markets
B-19	Global optimization of complete supply chains through synchronised exchange of transport data	Economic and environmental dimension	All	Operative	Efficiency	Return on capital	Sustainable value chains
B-20	Enhanced of Just-in-time (JIT) supply chains	Economic dimension	Commercial group	Operative	Efficiency	Return on capital	Sustainable value chains
B-21	Better surveillance and control of high value or sensitive products	Economic dimension	Commercial group	Operative	Security	Risk management	Operational risk management
B-22	Improved safety and security of transport units for dangerous goods and hazardous waste	Environmental dimension	Commercial group	Operative	Security	Risk management	Operational risk management
B-23	Mitigation of legal brakes concerning data privacy through translation of data privacy issues from vessel owner to cargo owner	Social dimension	Physical group	Social	Security	Risk management	Regulatory management
B-24	Performance metrics for the evaluation of safety in port terminal areas are feasible	Social dimension	Physical group	Social	Transparency	Risk management	Regulatory management

Table 7-2 : Summary of benefits of enhanced tracking and tracing systems out of participatory-creative workshop in categories and set of categories

7.5. Review of brakes to implement enhanced Tracking and Tracing systems

This section presents and thoroughly explains the brakes to implement enhanced Tracking and Tracing Systems from the analysis of the participatory-creative workshop. The codification is introduced in section 6.3 where the first nine brakes were introduced to keep their validity for the review. Thus, the listing in this section began with the brake number 10.

BR-10 Low-digitalized groups very present in the IWT sector

During interviews and workshop, the skipper milieu was identified as the critical group to determine eT&T system acceptance. Thus, any new solution implemented in the IW sector should carefully consider vessel operators´ average age and information system capabilities. Missing all relevant aspects of this user group for the integration eT&T system might lead to a forfeit.

BR-11 Different problems (other than visibility) with higher priority for IWT users, such as seaport congestions, low water levels

Significantly related to BR-1 explained in section 6.3, the diversity of problems in the IW, together with the perception of interviewees and workshop participants about the prioritization of these problems, make it difficult for decision-makers to assess how eT&T could contribute to the mitigation of risks such as seaport congestions, locks congestions, low water levels and others.

BR-12 Large amount of "one man" companies (vessel owners) increases efforts for closing data exchange agreements and achieve tool-full coverage

Workshop participants described the IW sector as a very fragmented industry. This issue is already identified in section 2.3.2 organizational trends were explained under the point of cooperation. Here it is introduced that the vessel owner sector is primarily built up of one-person companies and that cooperatives are still a rarity. This considerably increase the complexity of change management efforts and time to achieve a critical mass of users to achieve a flat covering eT&T service.

BR-13 Lack of clarity about the economic and operational benefits for tool users

Before investing, companies must determine if the investment will result in a positive return; this means the new product, service, or procedure is worth investing in financial resources. For this purpose, key performance indicators help companies objectively evaluate purchase/investment decisions. To calculated performance and thus these indicators, metrics measure quantitative assessment would be necessary. Nevertheless, the proposed idea of enhanced Tracking and Tracing systems is not implemented yet. Therefore, the performance data collection to evaluate these metrics and assess the economic and operational benefits of the implementation of eT&T is difficult. This triggers skeptical positions to become eT&T tool users.

BR-14 Fear of IWT operators generating "to much" information with the eT&T system

The issue of the amount and sensibility of data to be generated by the eT&T system could be reflected on several edges. The administration of cargo transport-related data over several stages in the supply chain represents a collection of business information about the product, the transport, and the companies across the network. Thus, it is well-founded that potential eT&T users could be suspicious of the system. Further, the amount of data to be managed demands efficient information processes. Otherwise, it could be an overwhelming more than helpful task. Not only are processes meant here, but physical resources should also couple with any intention to implement technology if the maximal use profit is the target. Hardware and security measurements should be then scalable adopted. For this purpose, it is essential to determine how much data (amount and measure-time) is indeed necessary. The more information administrated, the more time, resources and complexity of mechanism are needed for its efficient and secure administration.

BR-15 Fear of tool users about the transparent use, storage and administration of data collected on the eT&T system

Very related to BR-14, BR-15 addresses the edge of security in eT&T information management. While descripting business insides from non-standardized data in multiple information sources such as e-mails, Excel charts, or formulars secure a long, tedious task without high quality outputs, it is considered data saved from misused. So potential eT&T system users could be reluctant to be part of this information sharing network if the use, storage, and administration of data collected by the system are not trustable.

BR-16 Fragmentation of the IWT sector makes establishment of uniform systems difficult

The fragmentation of IWT and its effects on the implementation of eT&T in the IW was primarily introduced in section 2.3.2 and pages above in BR-12. Nevertheless, it is worthy explaining that a characteristic of this fragmentation in the skipper milieu considers a new order of factors, such as familiar traditions and personal and gremial preferences of vessel owners. The multiplicity of forms in these factors might define the expectations and intentions of using the eT&T potential users in the skipper milieu. Otherwise, for others, sharing arrival times and actual location could be seen as sensible or private. The past personal experiences and set of values will determine the preferences of each vessel owner and, therefore, how the vessel owner interacts and uses the system. This poses challenges for the uniform implementation of the eT&T system.

BR-17 eT&T for dangerous goods not seen yet as necessary as all transported through tank vessels

As discussed on BE-22, the transport of dangerous goods through waterways is nowadays, to a large extent, performed in tank vessels. Transporting dangerous goods in more minor or even standardized units, such as pallets or boxes is deemed a new market. On this basis, AIS systems that provides information about vessels, are enough to position dangerous goods and hazardous waste transported in tank vessels.

BR-18 Differences along national regulations are a challenge for achieving a single standardized tool for all NWE

In section 2.3.2 under the organizational trend of harmonization, it was explained that the legal navigation regime in international rivers is established explicitly for each international river. This leads to differences in the regulations in specific corridors and, therefore, in the arrangements for standardized information sharing.

BR-19 Fear of users about the increase of fraud and misuse of eT&T data for illegal purposes like cargo theft or legal ones like creation of more stringent regulations

BR-15 discusses the concerns of potential tool users about the transparent use, storage and administration of data collected on eT&T system. BR-19 extends this concern with the materialization of these fears. In general, it was appreciated that during the workshop, participants were enthusiastic about the benefits of eT&T systems and mentioned several ones. Once, they were asking to think about possible disadvantages, where the risks of fraud and misusing eT&T data were the most mentioned. Experts as well shared similar inputs during interviews. On one side, potential user shared their concerns about the possible misuse of it for cargo theft. Interesting was, as well, the possible use of eT&T data for the calculation of statistics, estimation of trends or formulation of causalities that could be used for the establishment of more stringent regulations by governments of appreciation of new risks maps or pricing schemas by insurance and IW actors in the physical or authorizing group.

BR-20 Achieving critical mass of users to guarantee high coverage of market

The service coverage for implementing eT&T is directly linked to the number of IW players adopting such a system to access the relevant transport-related data. Thus, getting a critical mass of continuous users over the time and guaranteeing flat coverage of eT&T information over the complete supply chain might be crucial for successfully implementation of eT&T systems in the IW.

BR-21 Developments toward new mobile networks (5G) to cope with

This is the only brake related to the use of a specific technology powering the eT&T system discussed in this thesis. Analysis of the benefits and impediments of a new way to share information about transport data of cargo is primarily influenced by the technology selected for the primary process that is the sharing of information. For a more straightforward example, one can argue that the benefits and obstacles resulting from eT&T based on e-mails as sharing medium would be different from a system that uses satellite data and, simultaneously, completely contrasting when using mobile data. According to the latest developments, is mobile communication, together with related mobile, especially smart phones, routers, and tablets devices the most selected technology for the transmission of voice and data. Requirements (e.g., data transfer volumes) and technologies (e.g mobile base stations and terminal equipment) for mobile communications evolve over time. Therefore, uncertainties are valid regarding how a certain eT&T system can operate in the future. For example, it is imperative to discuss how the performance of the system would be affected with the increase of higher data transmission rates through new frequency bands.

Brake Nr.	Brakes	Type
BR-10	Low-digitalized groups very present in the IWT sector.	Organizational
BR-11	Different problems (other than visibility) with higher priority for IWT users such as seaport congestions and low water levels.	Organizational
BR-12	Large amount of "one person" companies (vessel owners) increases efforts for closing data exchange agreements and achieve tool-full coverage.	Organizational
BR-13	Lack of clarity about the economic and operational benefits for tool users.	Organizational
BR-14	Fear of IWT operators generating "to much" information with the eT&T system.	Technological
BR-15	Fear of tool users about the transparent use, storage and administration of data collected on the eT&T system.	Technological
BR-16	Fragmentation of the IWT sector makes establishment of uniform systems difficult.	Technological
BR-17	eT&T for dangerous goods not seen yet as necessary as all transported through tank vessels.	Organizational
BR-18	Differences along national regulations are a challenge for achieving a single standardized tool for all NWE.	Legal
BR-19	Fear of users about the increase of fraud and misuse of eT&T data for illegal purposes like cargo theft or legal ones like creation of more stringent regulations.	Technological
BR-20	Achieving critical mass of users to guarantee high coverage of market.	Organizational
BR-21	Developments toward new mobile networks (5G) to cope with.	Technological

Table 7-3 : Summary of brakes to implement enhanced Tracking and Tracing systems out of participatory-creative workshop

7.6. Critiques and quality criteria of selected method

In the same fashion, the quality of the selected method was performed in section 6.4. The accuracy of the participatory-creative workshop´s findings was evaluated for the expert interviews´ content analysis. For this purpose, the same framework introduced in Table 6-5 will be used. Following the results of the several techniques selected to evaluate the pre-defined quality criteria-set of credibility and dependability of workshop findings will be explained. Finally, a quality criterion rating for the results of the content analysis of the workshop will be estimated.

Four techniques are selected to evaluate the dependability of the results from the content analysis of workshops: audit trail, construct validity check, transcripts checks, and track of codification.

As explained in section 6.4, a comprehensive audit trail (Finnlay 2006) is provided throughout the complete study to define the several steps of the content analysis and why each decision was taken as discussed in sections 4.2, 4.3, 7.1, and 7.2 for the workshops. Thus, a subjective rate of "Good" was given to the results of this technique.

For the construct validity check (Mayring 2014), the findings of the workshop were tested for plausibility confronting them, in the same fashion as for interviews, to knowledge gained in the introduction to inland waterway transport systems (Chapter 2), theoretical framework (Chapter 3) as well as background provided by the field immersion (section 1.4). As a result, a subjective rate of "Good" was given to the results of this technique.

For the transcript check (Creswell 2014), the workshop report was proved to identify possible mistakes during transcription. In the case of workshops, the photography of ideas poster of each workstation and notes from rapporteurs provided material for checking workshop reports. Consequently, the results of this technique were rated as "Excellent".

When tracking the codification (Bengtsson 2016), the coding list of the expert interviews was broadly appropriate. In the case of new categories identified, the list was again revised, extended and modified if necessary. Furthermore, all changes were correctly tracked, and explanations for new codes were protocolized to avoid the researcher´s cognitive change during the analysis. Therefore, the results of this last technique could be subjectively rated as "Excellent".

Three techniques are applied to evaluate the credibility of the results from the content analysis of the participatory-creative workshops: data triangulation, re-test and detailed description of the setting and multiple perspectives.

Using complementary data for the triangulation mitigates the one-sidedness or distortions that may result from one individual database (Steinke 2004). This complementary data was obtained during the theoretical framework and subsequent research to develop each benefit and brake. A subjective rate of "Excellent" was given as findings were validated through data collected from literature analysis.

Re-test (Mayring 2014) was done by conducting the content analysis of the workshop´s result documentation twice and testing if the same findings came out. A subjective evaluation of "Good" was rated as less material was available for analyzing workshops compared to the interviews. Here should be pointed out that the duration of the workshop was a restrictive condition as there was the fear that a more extended workshop (for collection of more material) could be seen as a barrier to the participation of practitioners not willing or not being allowed to invest so many hours in an exchange experience instead of office work.

A detailed description of each benefit and brake identified during the workshop should allow readers to understand the setting better and promote discussion while considering many perspectives to present the results as more comprehensive and realistic (Creswell 2014). A subjective rate of "Excellent" was given to the results of this technique as the findings were validated and fully explained to the reader. Finally, an average for the techniques rating was estimated to get an overall qualification for each quality criteria. As a result, the *credibility* as well as the *dependability* of the results from the content analysis of the participatory-creative workshop were rated each as "Good", confirming the results as trustworthy.

Table 7-4 summarizes the subjective rating for both selected qualitative quality criteria out of the performed techniques.

Qualitative quality criteria	Techniques to ensure quality	Technique Rating	Criteria Rating
Dependability	Audit: researcher´s documentation, methods and decisions	Good	Good
	Construct validity check	Good	
	Transcripts checks	Excellent	
	Codification track	Excellent	
Credibility	Triangulation of data	Excellent	Good
	Re-test	Good	
	Detailed description of setting and multiple perspectives	Excellent	

Table 7-4 : Techniques and quality criteria rating for the results of the content analysis of the participatory-creative workshop

8. Review of propositions

Chapter 8 extends the depth and reach of generated knowledge theoretically and practically. First, building additional layers for the analysis through benefits categories in section 8.1, makes it possible to reach new ways of meaning and interpretation (theoretical value). Further, in section 8.2 the value of this research is extended by formulating measures to overcome the brakes identified (practical value). After allocating the organizational brakes into problem categories, in sections 8.2.1 and 8.2.2, ideas on how brakes related to behaviour change management, operationalization and dissemination, and training and cooperation could be overcome are presented. Thus, this chapter enhances the worth of this study with both theoretical and practical means.

8.1. Building additional layers for the analysis through benefits categories

To maximize study outcomes, a value-added approach inspired by (Eakin and Gladstone 2020) was adopted. This approach aims to go beyond the surface meaning of data findings in qualitative research through a more critical and creative analysis to profound interpretations. For this purpose, additional layers for the analysis through benefits categories will be built to open new possibilities for the meaning and interpretation of collected data in this study. In this section we seek to "theorize" collected data by relating concepts to each other and gain a deeper understand of ground-level realities on a more abstract level. The significant value of this exercise is that this procedure helps to generalize the findings.

To build additional layers for the analysis, a quantitative analysis with a descriptive nature was performed to share graphical representations with connotations of relationships between identified benefits and categories in order to formulate more complex propositions. Hence, a comprehensive taxonomy that allows an efficient and consistent way to represent the findings was achieved. This taxonomy should allow the findings to be entirely understandable for readers, addressing ethical issues concerning the transparent reporting of results to maximize knowledge exchange.

Following, the results of this analysis will be graphically represented, and relationships between identified benefits and categories will be formulated with basis on the summaries of benefits of enhanced Tracking and Tracing systems out of expert interviews and participatory-creative workshop. Thus, the values for this analysis come from Table 6-1 and Table 7-2.

Sustainability dimension

As introduced in section 3.1.2, interfaces between SCM and sustainability are usually understood in an economic, environmental, and social dimension (Wilding et al. 2012) based on the Triple Bottom Line model proposed by (Elkington 1994) to measure the sustainability performance of companies. Benefits contributing to the *environmental dimension* promote processes that improve the company´s environmental impact in the IWT, for example, creating new eco-friendly services, improving waste management, and improving natural resources utilization (e.g., fuels), increasing awareness for greener operations in the IWT. Benefits boosting an *economic dimension* of sustainability aim to increase the profit and status value of the company in competitive IWT markets in the long term. Finally, benefits promoting the *social dimension* aim to bring the practices of IW companies to align with the accepted social values of stakeholders such as communities, authorities, research and development institutions, investors, partners and media. This dimension is difficult to assess. Thus, example of performance indicators on the social dimension, such as shipmasters´ service experience at terminals, number of accidents and fatalities, and contribution of the IWT sector to employment growth (Dobranskyte-Niskota et al. 2009) could make the performance evaluation of this dimension more explicit.

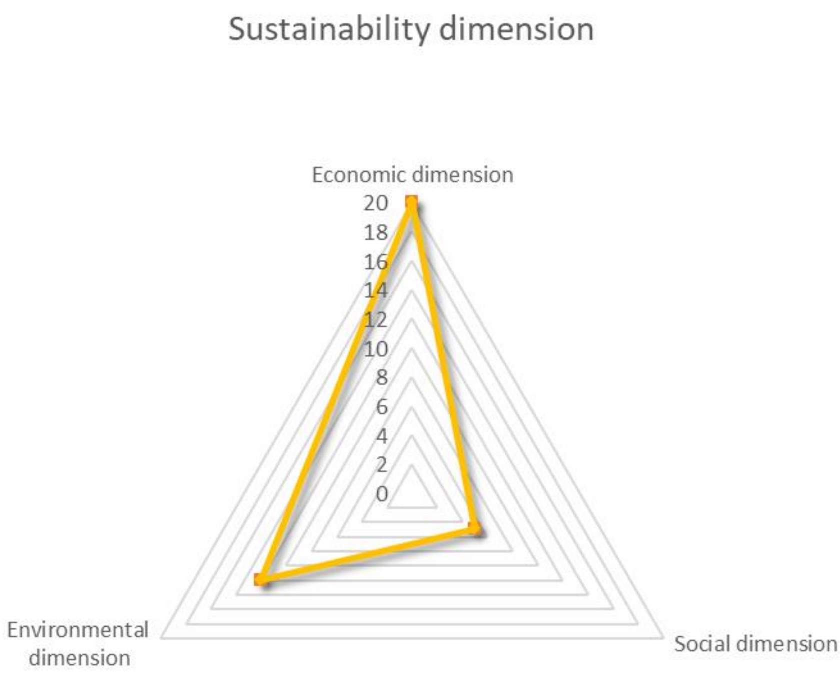

Figure 8-1 : Assessment for sustainability dimension in number of benefits

A multiplicity of sustainability dimensions per benefit is possible as the same benefit could boost more than one dimension. The assessment considers this condition in Tables 6-1 and 7-2.

According to the analysis, graphically represented in Figure 8-1, companies in the IW adopting enhanced T&T systems are expected to experience the most significant benefits on the *economic dimension* of sustainability. This can be explained mainly by the significant quantity of benefits boosting economic indicators such as savings in transport and operational costs, an increase of revenues due to new services, a reduction of waste costs in terms of time and resources, an increase in number and long-lasting customer relationships due to competitive advantage obtain through new services, increase in market participation, thanks to modal attractiveness and increase in cargo security levels (fewer thefts, better movement protocolization). The second dimension where IW performance is expected to be improved, in terms of number of benefits, is the *environmental* one. Several indicators in this dimension related to the identified benefits demonstrate this: increase of modal shift to IW with related reduction of emissions thanks to increased modal attractiveness, reduction of fuels consumption due to better planification of navigation, reduction on fuels consumption in terminals due to better planification of operations, reduction of land-space requirements due to better utilization of terminal areas (yard occupancies), better coordination of vessel-train transhipments for decreasing truck transports and thus emissions and improvement in the secure and safe transport of dangerous goods that are potential hazards for the environment. In the same fashion, the last dimension to be boosted is the *social dimension*, nevertheless, not in the same intensity as the economic and environmental dimensions. This is understandable as other instruments besides technology, such as entrepreneurial practices, legal framework, and similar, are more effective in this dimension. Nevertheless, enhanced T&T systems are expected to contribute to this dimension in several matters, such as task-time reduction and work quality improvement for workers when tracing cargo along IW. Further, it is expected that conditions for personal data protection will be improved as the focus on enhanced T&T systems is shifted from the vessel operators and their vessels to the cargo. Finally, safer operations along river canals and terminals by allowing personnel to concentrate on more critical tasks than registration and better planification of terminal operations should generate better work-safety conditions in general.

Impact level

By segmenting the boundaries of a company into levels, the impact of the identified benefits will be appraised. The *business level* includes all the activities for running a company in a long-lasting and profitable way, such as strategic business planning, risk management and marketing. The *administration level* cover tasks of organization and direction of the company’s resources under the directions of the business level actors. Next, the *operative level*, the company´s base, oversees technical workers conducting in-field operations. The last level, the *social level*, was added to the category list to denote elements outside the company´s boundaries but with a directly related to it, such as residents, unions, associations, and authorities. Figure 8-2 shows a graphical representation of this assessment.

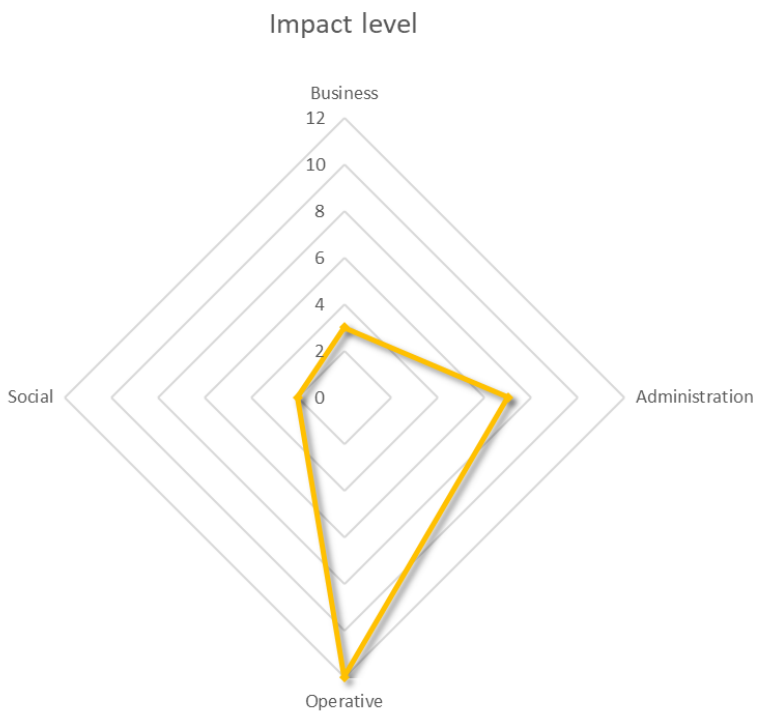

Figure 8-2 : Assessment for impact level in number of benefits

Most benefits impact the *operative level* through a vast list of potential actions. Enhanced T&T could increase resilience of communication networks for data exchange and shorter reaction times in the case of time deviations (vessel´s ETA, ATA, ETD, ATD at terminals), making possible the automation of service provided in terminals, optimization of cargo flows in IW boundaries and across modalities, through better coordination of transhipments, simplification of introduction and use of more robust transport and logistic performance metrics, increment of process visibility and improved safety and security levels of cargo handling and related in-field operations.

The next level to profit from enhanced T&T, in number of benefits, is the *administration level*, yet not in the same measure as the operative level. Here is the new eT&T able to assure, however, convenient advantages for the IW such as better decision-making resources deployment, increase in the automatization level of transport-related data, decrease in the complexity of tracking small consignments from multiple cargo owners, time reduction for compliance procedure upon customers and authorities and the simplification of communication channels with partners. The last two *business* and *social* levels imply fewer number of benefits: mainly creating the fundamentals for developing new customer-oriented services, improving access to new niche markets, and increasing the company´s market shares at the *business level*. Finally, the resulting improvement in work conditions and highly expected acceptance of data-use policies for traceability represent two advantages on the *social level*.

Impact dimension

For the assessment of the impact dimension, a categorization developed by (Boile and Sdoukopoulos 2014) for the project SMART-CM related to the tracking of containers was used as a reference. It was adapted and summarized in Table 8-1.

Term	Description
Transparency	Transparency and visibility on terminal processes Timely notification of arrival and departure times Transparent protocols in the case of anomalies Traceability of empty transport handling units Accuracy of cargo events
Security	Timely and adequate reporting of cargo manipulation Fight against cargo counterfeiting and theft Improved control of dangerous goods handling
Reliability	Trustworthy data collected in a consistent way
Efficiency	Time savings in operative tasks Improved intermodal transhipment Value-added services that allow processes improvement
Timeliness	Reducing transport time Minimizing waiting times or utilization of them for productive tasks (bunkering, maintenance, crew subsistence) Reduce dwell time at terminals

Table 8-1 : Description of impact dimension. Own description adapted from (Boile and Sdoukopoulos 2014)

Out of Figure 8-3, it can be appreciated that most of the benefits are expected to foster the *efficiency* of operations compared to other impact dimensions. Under the *efficiency* impact dimension, enhanced T&T systems would yield several advantages, such as better terminal operations planning, improved occupancy levels of resources, smoother intermodal operations, time savings when tracing cargo and better communication channels to exchange transport-related data.

Impact dimensions of *transparency* and *security* are expected to be lightly strengthened by implementing more detailed key performance indicators, improving protocolization in the case of anomalies and allowing timely identification of these irregularities (*transparency*). The *security* issues include shorter reaction time in cargo anomalies, better surveillance of dangerous goods and hazardous waste, and improved handling of sensitive vessel-related data.

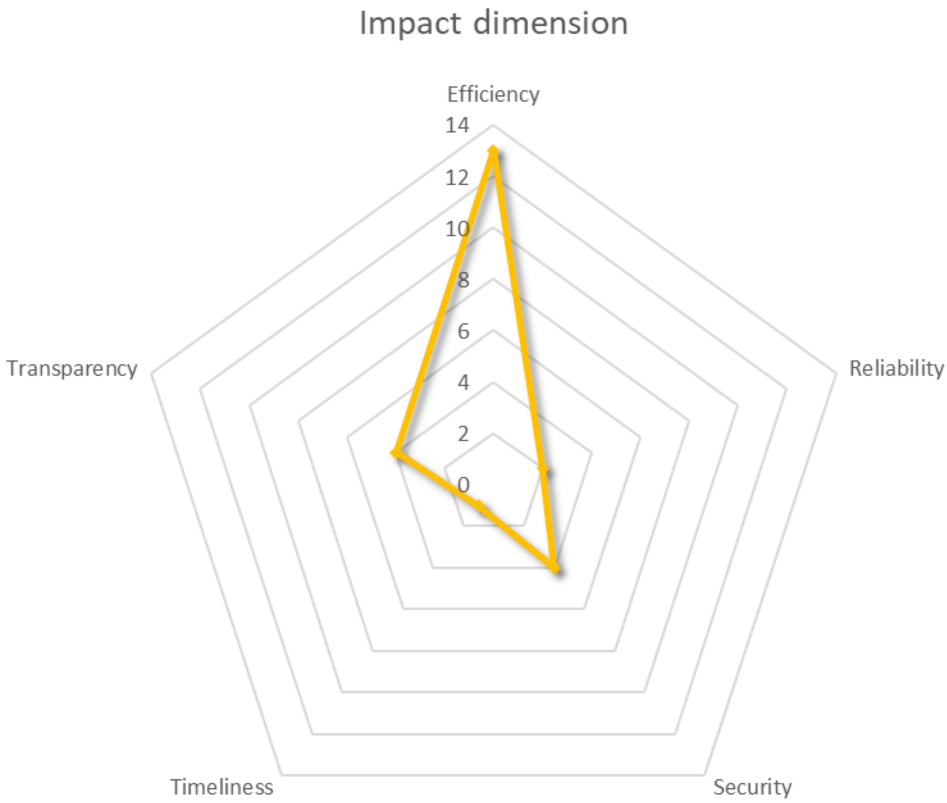

Figure 8-3 : Assessment for impact dimension in number of benefits

Finally, some of enhanced T&T benefits promise contributions to more *reliable* and *timely* IW operations. These are namely: the potential improvement of system robustness for the exchange of transport-related data, the increase of trust in the IW system with transparent, trustworthy data collected by reliable means (*reliability*) as well as the improved reaction time in the case of transport deviations to keep planned times of minimize delays (*timeliness*).

Areas of value creation

As introduced in section 3.1.2, companies can use sustainability initiatives to improve their long-term business. By shifting from merely financial to social, environmental, and economic performance metrics, companies commit themselves to continuous improvement in several ways, creating value and assuring long-term success. According to (Bonini and Görner 2011) benefits could be achieved in *capital returns*, *growth,* and *risk management*. *Returns on capital* are achieved when cutting costs and increasing revenues. Expanding operations for new niche markets is the primary *growth* opportunity for companies incorporating sustainability in their agendas. Finally, properly managing *risks* arising from sustainability issues can help companies better identify, asses and control threats.

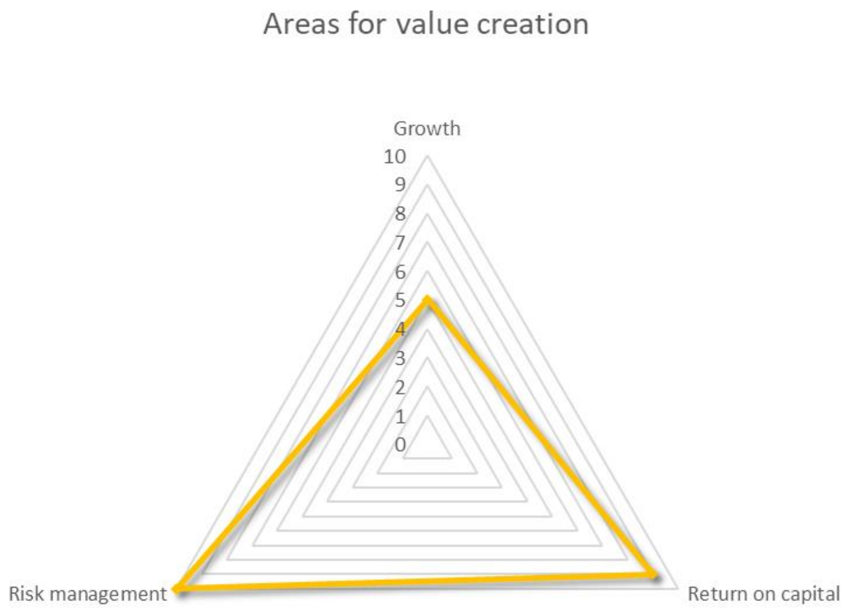

Figure 8-4 : Assessment of areas of value creation in the number of benefits

As in Figure 8-4, the assessment yields that the number of benefits for creating value with the implementation of enhanced T&T systems in *return on capital* and *risk management* is alike. Significant fewer opportunities for *growth* were identified. Opportunities for value creation in *risk management* were identified for enhanced T&T, such as improved reaction upon transport alterations, prompt identification and location of cargo discrepancies, better surveillance and control of high-value or sensitive products as well as dangerous goods and hazardous waste and the possibility for the implementation of new performance metric systems for more secure cargo movement and operations. In the same proportion, *returns in capital* are expected through costs savings due to the minimization of idle capacities, operational costs savings thanks to better planification and utilization/occupancies levels, transhipment cost savings between transport modalities, and administration costs savings related to the exchange of data and tracking of consignments. *Growth* opportunities were only identified as the new potential services for automatic reservation procedures and the expansion of operations to new niche markets and new customers attracted by increased visibility.

Opportunities for value creation

A more detail assessment of opportunities within each value creation area for companies implementing enhanced T&T systems is carried out to identify more specific initiatives fostered by the potential benefits. Concrete opportunities were identified as the adequation of existing products or development of new innovative services related to sustainability (*Innovation and new products/services*), opportunities to expand into new business (*new markets*), improve natural-resource management within company boundaries (*sustainable processes*) and along value chain (*sustainable value chains*), as well as enhance identification, assessment, and reaction to operational disruptions (*operational risk management*) and upon new regulations related to sustainability (*regulatory management*).

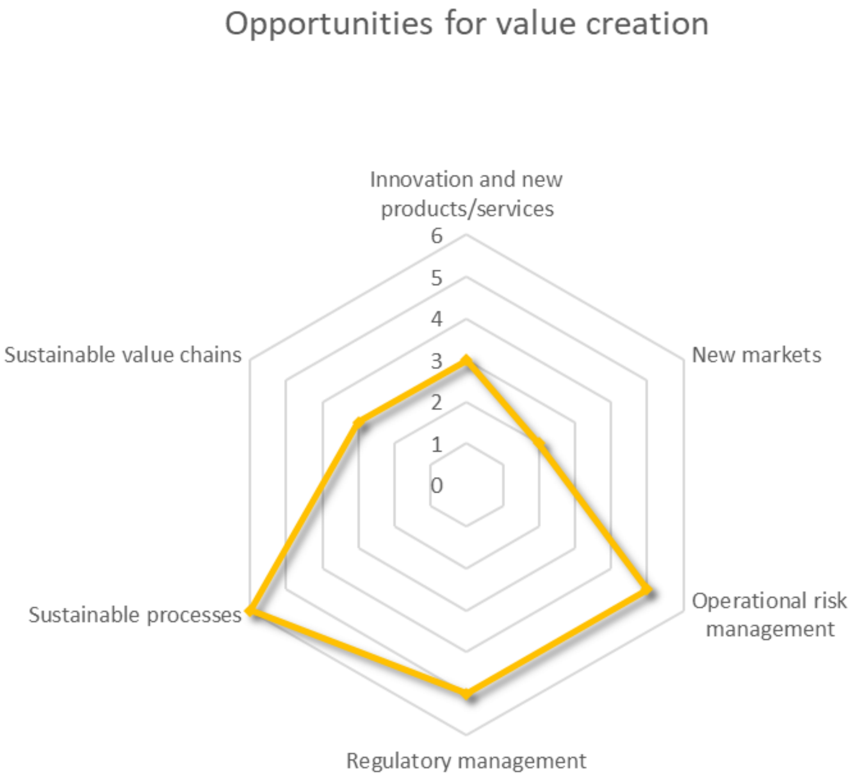

Figure 8-5 : Opportunities for value creation in the number of benefits

Companies adopting enhanced T&T could expect the benefits of providing advantages to create value to the same extend in *operational risk management*, *regulatory management,* and *sustainable processes*. The expectations are, nevertheless, low for accessing *new markets* of commercializing *new services*. Estimations to rippling the sustainability impacts to the complete *value chain* are, as expected, moderate, as meaningful conclusions are only possible considering other transport modalities that are out of this study´s focus.

Player group

Finally, an assessment was performed to explore which player groups would benefit the most from implementing enhanced T&T systems in the IW. The results are presented in Figure 8-6.

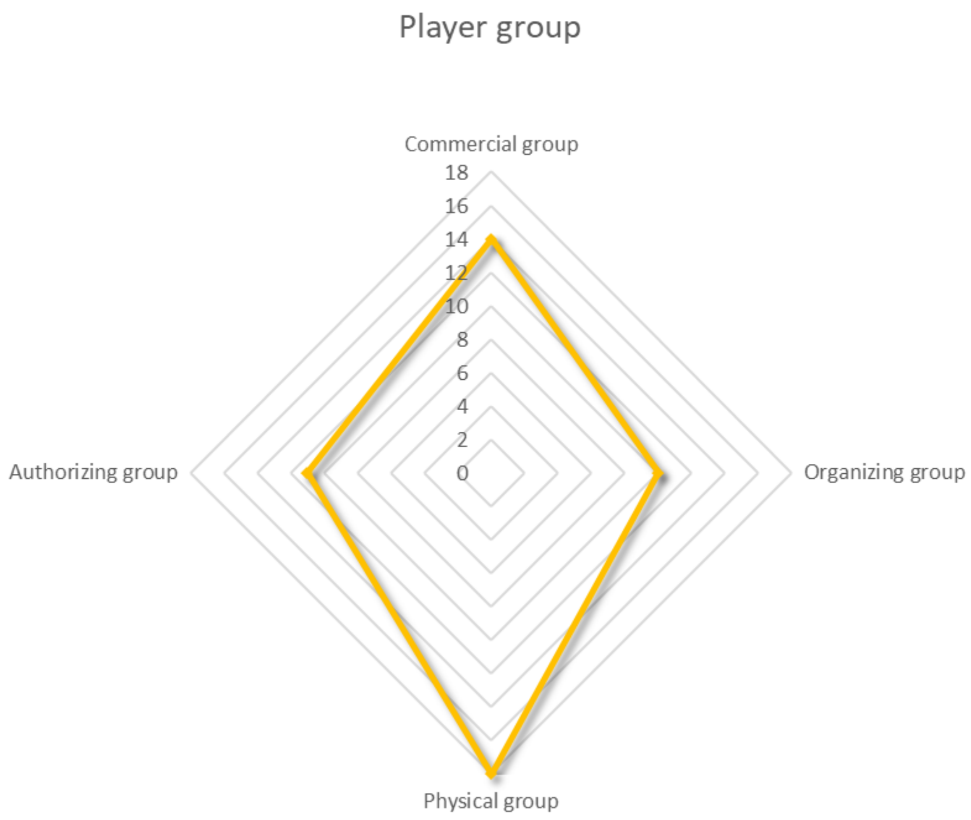

Figure 8-6 : Assessment of benefits for player groups in the number of benefits

The *physical group* could benefit from implementing enhanced T&T systems, followed by the *commercial group*. It can be inferred that the closer the company is to the product and its physical flow, the highest the benefits. As companies in the *physical group* oversee the physical logistics processes and movement of good and the *commercial group* on the production of these goods, benefits are more relevant for optimizing their value chains as these data are core for their operations. In the last stage, companies of the *authorizing* and *organizing group* are expected to benefit but not in the same measure. These two last groups´ competencies concentrate on the surveillance role as a landlord or the flow organizer. Therefore, transport-related data and cargo status are more desirable than necessary.

8.2. Measures to overcome the identified brakes

Along with identifying benefits, Chapters 6 and 7 were the brakes to implementing enhanced Tracking and Tracing systems from expert interviews (Table 6-2) and participatory-creative workshop (Table 7-3) introduced and thoroughly explained. Successful implementation of enhanced T&T for more sustainable operations in the IW sector begins with identifying challenges and barriers to be managed. IW supply chain players must understand and plan for technology adoption and implementation obstacles. Thus, this section represents the interest of this study to help companies operating in the IW sector overcome these barriers and successfully adopt enhanced T&T for more sustainable operations. How a particular company in the IW sector addresses these impediments will depend on the circumstances and resources available. Thus, the proposed general framework should be a spark for tailored road mappings.

In Figure 8-7, the identified brakes are summarized and grouped into four main categories: *technological*, *organizational*, *ethical,* and *legal,* considering the type of limitation of organization in adopting the new technology.

Technological barriers are summarized system-relevant obstacles due to limited access to practical, relevant, and appropriate hardware and software to accomplish the objectives for which the technology was initially conceived (O´Connor et al. 2016). As *organizational* barriers can be understood, obstacles in communication, information flow, achievement of business objectives, innovation, rules and procedures, cultural attitudes, company hierarchy, centralized decision making, lack of partners involvement, and more. *Legal* barriers are set out as regulations and contractual forces that discourage or prevent potential system users from implementing new technology. Finally, *ethical* barriers lead to system mistrust due to ethical dilemmas related to using this new technology.

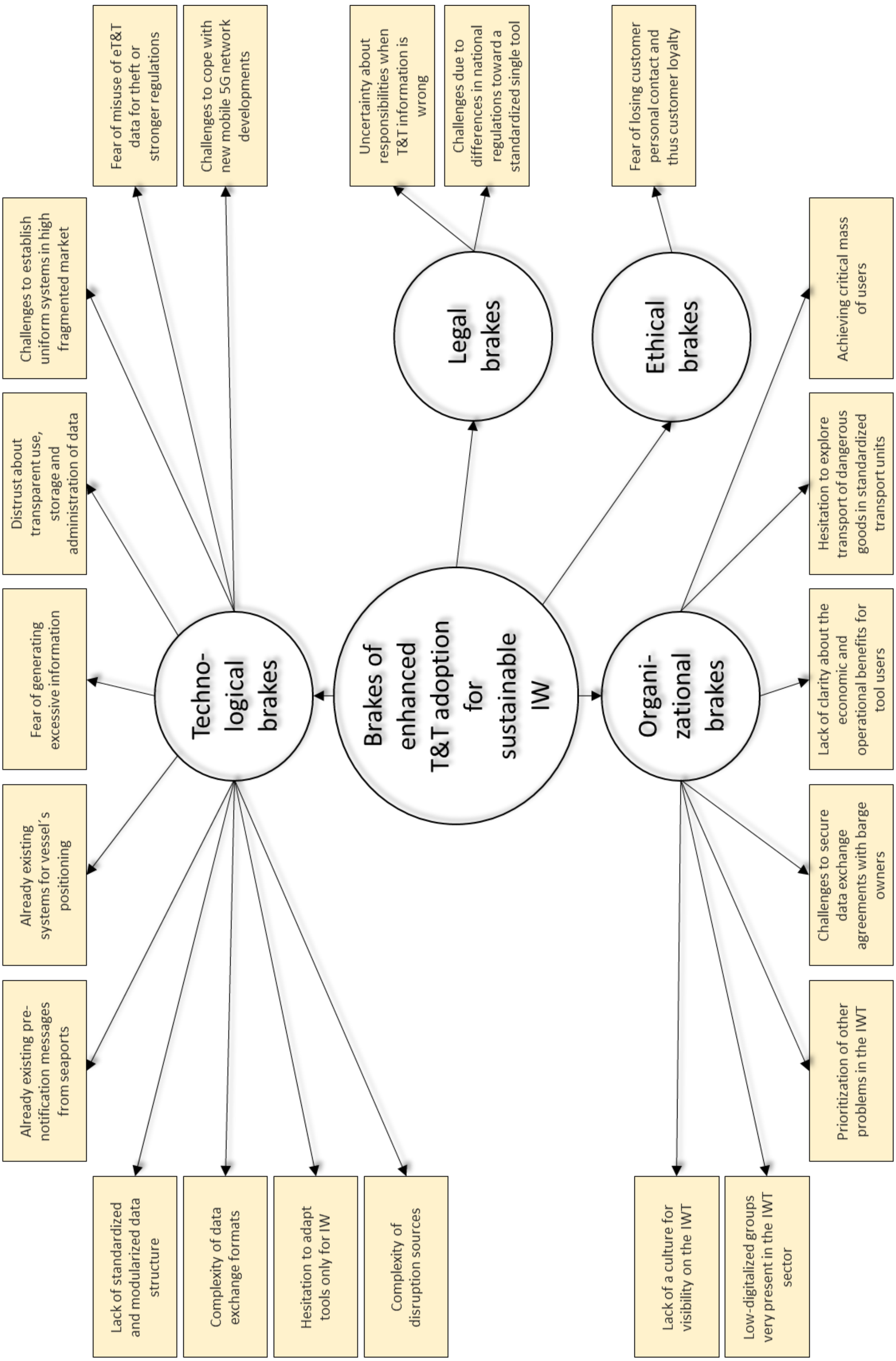

Figure 8-7 : Brakes of enhanced T&T adoption for sustainable IW

Out of the assessment of these four types of brakes (Figure 8-8) it could be appreciated that system-related issues (*technological*) are the largest group of obstacles to implementing enhanced T&T systems for more sustainable operations in the IW, followed by *organizational* barriers. However, e*thical,* and *legal* aspects pose some challenges in a very neglectable way. As *technological* aspects of the system are out of the scope of this exploratory study, these barriers will not be deeply addressed. Nevertheless, first ideas about how to cope with these challenges will be shared.

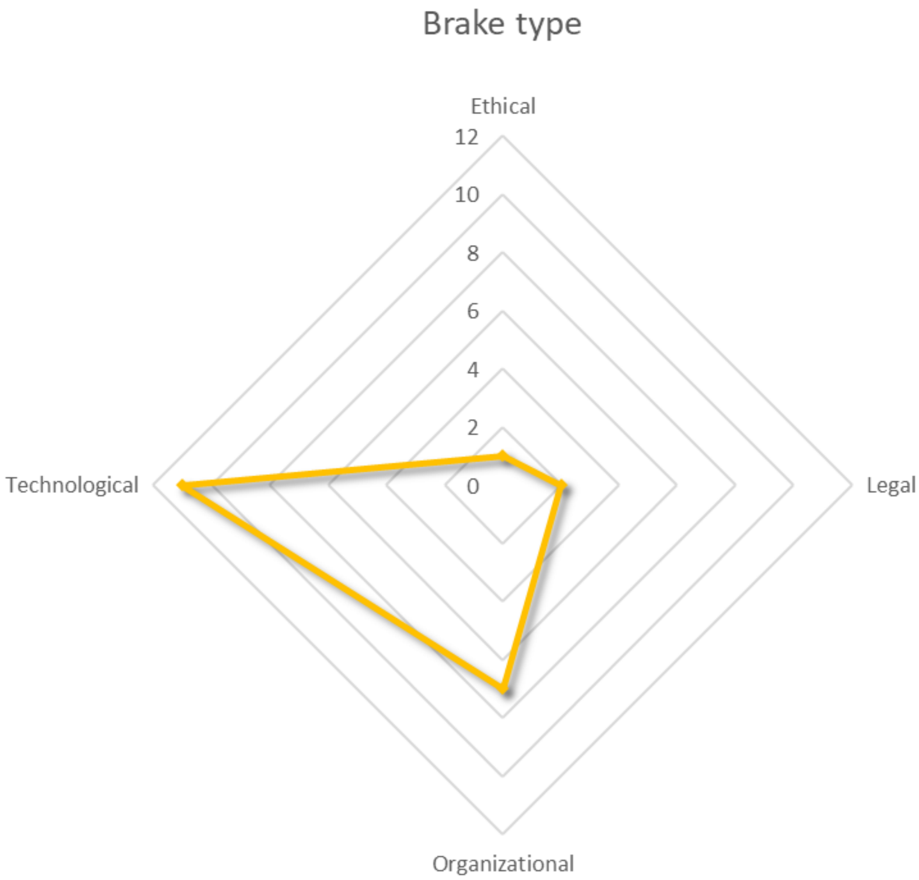

Figure 8-8 : Assessment of the type of brakes

As a result, the focus will be placed on the development of facilitators to address *organizational* brakes for eT&T adoption in the IWT. Since *legal* and *ethical* obstacles are not assessed as relevant for successfully adopting enhanced T&T systems in the IWT, the analysis will be limited to formulating first measures ideas to counteract these brakes. The seven *organizational* brakes will be analysed to formulate measures (facilitators) to overcome them. For this purpose, relevant literature including books, journals, conference papers, and study cases, were reviewed to identify practical measures to attenuate these brakes. This information will be enriched with findings of the participatory-creative workshop, where addressing barriers was part of the workstation’s questions.

After a review of the seven organizational brakes, it was confirmed that they could be grouped into three broad categories: corporate brakes related to *operationalization and dissemination* issues, organizational brakes related to *cooperation* challenges between IW players, and organizational brakes for which each company remains *without influencing*. Figure 8-9 depicts the allocation of the organizational brakes to each category.

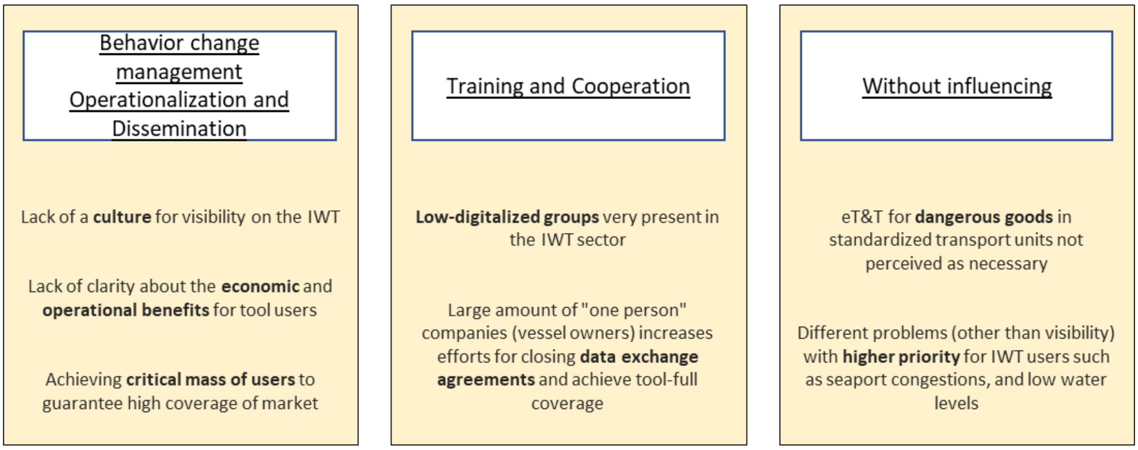

Figure 8-9 : Allocation of organizational brakes to problem categories

As brakes in the last problem category *without influencing* cannot be faced uniquely by each company as they obey unalterable blended market forces, they will not be focus on the action´s formulation. Nevertheless, the first ideas about how to cope with these challenges will be shared. After that, measures for overcoming organizational brakes in the problem categories of *operationalization and dissemination,* as well as *training and cooperation,* are explained.

8.2.1. Brakes related to behaviour change management, operationalization, and dissemination

This sub-section discusses measures to overcome the brakes related to behaviour change management, operationalization, and dissemination. As in Figure 8-9, these brakes are a lack of culture for visibility on the IWT, a lack of clarity about the economic and operational benefits for users and achieving critical mass of users to guarantee high market coverage.

Lack of culture for visibility on the IWT – behaviour change

User companies of IW are eager to take profit of the multiple benefits visibility can provide to their operations, such as:

1. Smart transportation, thanks to automating onboarding processes,

2. Increased possibilities to collect and share transport data meeting international regulations such as the European General Data Protection Regulation through blockchain technology,
3. Enhanced use of transport visibility data to generate forecasts through advanced data analytics,
4. Increased possibilities to enhanced transport visibility with Internet of Things sensors to monitor and report cargo status and react timely upon discrepancies,
5. Optimization of fleet management systems to increase transportation efficiency (resources deployment, navigation settings, reduction of idle times),
6. This should, in turn, improve the transport experience and make the job more attractive,
7. Incursion in digital freight marketplaces (Uberisation) for improved utilization of transport capacities, and
8. Utilization of transport data to make possible platooning, automated and autonomous driving systems on the IWT with the related advantages of personnel cost and fuel savings as well as emission reduction.

This will demand a new culture for visibility in the IW sector, and changing culture starts with changing behaviour. For this purpose, the basics of change management were reviewed. At present, there are eight main basic Models for the effective and successful implementation of change management:

1. Lewin’s Change management model consists of three phases unfreeze-change, and unfreeze (Lewin 1958),
2. The McKinsey 7S model, which consist of seven steps oriented toward the employee organization (Channon and Caldart 2015),
3. Kotter’s theory, which consists of eight steps oriented toward people’s effective management throughout transition period (Kotter 2018),
4. Nudge theory aimed at reducing resistance to change by respecting individual norms and increasing the efficiency of the transition period of change by eliminating time-consuming variables not connected with the change itself (Leonard 2008),
5. ADKAR model, an abbreviation for A-Awareness, D- Desire, K- Knowledge, A- Ability, and R-Reinforcement. A people-centred approach to facilitate change at the individual level (Hiatt 2006),
6. Bridge’s transition model aims to focus on transition of people´s mindset when dealing with change (Bridge 1991),
7. Kübler – Ross change curvature, which is used to support employees to go through a transition period and move forward to change (Kübler-Ross 1969), and

8. Satir change management model focuses on the emotions of employees going through change to manage the impact of these emotions on overall performance of employees themselves (Satir 1983).

This study suggests the utilization of Kotter's 8-step model to manage the change to a culture of visibility in the IWT following the steps of Figure 8-10:

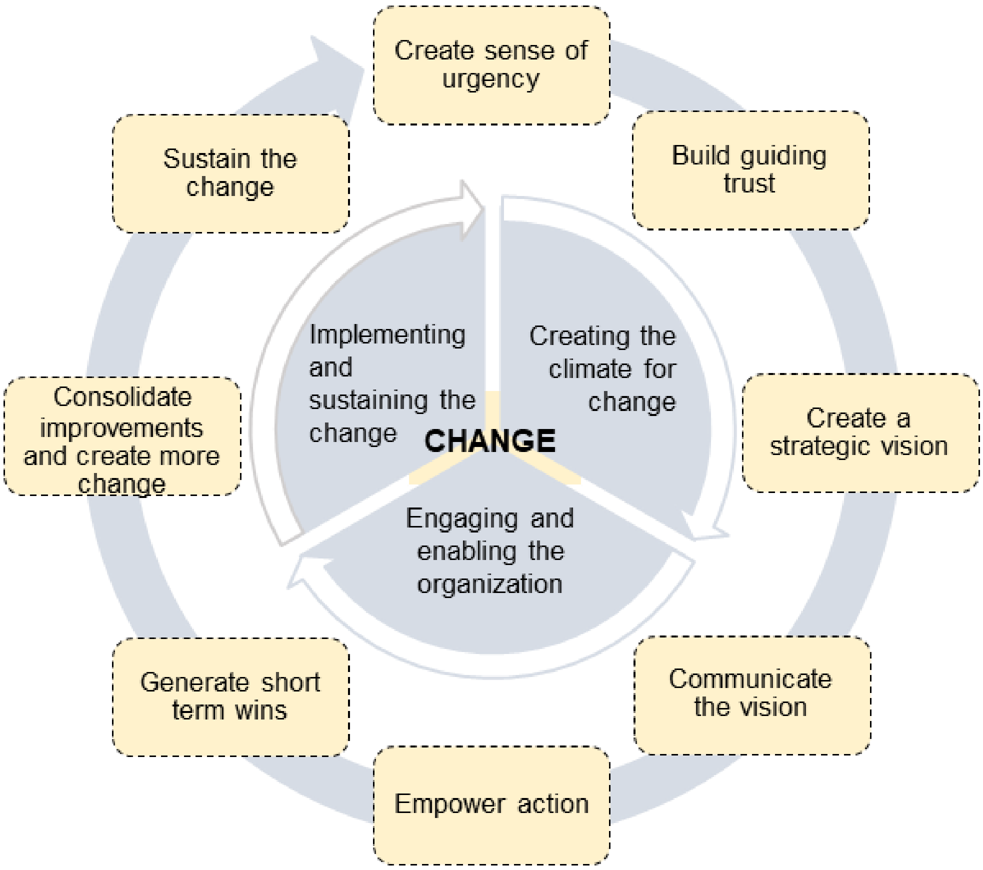

Figure 8-10 : Kotter's 8-step model (Kotter 2018)

1. Create a sense of urgency: Top leaders should describe, for the time being, the opportunity for the company to profit from the implementation of enhanced T&T based on the benefits mentioned above in Chapters 6 and 7,
2. Build a guiding trust: IWT companies should create a diverse group with members from multiple layers of hierarchy, performing different functions to promote the change to enhanced T&T,
3. Create a strategic vision: Targeted and coordinated activities should be designed to motivate people and provide meaning to their efforts to change the actual way of operation and take advantage of the opportunities related to the implementation of enhanced T&T,

4. Communicate this vision: The next step is to engage many employees with the strategic vision. Keeping the interest of this group throughout the change process is also essential as well as participants should be empowered and keep genuinely convince of the vision to hold the energy,
5. Empower action: Barriers to change should be identified and abolish, such as: bureaucratic practices, pressure to reach numerical targets, limited communication with stakeholders and change leaders, and silos working practices,
6. Generate short-term victories: Progresses in the track to implement enhanced T&T systems should be recognized and communicated to keep momentum and learn from success milestones,
7. Consolidate improvements and create more change: After the first successes in implementing enhanced T&T systems are achieved, more persistency is required to take profit of the momentum an keep the course of change over time. For this purpose, the strategic vision could be revised according to new urgency issues, more employees for the change should be recruited empowering them and removing possible new barriers for their contributions, and
8. Sustain the change: Now the achieved results should be institutionalized to be valid over the long term. A reflection about how the new behaviour leads to improvements and the communication of this reflection will be necessary. New practices should be anchored, and old ones replaced.

As supporting instrument to create a sense of urgency, create a strategic vision, empower action and formulate short-term wins, a SWOT (Strength, Weakness, Opportunities and Threats) analysis could be conducted. Following, Tables 8-2 and 8-3 present spreadsheet for conduction a SWOT analysis based on the TOE framework and (Iacovou et al. 1995) theory to support change management and adopt eT&T. Addition and or adequation of criteria should be done based on the company's values. For the assessment of relevance of each criterion, the Likert scale is used.

Strengths of eT&T implementation	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Comments
Improved reaction time and quality in the case of transport disruptions						
Support for the creation of new related services						
Better utilization of capacities						
Better planification of operations						
Smoother intermodal transshipment						
Generation of T&T data valuable for new performance metrics						
Automatization of transport data management						
Time and errors reduction on the administration of transport related data						
Increased customer´s satisfaction						
Increased business partners´s satisfaction						
Improved security and control levels for cargo to neutralize growing cargo theft trend						
Better access to JIT and JIS supply chains						
Legal constraints related to data protection shifted from vessel owner to cargo owner						
Shift from a pull to a push communication method						
Opportunities of eT&T implementation	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Comments
Imperative need for cargo visibility along supply chains						
No (direct) competitor in IW sector offering similar services						
Important potential market for the transport of palettized goods with barges into dense urban areas						
Growing interest of IW players to enter the digitalization era						
Growing interest of companies to improve their supply chain´s carbon footprint						
Pressure to reduce greenhouse gas emissions for the transport sector by almost 40% by 2030						
Concrete possibilities to multiply benefits when copling with other technological trends such as blockchain, IoT, cloud computing						
Synergy possibilities with past or running projects conducted in the company						
Possibilities for collaboration with partners to implement together the new system - resources and risk sharing						

Table 8-2: Spreadsheet for conduction of a SWOT analysis based on the TOE framework and (Iacovou et al. 1995) theory to support change management

Weaknesses around eT&T implementation	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Comments
Already existing vessel's tracking services through AIS						
Already existing EDIFACT message with pre-notifications of departing times from seaports						
Users will be reluctant to adopt a system only for one transport modality						
Missing legal framework to regulate responsibilities about wrong T&T data						
Need to develop interfaces with standalone companies' software solutions						
Doubts about the secure management of sensitive transport related data generated by the system						

Threats related to eT&T implementation	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Comments
Fear upon excesive visibility by IW players						
Complexity of data exchange formats - missing of standardization						
Fear of IW players to loss "direct" contact with partners - loyalty						
Low-digitalized groups in the IW sector						
Other problems with higher priority in the IW sector (water levels, seaport congestion)						
Challenges to close necessary data exchange agreements with high fragmented barge operator group						
Challenges to get the critical mass of users						
Scare resources of the company to conduct this type of project - IT, human, financial						

Table 8-3 : Spreadsheet for conduction of a SWOT analysis based on the TOE framework and Iacovou et al. theory to support change management (cont.)

Lack of clarity about the financial and operational benefits for tool users

Before investing, companies need to determine if the investment will result in a positive return. This means the new product, service, or procedure is worth investing in financial resources. For this purpose, key performance indicators help companies to objectively evaluate purchase/investment decisions. Additionally, calculating key performance indicators for the profitability of an expenditure provides unequivocal arguments when applying for technology funding.

A set of four metrics in Table 8-4 provides simple instruments to better appraise potential financial benefits for enhanced T&T users. For the definition and explanation of this set, the Book of (Rico 2004) “ROI of Software Process Improvement – Metrics for Project Managers and Software Engineers” was consulted.

Term	Description	Formula
Costs	Total amount of money spent on technology readiness	$\sum_{i=1}^{n} Cost_i$
Benefits	Total amount of money earned from technology implementation	$\sum_{i=1}^{n} Benefit_i$
B/CR	Ratio of technology benefits to costs	$\frac{Benefits}{Costs}$
ROI%	Ratio of return of investment	$\frac{Benefits - Costs}{Costs} \times 100\%$

Table 8-4 : Set of key performance indicators for the evaluation of profitability of an IT investment (Rico 2004)

<u>Costs</u>

Costs are the amount of money spent to run the eT&T system in the company. This could include the cost of the tool, new hardware, training, and travel expenses.

<u>Benefits</u>

The benefit is the amount of money that is saved when implementing eT&T systems. While costs are clear to identified, benefits might not be so obvious. Benefits of an eT&T could include the personal salary costs saved from doing telephone calls or visiting several websites/platforms to check cargo status.

<u>B/CR</u>

The B/CR ratio is the ratio of benefits to costs. It measures the economic magnitude of implementing the new eT&T system. If the B/CR ratio is 1:1, one Euro is earned for every Euro spent.

The system pays itself. A B/CR ratio of 2:1 means that for every Euro spent, 2 Euros are returned. The system is this last case, profitable.

ROI%

ROI quantifies how earnings increase after spending money to implement eT&T. A ROI of 5 % would mean that for every Euro the company invested, 5 cents are returned. As costs are subtracted from Benefits, ROI calculates profits. An investment with B/CR ratio of 2:1 has a ROI of 100 %. In other words, for every Euro invested, 2 Euros were earned. After subtracting the costs of the investment (1 Euro) from the earnings (2 Euros), the profit is the result (1 Euro). This profit of 1 Euro is as high as the cost of investment (1 Euro), what means the investment made one time its investment cost. Average ROI ratios are typical to each field. For example, research and development ROIs in a particular field could be around 2% normal while other sectors are around 24 %. Even a specific project in a particular sector could yield a 1000 % ROI. ROI should be then evaluated according to type of project and field. Market trends could as play a role.

Operational benefits were extended, identified, and fully introduced in sections 6.2 and 7.4. Additionally, this study suggests using Serious Simulation Game (SSG) to make these benefits more tangible for potential users. Issues related to decision making are significant, especially in the supply chain domain. Thus, several studies have been conducted to find methods to improve learning experiences. It has been proved that when participants can observe and conceptualize a problem, this means “playing” with it, providing more profound experiences than other methods (De Gloria et al. 2014). SSG is such a medium used with success to boost experimental learning in supply chain. Through SSG, a real-world problem is simulated, and the player can test different decisions to solve the problem and appreciate the resulting consequences of the system (Hidayatno et al. 2019). SSG helps players to understand the variables related to a problem that affects the performance of a system, providing a virtual lab to test solutions. Further, SSG can be a powerful tool to raise awareness about a problem and help formulate strategies to resolve then. Participation, interest, and joy are increased due to the dynamic play of SSG.

An example of a related SSG tool is the Inland Waterway Network Simulator (IWNS) developed within the Impuls Dynamic Traffic Management Waterways program of the Dutch Government. IWNS help in gaming sessions with practitioners to develop new logistics concepts for the inland waterway transport. An essential appreciation of the game developers is that IWNS proved to be very effective in stimulating discussions on innovations in the IW sector (Veenstra et al. 2015). In six sessions with 70 practitioners from ocean shipping lines, deep sea terminals, vessel operators, inland terminal operators, logistic service providers and port authorities, four selected concepts were designed and tested, from setting up a hub terminal to the re-use of empty containers in terminals. Participants developed scenarios in the digital environment, combine concepts, and evaluate the impacts of their new concepts in aspects such as waiting times, vessel utilization, costs, and emissions.

Achieving a critical mass of users to guarantee high coverage of market

"Getting a new idea adopted, even when it has obvious advantages, is difficult." (Rogers 2003)

As introduced in section 7.5 (BR-20), the service coverage for the implementation of eT&T is directly linked to the number of IW players adopting such a system to access to the relevant transport-related data. Thus, achieving a critical mass of users of eT&T is an important concern for any potential user. Technology diffusion plays a vital role in achieving this critical mass. Technology diffusion can be defined as "the process by which new technologies are adopted for use across individual firms in a given market, and across different markets" (Jaffe 2015).

A prominent theory that seeks to explain at what rate new technologies are spread is the DOI theory of (Rogers 1995). The DOI theory holds that diffusion of innovation is a social process determine by the adopters themselves, place or culture, communication channels and period (Rogers 2004). (Rogers 1995) observed that the diffusion rate (a portion of the population adopting an innovation) describes a normal distribution over time following and S-shaped curve as in Figure 8-11.

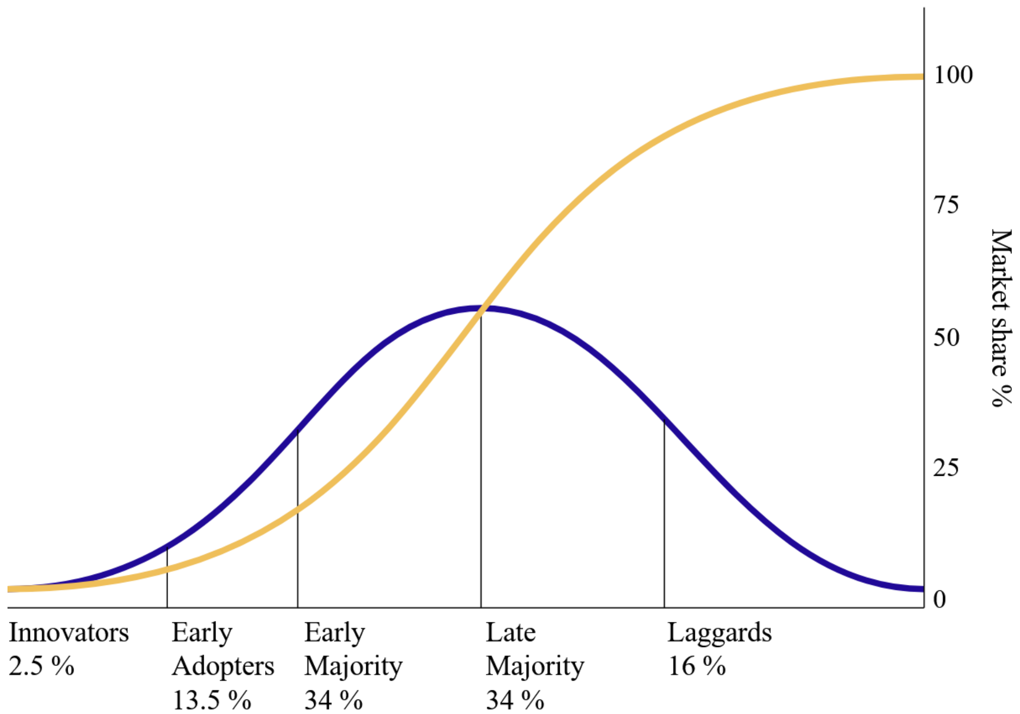

Figure 8-11 : Expect innovation´s adopter distributions over time (Rogers 1971)

Shortly explain, *innovators* are risk-taking; *early-adopters* pay attention to leader´s opinions; *early majority* deliberate more before adopting new ideas but like to stay ahead; the *late majority* are sceptical and adopt considering peers´ opinions; and finally, *laggards* are more suspicious of innovations and take longer in their decision process.

Additional to the characteristics of the potential users, the innovative product or service´s characteristics play a vital role in its diffusion according to the DOI theory. Thus, the innovation diffusion rate depends, according to (Roger 1995):

1. The degree to which an innovation is perceived as more advantageous than the traditional way (*Relative advantage*),
2. The degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential users (*Innovation compatibility*),
3. The degree to which an innovation is perceived as challenging to understand, learn, and use (*Innovation complexity*),
4. The degree to which an innovation is perceived as possible to learn by doing (*Innovation trialability*), and
5. The degree to which the results of an innovation are visible to others (*Innovation observability*).

Participants were asked to formulate the most critical requirements to develop in the II information transfer phase of the participatory-creative workshops. These requirements should be understood as the characteristics of eT&T as innovation for successful diffusion of the technology and wide market adoption. Out of the data collected, word-frequency count was performed, and the results were graphically represented in a tag cloud as in Figure 8-12, where terms are represented in sizes proportional to the number of times, they were mentioned over the four workstations.

Word-frequency count is a notion width applied for analysing text in qualitative research under the assumption that the words that are mentioned most often are the words that reflect the most significant concerns (Stemler 2001). Word-frequency count is increasingly used in big data analytics to extract valued information from large-scale, numerous and rapidly growing data sets (YanHong et al. 2018).

While counting word-frequency, it should be considered that synonyms may be used for stylistic reasons throughout the document and thus may lead the researcher to conclude wrong leading importance of a concept (Weber 1990). On the other hand, language issues play an important role in the meaning of the word. For example, “mobile” could refer to the adjective to be able to *move easily* or the noun *mobile phone*. Further, the question in which context a word was used should be addressed to ensure consistency of usage of words. Qualitative research software (e.g., NUD*IST, HyperRESEARCH, NVivo, ATLAS.ti, Provalis Research Text Analytics Software, Quirkos, MAXQDA) are equipped with features to pull up the sentence in which a word was used so that the word is related to a context.

For the analysis, closely associated words were grouped under common terms. For example, "Business model" was referred to in each of the four workstations as an essential characteristic of the new eT&T system to address successful adoption; "Mobile networks upgrade", on the other hand, was mentioned in only one workstation.

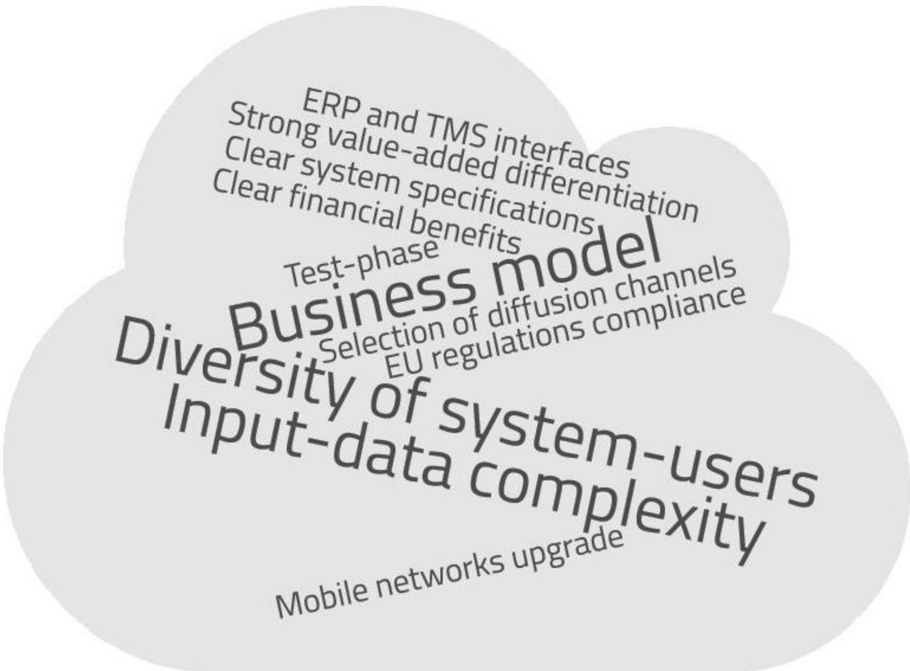

Figure 8-12 : Word-frequency count about eT&T required characteristics for successful adoption – Tag cloud

Out of the word-frequency count across participatory-creative workshop´s workstations, it could be concluded that *Diversity of system-users* -meaning wide-spread use of the eT&T system across the different IWT players- is a fundamental issue for the successful adoption of eT&T in the IW sector. This is understandable as the value of the eT&T depends significantly on the multiplicity of sources to assure complete chain visibility with detailed and reliable transport-related data. Further, only a comprehensive system network assures the utilization of single to fewer systems and the corresponding time/costs savings. To achieve this necessary high diversity of system-users, it is imperative to consider the expectations of the different players groups (potential users) of the eT&T system so that the final solution provides a tangible value added to all groups.

The *Business model* aspect is the second principal concern for the successful adoption of eT&T in the IW sector. Here are aspects such as the solution costs for the implementation and operation of high importance as they play an essential role in calculating the key performance indicators for evaluating the profitability of an IT investment at each company.

Input-data complexity is the third most important aspect. This denotes the faithful consideration of all necessary input-data that the eT&T should manage to ensure differentiation from traditional transport-related data management ways. According to participatory-creative workshop participants, the eT&T system´s database should manage the following:

- Data from AIS,
- Data about the inbound and outbound transport,
- Data from waterways and shipways office,
- Data about the status of the cargo,
- Data about the status of waterway network (water levels and events in river, canals, locks),
- Timetable of passenger vessels,
- Data from terminal occupation levels, and
- Planning board of dispatcher.

8.2.2. Brakes related to training and cooperation

<u>Cooperation</u>

Low-digitalized groups very present in the IWT sector - training

Finding the adequate measures to overcome this brake appreciation is largely based on contributions from the book “Managing Technology and Middle- and Low-Skilled Employees” from (Hughes et al. 2019). Although this thesis does not aim to develop a Roadmap to manage the implementation of eT&T among middle- and low-skilled workers in the IW sector, some thoughts are shared. They should be considered as a spark for further discussion. Besides the cognitive side of this issue, a physiological aspect is worth mentioning. Technology implementation is coupled with increased user anxiety as users fear being replaced by technology, which can only be alleviated with good communication strategies (Hughes et al. 2019).

Adopting an eT&T is mainly seen as training rather than a learning process. Therefore, reskilling, and upskilling opportunities for eT&T users should be well formulated and explained to clarify the new pallet of opportunities for the middle to low-skilled workers in the IW sector that are expected to interact with the eT&T system. Parallel to caring about existing workforce, the IW sector should focus on recruiting new ones. A recruitment structure with innovative and well-designed programs or activities increased the probability of attracting high-quality candidates with the required knowledge and abilities. Visit days, immersion programs and mentoring offers are some examples. The recruiting of younger digitalized workers could parallel promote the creation of mentoring programs between new and older workers. Mentoring relationships have multiple advantages; the training process becomes more human thanks to personal interaction, leading to greater satisfaction, respect, and contribution to a legacy. In a reverse mentoring relationship, the junior employee shares with the senior technological expertise and generational perspective (Murphy 2012).

Regarding cultural aspects, the digitalization of workforce in the IW should not be promoted for specific projects like the implementation an eT&T system but be deeply founded as a lifelong learning looking to increase workers´ well-being.

Finally, in a study it was found that the low participation in training among low-skilled adults and older workers obey several factors that for the average European worker were mainly three obstacles found: family responsibilities (23%), work schedule (22 %) and cost (15%) (Eurostat 2007). Job Training (OJT) could be a way to overcome these training-participation obstacles.

Challenges for closing data exchange agreements and achieve tool-full coverage- cooperation

Trust is a decisive factor in ruling data exchange agreements (DSA). Clear rules that define a fair and trustful management of data are fundamental to govern the access to and exchange of data between stakeholders in a big data analytics lifecycle. Thus, the lack of a legal regime limits the various actors to implement data-driven innovations. The European Commission issued Guidance on sharing private sector data in the European data economy to tackle this challenge. The guidance defines principles for a proper management of data as displayed in Table 8-5 and aims to promote commercial actors´ participation in new data economies.

Principle	Requirement for DSA
Transparency	Identify transparently and understandably the users that will have access to the data, the type of data, level of detail and the purpose of use.
Shared value creation	Recognition of the several parties that contributed to create the data.
Mutual respect of commercial interests	Recognize the need to protect data holders´ and users´ commercial interests and secrets.
Ensure undistorted competition	Recognize the need to ensure undistorted competition when exchanging commercially sensitive data.
Minimization of data lock-in	Allow and enable data portability as much as possible. Offer the same product or service without or with only limited data transfers where possible.

Table 8-5 : Principles for business-to-business (B2B) data sharing (EC 2018)

Brake [BR] Nr.	Brakes	Measure	Type
BR-1	Multiple sources of disruptions in IWT (congestions, low water levels)	Consideration of this multiple sources of disruptions on the tool-engine	Technological
BR-2	Potential users would rather prefer single tools with information for multiple transport modes	Future enhance of tool boundaries to include other modes of transport than IWT	Technological
BR-3	Uncertainty about responsibilities (who will pay e.g. demurrage charges) when eT&T information is wrong	Establishment of legal provisions to define responsibilities in the case of wrong eT&T informations	Legal
BR-4	Complexity of exchange formats	Exchange formats of tool should be easier to understand for all IWT stakeholder groups	Technological
BR-5	Fear of IWT operators to lose contact with customers and jeopardize loyalty due more "impersonal" digitalized processes	Other services to maintain this customer loyalty should be added to the IWT operators portfolios	Ethical
BR-6	Actual lack of standardized and modularized data structure for the data exchange	Delivery of a standardized and modularized data structure for all players	Technological
BR-7	EDIFACT messages with pre-notifications of departing times already exists for IW cargo coming from seaports	Tool focus for other cargo movements rather than the ones going overseas	Technological
BR-8	Tracking of vessels already possible	Offer of more specialized services with more reliable data than these platforms	Technological
BR-9	Lack of a culture for visibility on the IWT	Clear and detailed definition of the benefits for users when adopting these systems	Organizational
BR-10	Low-digitalized groups very present in the IWT sector	Back-door solutions should be offered for these groups and/or tool-user friendliness should be a main concern	Organizational
BR-11	Different problems (other than visibility) with higher priority for IWT users such as seaport congestions, low water levels	Exploration how intended eT&T systems could contribute to address this problems (directly or indirectly)	Organizational
BR-12	Large amount of "one person" companies (vessel owners) increases efforts for closing data exchange agreements and achieve tool-full coverage	Begin implementation through barge associations	Organizational
BR-13	Lack of clarity about the economic and operational benefits for tool users	Clear estimation/definition of economical and operational benefits that supports the investment	Organizational
BR-14	Fear of IWT operators generating "to much" information with the eT&T system	Clearly definition of what information is mandatory for the eT&T and should be collected and which not	Technological
BR-15	Fear of tool users about the transparent use, storage and administration of data collected on eT&T system	Definition of clear "Data Protection" mechanism	Technological
BR-16	Fragmentation of the IWT sector makes establishment of uniform systems difficult	Extensive Roll-up plan considering the interest of all these different groups	Technological
BR-17	T&T for dangerous goods not seen yet as necessary as all transported through tank vessels	Exploration of shifting cargo volumes to the IWT with other cargo types (waste, fertilizer) to be transported on standardized containers/boxes	Organizational
BR-18	Differences along national regulations are a challenge for achieving a single standardized tool for all players	Consideration of inputs from Governance Oriented Analysis	Legal
BR-19	Fear of users about increase of fraud and misued of T&T data for illegal purposes like cargo theft or legal ones like creation of stronger regulations	Protection of eT&T data through high-security technologies such as Blockchain	Technological
BR-20	Achieving critical mass of users to guarantee high coverage of market	Extensive Roll-up plan considering this issue	Organizational
BR-21	Developments toward new mobile networks (5G) to cope with	Monitoring and pro-active tool-maintenance to keep it upgraded	Technological

Table 8-6 : Summary of measures to overcome barriers to the adoption of enhanced T&T systems for more sustainable operations in the IW

9. Conception of a causal model

In this chapter, a causal model will be set up to address the analysis of eT&T implementation for more sustainable operations in the IWT holistically. In the opening chapter, section 9.1 introduces the modelling approach. Following this, section 9.2 examines the details of the model, discussing its purpose and assumptions in sub-section 9.2.1, considerations regarding granularity in sub-section 9.2.2, and the setup of the model in sub-section 9.2.3, as well as the selection of model elements in sub-section 9.2.4. Section 9.2 describes the SusInWa model for evaluating the implementation of information exchange technologies towards sustainable operations in the IW sector. Section 9.3 provides insight into the methodology used to assess the validity of this model. Chapter 9 concludes by examining the resulting model and reflections in section 9.4.

9.1. Modelling approach

Through the comprehensive evaluation of the benefits and brakes of eT&T systems for IW in Chapters 6 and 7, accompanied by the development of supplementary layers for analysis in section 8.1, as well as the establishment of measures to overcome obstacles in section 8.2, it has become apparent that the study system is quite intricate and challenging. As a result, a complementary approach is being utilized to enhance the systematic analysis of the issue.

(Besiou and Van Wassenhove 2015) suggested that rather than jumping straight into using complex classical optimization models like operation research to address socially responsible issues. First, it is advisable to conduct alternative soft methodologies to understand the entire system before optimizing parts of it. Sustainability is a complex concept that encompasses economic, environmental, and social dimensions. The detailed model presented into this step-by-step approach enhances understanding of the system´s overall behaviour before conducting further studies.

By utilizing Systems Thinking, individuals can effectively navigate complex systems and maintain the delicate balance between various factors over the time. Systems Thinking could be defined as “a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviours, and devising modifications to them to produce desired effects. These skills work together as a system.” (Arnold and Wade 2015).

This systems approach considers complexity by moving away from linear relationships to circular ones involving multiple factors, even those that may not seem related at first glance. Additionally, it encompasses the effects of feedbacks, accumulation, and time to provide a more comprehensive global picture. After completing this exercise, a causality diagram will be elaborated, offering a valuable representation of the entire system.

Nevertheless, several limitations and challenges associated to causality modelling have been identified by multiple authors. (Currie et al. 2018) comply with these findings and group them into user-related, and technical limitations and challenges. In this study, we have provided additional information and identified limitations specific to using IW transportation. These challenges arise due to the unique nature of this mode of transportation. The compiled data can be viewed in Table 9-1. We considered the challenges and limitations during the model development process and implemented solutions.

Serie	Limitation / Challenge
User-related	Model´s users not closely involved in model-making process struggel to understand and trust the model and its results.
	Complexity of causal model may make difficult for users to understand the details and have the perception that the problem is so complex that is not feasible to tackle.
	Potential unwillingness of model´s users to be open for new perceptions / beliefs about the problem.
Technical-related	The inclusion of subjective variables whose behaviour may be influenced by interpretation-bias.
	Key variables being unintentionally omitted from the model due to uncertainty resulting from complexity.
	The inclusion of parameters whose values are unknown and cannot reasonably be estimated.
	The accuracy and comprehensiveness of the model depends heavily on the inclusion of an appropiate mix of stakeholders-insights.
	The model provides rather than an specific direction, possible future trends and relative magnitudes of impact.
IW-related	Precarriage and Oncarriage transports with consequent transhipment into further transport modalities (train/road/maritime) increase the complexity of the IW transport and therefore the modelling.
	IW is the transportation mode the most challenged by weather conditions, specially low and high water levels phenomenom, what makes difficult the evaluation of such variables in models.
	IW by nature takes place over dedicated networks (rivers and canals) and specialized infrastructure and equipment are needed for loading/unloading processes at transhipment points. To include this infrastructure factor is demanding.
	Historical evolution of industry has a strong influence on IW market constellation. This makes difficult to cover the different and several stakeholders interests.
	The differences in network´s infrastructure/equipment, cargo type, navigation conditions and legal framework between the several IW Corridors struggel modelers and decision makers to generalize model´s outcomes.

Table 9-1 : Limitations and challenges associated with causality modelling in general and specific for the IW with information from (Currie et al. 2018).

9.2. Model description

In this section, we provide a thorough description of the model. Creating detailed documentation of the model-building process is a fundamental aspect of the philosophy and ethics of technology behind this study. To ensure the proper utilization of models, modellers must provide potential users with ample information. This includes the model´s purpose, assumptions, building process, underlaying logic and variables. By doing so, potential users can fully comprehend the model, assess its efficacy, and acknowledge its limitations. Ultimately, this will enable users to apply the model effectively.

9.2.1. Model´s purpose and assumptions

The causal model should serve the purpose of understanding which specific factors and how their behaviours can affect the implementation of IS technologies such as eT&T in the IW sector for more sustainable operations.

The following conditions should be met before inferences regarding the model are drawn and before the model is used to analyse the implementation of IS technologies such as eT&T in the IW sector for more sustainable operations. These conditions built the model assumptions:

1. It is assumed that social factors (familiar tradition, personal or gremial preferences) related to the adoption of new technologies in the IW are defined by the system´s user satisfaction,
2. The level of participation in addressing climate change among potential technology users is believed to be connected to productivity factors and motivations for implementing new technologies in the IW sector,
3. It is assumed that traceability over the inland waterway ledge suggest implies traceability over further transport legs. This is possible as T&T systems are already widespread e.g., over road transportation. Furthermore, transportation ledge from IW transhipment points to destination are usually at the city or regional level (short distances), and
4. IW stakeholders are expected to demonstrate flexibility and adjust their actions in response to political, economic, social, and ecological changes.

9.2.2. Considerations about granularity

Finding a suitable level of granularity in a model is crucial to ensure that the model is as detailed as needed to achieve the selected target (purpose and audience) without confusing the users or distorting the results. In our study, we adopt the definition from (Maier et al. 2016) to define granularity of a model as “a manifestation of the level of detail in which it represents its target system.” (Maier et al., 2016) This is determined by the number of components in the model and the type of connections between them.

When choosing a model´s level of granularity, there is a trade-off to consider. Highly complex models can be difficult to calibrate and achieve an “equilibrium”, while precise models may still be inaccurate. Conversely, simple models may fail to represent the real world accurately. Life is complex, and it´s essential to quantify uncertainty. To determine the appropriate level of granularity, we evaluated five factors summarized in Table 9-2.

	Model´s Factor [Selected granularity]	
Low	Desired model´s reproducibility [2]	High
KPI estimation	Model´s purpose [2]	Understanding
Long	Development time [3]	Short
Detailed	Data quality [2]	General
Experienced	Target audicence [3]	Mixed

Table 9-2 : Factors evaluation for selecting the model´s granularity

Selecting between a coarse-grained (granularity level 1) and a fine-grained (granularity level 4) model depends on the appreciation of following factors:

1. The desired model´s reproducibility was set at a granularity level 2 since the model is expected to be used for similar studies. Nevertheless, assessing a high model´s reproducibility (level 1) would be only possible with a too-general model,
2. Model´s purpose was set at a level 2. As explained in the introduction, this is an exploratory study, but more than understanding, the model should allow us to analyse the system,
3. Development time was set at a granularity level 3. Development time is not a limitation,
4. Data quality was set as level 2. Through interviews, participative creative workshop, field immersion, and literature review, we gathered significant insights in form of written text. These insights were more specific than general data, and
5. The intended audience for the model was set at a granularity level 3 to make it understandable to a broad range of people. However, the primary focus is providing a valuable tool for IW stakeholders. Consequently, a high level of granularity is required to ensure that all relevant variables and complex relationships are incorporated.

As a result, a granularity level 2 was appraised for the causality model.

9.2.3. Setting up the model

In this study, the graphical representation of the model effectively captures, synthetizes, and materializes the knowledge gained. It also documents and visually presents the findings explained in Chapters 6, 7, and 8. We aim to create a causal model that will efficiently organize and combine information, considering multiple perspectives. This will ultimately result in a clear visual representation of the study results.

To develop the causal model, we analysed the results of interviews and the participatory-creative workshop and formulated variables for the model using the connection circles technique. This technique helps identify causes and effects between variables and is an intermediate step towards creating the causality diagram. The initial version of the connection circle had 36 variables with 630 potential connections, but after refinement, the final version includes 28 variables with approximately 50 references, as shown in Figure 9-1.

Figure 9-1 : Connection circles with factors influencing the implementation of eT&T in the IWT for more sustainable operations

On the connection circle, the variable´s names act as a noun and the links are actions that represent how a variable affects another one. Once the variables are identified and the connections between them drawn, we can "walk" through the loops and "tell the story" to be sure the loops capture the system´s behaviour. For example, the *advances in supporting communication technologies* can contribute to the *creation of new information-related services* that allow IW players to gain a *service differentiation* with new transport products and expand business portfolios to obtain market niches of *small-scale freight volumes*.

9.2.4. Selection of model elements

The connection circles act like a spider web, and variables are now rearranged, without alteration of the relationships, to let the causality diagram of the model emerge. Table 9-3 lists the model´s variables. Various variables were identified: economic, legal, market organisation, company/organisation, process, and technical/technological. Moreover, five additional variables were discovered, resulting in 33 variables in the connection circle. Each variable is accompanied by the section in this document that explains and justifies its selection. The abbreviation "BE" stands for Benefit, and "BR" stands for Brake, as referenced in sections 6.2, 6.3, 7.4, and 7.5.

Type	Nr.	Variable	Source in study documentation
Economical	1	Cargo movement metrics	BE-8, BE-24
	2	IW capacities utilization	Section 6.2. and BE-4, BE-6
	3	Cargo status check time-savings	Section 6.2. and BE-10, BE-11, BE-17
	4	Reaction time when disruptions	Section 6.2. and BE-10, BE-17
	5	IW Travel times	Section 6.2. and BE-3, BE-5, BE-6, BE-7
Legal	6	Data protection regulations	Section 2.3.2. and BE-14, BE-23
	7	Harmonization of data exchange protocols	Section 6.2. and BE-9, BR-18
Market	8	Evolution of small-scale freight volumes	BE-13
	9	Adoption of IW in city logistics	Section 2.3.
	10	IW-Market fragmentation	Section 2.1.4. and BR-12, BR-16
	11	Volume of high-value or sensitive cargo	BE-21
Organizational	12	Action level in climate change	BE-16
	13	Cooperation forms among IW operators	Section 2.3.2.
	14	IW user-operator long-term relations/contracts	Section 2.3.2.
	15	Services differentiation	BE-12
	16	Creation of new information related services	Section 6.2. and BE-3, BE-5
	17	Just-in-time SC	BE-20
	18	Cooperation with other transport modes	BE-7
	19	IW integration in synchromodal chains	Section 2.3.2.
	20	Complexity of information sharing process	Section 3.1.3.
	21	Attitude toward information sharing	Section 3.1.3.
Process	22	Number of data exchanges per Trip	BE-17
	23	Process image	BE-18
	24	Risk of cargo theft	BE-14
	25	Black-box image	BR-9, BE-16, BE-18
	26	Advanced analytics	BE-12
Technical	27	Port-city infrastructure	Section 2.1.5.
	28	Number of small ships	Section 2.3.2.
Technological	29	System´s user satisfaction	Section 3.2.1.1.
	30	IW operator´s digitalization level	Sections 2.3.1, 2.1.6. and BR-10
	31	Critical mass of eT&T users	BR-20
	32	Advances on supporting communication technologies	BR-21
	33	Multimodal tracking coverage	BR-2

Table 9-3 : List of model´s variables

New variables were added in Table 9-3, and the final model is displayed in Figure 9-2. The model is named SusInWa for convenience in referring to it in the document. Self-balancing feedback loops are visually distinguished by different colours. The causality model´s flow can be traced by examining each loop that consists of closely related variables. The diagram shows eight primary feedback loops:

Technology adoption loop (brown-coloured loop): The digitalization level of the system user (*IW operator´s digitalization level*) affects the *advances in supporting communication technologies* in the IW sector. These advances are relevant for the *creation of new information-related services* that allow a *service differentiation* strategy for IW stakeholders. These new services stay in direct relationship with the increase in *IW user-operator long-term relations/contracts*. When it comes of T&T technologies, the way IW operations are perceived as a "black-box" can significantly impact the maintenance of long-term relationships and contracts. Nevertheless, only a *critical mass of eT&T users* can positively affect the chain visibility and reduce this negative image.

River city logistics approach loop (purple-coloured loop): The *adoption of IW in city logistics* directly impacts the *evolution of small-scale freight volumes*. This evolution requires the necessary *advances in supporting communication technologies* to make it possible. This synergy has an impact on the *creation of new information-related services*.

Market expansion loop (dark green coloured loop): The *evolution of small-scale freight volumes* in the IW largely depends on the *advances on supporting communication technologies* that enable the trace and tracking of products (rather than vessels) and the availability of *port city infrastructure* to facilitate the transhipment of *small-scale freight volumes,* especially in densely populated areas. Such IS technologies are essential for a comprehensive *multimodal tracking coverage*. This can determine the *attitude toward information sharing* in the sector and is vital for new *cooperation forms among IW operators*.

Cargo security loop (light green coloured loop): The *volume of high-value or sensitive cargo* transported through rivers and canals is influenced by the perceived *risk of cargo theft* in supply chains involving the IW. However, this risk perception is mitigated by the *multimodal tracking coverage*.

Supply chain disruptions loop (red coloured loop): The *multimodal tracking coverage* helps improve reaction time in the event of disruptions, what can significantly impact *cargo movement metrics*.

Supply chain coordination loop (light blue coloured loop): The *IW coordination with other transport modes* promotes the *IW integration in synchromodal chains* affecting *IW capacities utilization*.

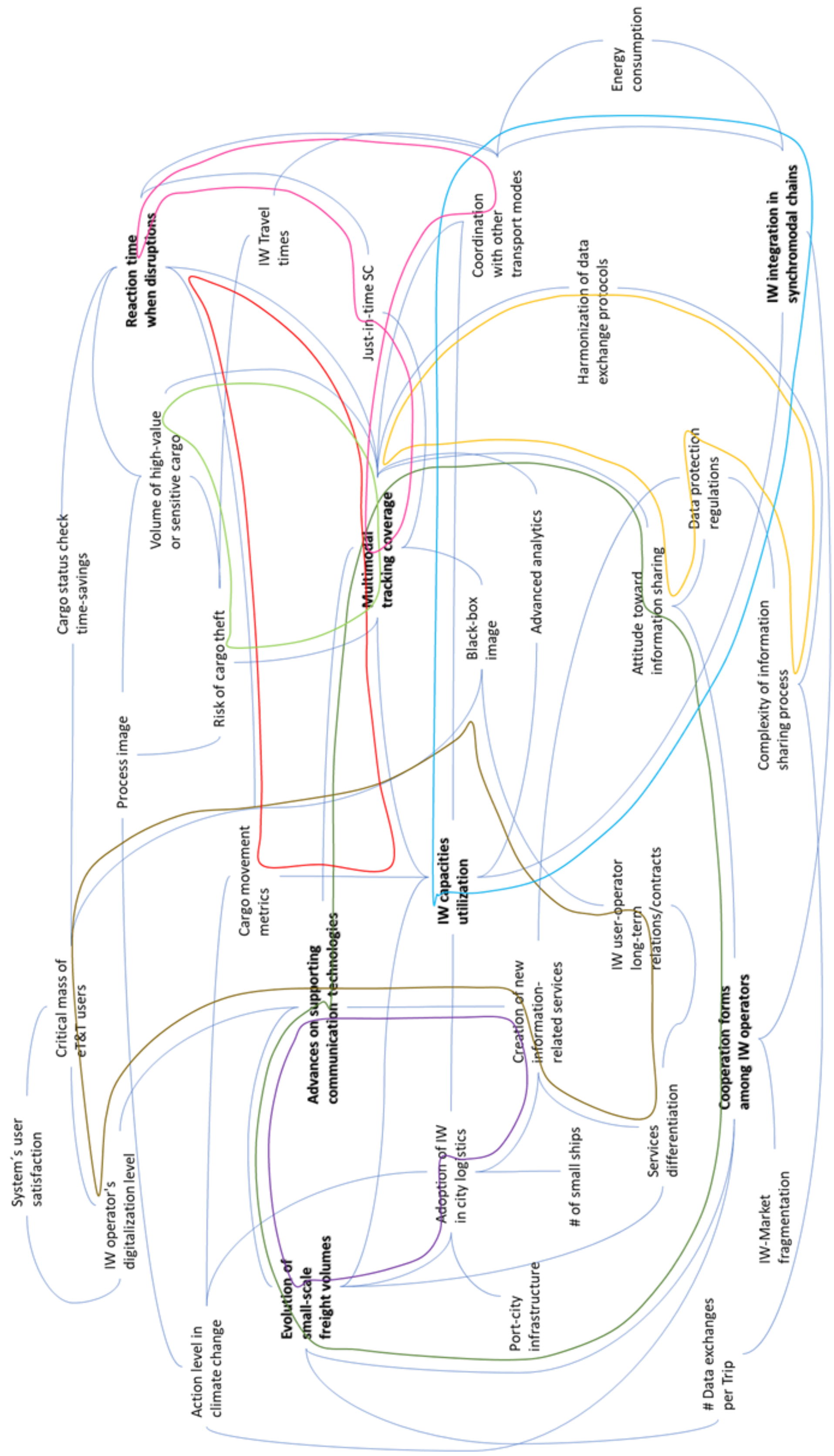

Figure 9-2 : Causality model for evaluating the implementation of information exchange technologies for more sustainable operations in the IW sector with loops (SusInWa)

Information sharing process loop (yellow coloured loop): *harmonization of data exchange protocols* and *data protection regulations* determine the *complexity of information sharing process*. The extent of *multimodal tracking coverage* is directly linked to the *attitude toward information sharing* (from a market perspective) and the *harmonization of data exchange protocols* (from a technical standpoint) that are necessary for enabling *multimodal tracking coverage*.

Supply chain resilience loop (pink coloured loop): the *reaction time when disruptions* in the IW set off the level of *coordination with other transport modes* and incorporation of IW in *Just-in-time SC* because of *multimodal tracking coverage*.

9.3. Assessment of the model´s validity

We first considered the philosophical and ethical issues to assess the model´s validity, as discussed in section 1.8. Introducing ethical considerations promotes a reflective process throughout all stages of model conception, encouraging self-criticism. The author´s clear discourse and inclusion of all necessary information to justify the work done, can be greatly appreciated throughout the modelling process. This gives the reader a solid initial impression of the model´s validity. However, additional measures should be taken to conduct a formal assessment.

Model validation may be defined as the process of establishing confidence in persons not directly involved in model construction about the usefulness of the model to achieve its purpose (Barlas 1994) (Forrester and Senge 1980). After constructing the model, a series of validation activities were carried out to ensure its validity through structured and rigorous assessment. This is known as formal validation. Due to its causal nature, the validity assessment of the model developed in this study differed from the physical ones. A causal model is a way of describing a system, and this can be done in many possible ways. “No model can claim absolute objectivity, for every model carries in it the modeler´s worldview. Models (causal ones) are not true or false but lie on a continuum of usefulness” (Barlas and Carpenter 1990). The assessment of validity of the causal model developed in this work hinges on this principle: evaluating the model´s worth for its intended purpose.

There isn´t a sole test to validate causal models; however, multiple tests enable a gradual boost in confidence within a model as each test is successfully completed. Every test provides a valuable opportunity to explore deeper into the studied system and improve the model itself. In the first exercise, the model was tested using a checklist proposed by (Coyle 1996):

1. Does the model purpose match the target audience?
2. Are the model components consistent with the purpose?
3. Are the relationships clearly shown in the diagram?

4. Are exogeneous factors that might present setbacks or opportunities identified in the model?
5. Are elements easy to understand by target audience?
6. Do variables express a time-changing notion and can be measured over time?
7. Is the model neat, with a minimum of lines crossing?
8. Can the model be redrawn to be one level lower or higher without losing conceptual consistency?

Analysis of questions 1. to 7. arose positive results; for question 8, it was necessary to build new model representations. The resulting image of the *SusInWa* model aggregated to a level 1 and decomposed to a level 3, are enclosed in Appendix L and Appendix M respectively.

For the formal assessment, the structure of the model was tested. By structure of the model should be understood as the objects in the model and the relationships between them. Figure 9-3 displays the formal validation steps followed for the *SusInWa* model.

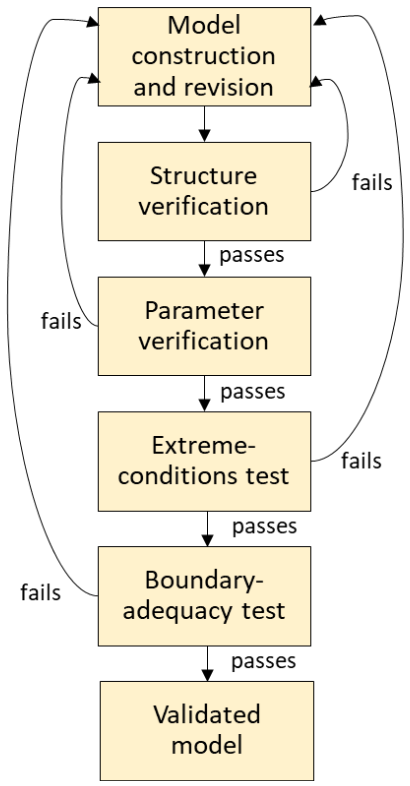

Figure 9-3 : Logical sequence of steps for formal validation of the SusInWa model

Once the model was complete, the first test was conducted: the structure verification test. In this step, the structure of the model was compared against the structure of the real system (Forrester and Senge 1980). For this purpose, model assumptions were first reviewed. Then the structure of the model was reviewed against empirical and theoretical knowledge gained about the system in the IWT system introduction (Chapter 2), Theoretical framework (Chapter 3), Proposition and validation of benefits and brakes (Chapters 6 and 7), as well as Review of propositions (Chapter 8). The model failed the structure verification test if important objects were missing in the model to resemble real life. If so, the model was revised and improved. When the structure verification test was successful, parameter verification took place. This test aimed to compare the model´s parameters to the knowledge of the real system and determine if they aligned with each other (Forrester and Senge 1980). Structure and parameter verification are very interrelated steps, and the same empirical and theoretical understanding of Chapters 2, 3, 6, 7, and 8 served as the basis. Furthermore, the model representation on the granular level 3 (Appendix M) was a reference input. After constructing the model parameters to reflect the decision-making process, the subsequent stages involve testing its validity through an extreme-conditions test. If failed, the model was revised and improved. The extreme conditions test was conducted to verify if the model allows for analysis of the system´s performance in extreme conditions (Forrester and Senge 1980). For the *SusInWa* model, the following harsh conditions were evaluated:

1. No stakeholder was willing to share T&T information,
2. Small-scale freight volumes in the IW sector increased to infinity plus, and
3. Users were overwhelmed with T&T data, and satisfaction with system decreased to minus infinity.

For the extreme-conditions test, brakes identified in Chapters 6 and 7 and their implications were the primary sources for the analysis. If the model could not adequately analyse extreme conditions due to limitations in its structure or parameters, the test would fail, and the model would be revised. It is crucial that the model objects and relationships between these objects replays these extreme conditions. The successful test-execution leads to the final validation step, the boundary-adequacy test.

To ensure the boundary-adequacy test was successful, we verified if the model aggregation was suitable and if all relevant structures were included to address the target purpose effectively. For this assessment, it was crucial to confirm if the model had all the essential sub-systems, their interconnections, and the focus system of the study. After aggregating the model variables and making the sub-systems visible, the system´s behaviour was studied for the formulated purpose at granular level 1 (Appendix L). The aggregated model representation was thoroughly verified and checked to ensure all necessary sub-systems were built. To verify the information, the inputs considered were the introduction of the IWT system from Chapter 2, the theoretical framework presented in Chapter 3, and the technology adoption concerns addressed in Chapter 8. After undergoing thorough validation, the model must encompass not only technological and economic aspects but also legal, market, and organisational factors and how they interact with the focus system. This approach ensures a holistic analysis of eT&T implementation for sustainable operations in the IWT.

9.4. Analysis of result and discussion

The *SusInWa* causality model is a helpful tool that visually represents the complexity of the matter and serves as a common reference point for all parties involved in this subject. The main objective of using the causal model is to gain insight into how certain factors and their actions impact the system. This model is valuable for making informed decisions in present or future processes. In addition, it assists players by offering tools to facilitate productive discussions, helping to identify opportunities and risks for making more informed decisions, even when dealing with players from different sectors. The model´s various elements are rich, and a glance at the diagram provides valuable dynamic insights.

Nowadays, there is a widespread notion that Tracking and Tracing Systems have a limited effect on monitoring the logistical flow of goods or serving as a control instrument for consumer protection to ensure product quality. However, the model aims to improve this perception. As T&T systems are implemented, they give rise to more complex constructs. The model proves that diversification of freight type in the IW could lead to new constructs such as the emerging of new services and new distribution concepts in urban areas. For this evolution in the IW sector, it is not only important to have the interest and involvement of companies but also essential components like infrastructure (public or private), ship manufacturing, and technology developers. This information and the knowledge-sharing processes are anticipated to lead to the development of novel collaboration methods among IW operators. This will affect the overall perception of information sharing in the sector. Certain conditions need to be met to ensure a positive progression in this area, such as uniform data exchange protocols, strengthened data protection regulations, and simplified information-sharing procedures.

Implementing eT&T in the IW sector can improve coordination with other transport modes, making it easier to integrate into synchromodal chains. This will impact the utilisation of IW capacities and the energy consumption. The IW network has been redefined, with increased visibility and transparency in the process. This has made it a more appealing transportation mode for high-value and sensitive cargo and new commodities that require just-in-time delivery. It is important to note that the successful adoption of eT&T relies heavily on many users to attain seamless coverage. Therefore, based on the data, user satisfaction is crucial to the system's success. It can be inferred that eT&T information and knowledge-sharing systems significantly contribute to the overall sustainability of IW networks. They are considered essential catalysts in promoting sustainability across various dimensions.

Remembering that this model cannot be seen as final is crucial. The Systems Thinking approach acknowledges the dynamic nature of things, what means that things evolve. As a result, new changes may require adjustments or even an expansion of this model. The model is a reliable and significant foundation for assessing the impact of new Information Exchange technologies, like eT&T, on the IW to achieve sustainable operations. Moreover, the model possesses predictive capabilities that can serve as a benchmark for comparative research and enable an analysis of the effects of introducing innovative technologies across a broader range of legal, societal, environmental, and market contexts.

10. Summary and Conclusions

In this chapter, the author will summarise the accomplishments of this thesis, emphasise the significant contributions of this research and lay out a direction for future work. Section 10.1 will provide an overview of how the work addresses the research gap identified and answers the primary research question. Section 10.2 will summarise the key contributions made by this thesis to the current literature. Lastly, considering the scope and achievements of this thesis, section 10.3 will take a reflective approach towards future research.

10.1. Findings

Given the challenges posed by climate change, it is crucial to utilise the available capacity-reserves of more sustainable transportation modes, such as inland waterways. To achieve this goal, developing concepts that can effectively organize cargo flows and seamlessly integrate inland vessels into multimodal logistics chains is essential. This research has identified a gap in this area, leading to the primary focus of this work: ***„How can new enhanced Tracking and Tracing systems support more sustainable Inland Waterway Transport operations?”*** Four sub-issues were addressed in detail throughout this study to answer this question.

The initial aim was to identify *which benefits arise from the implementation of enhanced Tracking and Tracing systems for small-scale freight transport*. To gain a comprehensive understanding of the matter, the study focused on the perceptions of various stakeholders in the IWT industry and potential system users. Chapters 6 and 7 employed two methods - expert interviews and participatory-creative workshops - to triangulate the benefits. The results were compiled in Tables 6-1 and 7-2.

The second concern was to identify *how these benefits have repercussions on the sustainability of inland waterway networks*. Through content analysis of expert interviews and a participatory-creative workshop, we identified how eT&T could support more sustainable operations in IWT. The results of this analysis are fully described in sections 6.2 and 7.4 To enhance the findings, categories were established to identify relationships that aid in the interpretation process of describing how new eT&T systems can support more sustainable IWT operations. First categories determined for which sustainability dimension(s) (economic, social, and environmental) does a benefit contribute for; and set the player group that takes the largest profit. Additional categories determine the level (business, administration, operative, political, societal, and scientific) and the manner (transparency, security, reliability, timeliness, and efficiency) in which each benefit affects the overall impact. The final set of categories, as identified by (Bonini and Görner 2011), offers various ways to create value. These include exploring new markets, innovating, and introducing new products, optimizing business portfolios, promoting green sales, and marketing, establishing sustainable value chains, optimising operations for sustainability, managing operational risk, preserving reputation, and complying with regulations. Tables 6-1 and 7-2 summarizes these findings.

The third aim was to identify *which are the impediments to implement enhanced Tracking and Tracing systems in inland waterways*. We gathered information through expert interviews and participatory-creative workshops to understand the benefits. Chapters 6 and 7 highlight the content analysis results and thoroughly discuss each obstacle. Figure 8-7 summarises these findings, grouping obstacles into four categories: technological, organisational, ethical, and legal.

In Chapter 9, we addressed the fourth concern of exploring *how can the identified benefits and impediments be considered on the formulation of an analytical model to analyse the implementation of enhanced Tracking and Tracing systems for more sustainable inland waterway operations*. We developed a causal model that enables a holistic analysis of how eT&T can promote more sustainable operations in the IWT. This model facilitates decision-making in present and future processes by providing insights into how specific factors and their behaviours impact the overall system. Sustainability encompasses several aspects, including economic, environmental, and social factors. To gain a comprehensive understanding of the system's behaviour and maintain a delicate balance between these factors over time, the Systems Thinking approach is preferred. A crucial aspect of this approach is a thorough documentation of the model-building process, which includes milestones such as defining the model's purpose and assumptions, selecting variables, and creating graphical representations using connection circles and a causal model. This study adheres to the philosophy and ethics of technology to ensure transparency and integrity in the model-building process.

After a thorough evaluation, the validity of the model was confirmed. This was determined through a checklist proposed by (Coyle 1996) and then through a formal procedure involving multiple tests to ensure accuracy.

10.2. Key contributions

This study makes valuable contributions to both theory and practice. The nature of the research for this thesis gives a clear idea of the type of these contributions. Thus, it is worth to recapture at this point that, as in section 1.5 explained, this work was conceived as empirical qualitative research with a social constructivist philosophical orientation.

Chapter 2 provides a thorough overview of the Inland Waterway transport system. Valuable insights were obtained by analysing information from prominent IW figures, cutting-edge research projects, and formal literature. The portrait of the IWT presented here is comprehensive and covers the technical, organizational, and legal aspects of this mode of transportation. Additionally, the last trends in the IW are compiled to showcase new areas of interest for future research and innovation in the sector.

In the section 3.2.3 of the report, a new analytical model called eT&T-SusInWa was developed. It offers a more comprehensive approach to analysing the implementation of new information system technologies for more sustainable transport and logistic operations across rivers and canals. Considering legal, societal, environmental, and market factors, this model can be used as a reference for future empirical research and theoretical development in this area. Previous models such as (DeLone and McLean 2002), (Ipe 2003), (Kembro et al. 2014), and (Gharawi and Dawes 2010) were too general and didn´t consider the relationship between information sharing and sustainability.

The model proposed by (DeLone and McLean 2002) focuses on dimensions closely tied to information, considering various elements related to the systems and users responsible for managing this information. The model assesses the impact of these elements on decision-making and economic performance, with a particular focus on organisational behaviour as well as technological and economic aspects.

(Ipe 2003) On the other hand, it depicts the information sharing process as a social phenomenon and consider men-related factors such as culture, motivation, and external factors like opportunities to share. The model concentrates on the individual level and illustrates why and how persons share information and knowledge.

(Kembro et al. 2014) and (Ipe 2003) explore human behaviour within organisations and integrate governance mechanisms into the information-sharing process. Their model prioritises organisational perspectives and excludes economic factors such as profit.

(Gharawi and Dawes 2010) expanded on previous models by considering inter-organizational and international macro-level factors, including market, legal, organizational, and geographical aspects. This resulted in a more comprehensive understanding of the complexity surrounding knowledge and information sharing. However, while their conceptual framework is more thorough, it does not address sustainability concerns or establish causal relationships between system variables. As a result, there is currently no published model that fully encompasses all dimensions of sustainability.

Sections 6.2 and 7.4 showcase the potential benefits of implementing enhanced T&T systems that can lead to more sustainable operations in the IW and other transport modalities. The extensive catalogue of possibilities outlined in these sections is a valuable contribution to the industry, as no previous studies have explored these insights in such depth with the participation of leading actors in the IW sector. This outcome highlights that sustainability efforts lead to more environmentally friendly processes and more profitable and socially responsible operations. The report can be used to promote climate change in the transport sector and accelerate actions towards achieving climate targets.

The hindrances to implementing eT&T systems in the IWT have been thoroughly outlined in sections 6.3 and 7.5, while Figure 8-7 offers a detailed perspective on the obstacles that impede the integration of eT&T systems. This research contributes to the existing literature on information sharing by providing a more comprehensive description of the various barriers, ranging from technological to organisational, legal, and ethical. Such an extensive analysis is not commonly found in current studies. Although these hindrances were identified through conversations with IW actors, the findings can be easily applied to other systems beyond transportation. Additionally, these findings can be valuable for risk management and innovation adoption studies that aim to analyse the implementation of information and knowledge-sharing systems. To provide practical value and assist companies in overcoming these barriers and adopting eT&T for more sustainable operations, a general framework is proposed in section 8.2 and summarised in Table 8-6 that includes measures to overcome these hindrances.

In this work, we utilised the value-adding approach suggested by (Eakin and Gladstone 2020) to "theorise" the data gathered from expert interviews and the participatory-creative workshop. This approach helped us to move beyond a mere exploratory exercise and laid the foundation for grounded theory. We found this approach extremely useful in maximising the outcomes of qualitative studies and demonstrating how the findings could be applied more broadly. Section 8.1 presents our analysis and several conclusions. The propositions that emerged from our research provide valuable insights into the impact of innovative information and knowledge-sharing systems, such as eT&T systems, from the perspective of the IW sector.

The causality model (SusInWa) developed in this thesis and presented in section 9.2 serves to understand which specific factors and how their behaviours can affect the implementation of IS technologies, such as eT&T, for more sustainable operations from the perspective of the IW sector. When dealing with complex systems, Systems Thinking's approach involves identifying circular relationships between multiple factors to understand how the systems work comprehensively before further studies can be performed. This provides a valuable reference for all stakeholders and facilitates more productive discussions across different sectors. This approach is precious, as very few works currently address the interactions between information and knowledge-sharing systems like eT&T and sustainability, with most focusing on consumer protection or sustainable manufacturing practices. Some notable works that address these interactions include (Marucheck et al. 2011; Thöni and Tjoa 2017; Garcia-Torres et al. 2019; Denuwara et al. 2019).

In addition to the thesis's main objectives, contributions were made towards improving the scientific quality of research work. These informal contributions included the development of an ethical infrastructure and the incorporation of an interactive inquiry approach based on Action Research, as established by (Lewin 1946).

Through this thesis, it has been demonstrated that adopting a philosophy and ethics of technology approach can enhance the credibility of the results obtained and enable the study to identify potential conflicts early, thereby managing them effectively. The ethical framework designed for this thesis is comprehensively presented in section 1.8. It consists of four key areas: ethics in research, ethics in the exercise of the engineering profession, ethics in qualitative research, and ethics related to engineering sciences and T&T technologies. This framework can serve as a helpful guide for future research works to develop their ethical guidelines.

By utilising the Action Research approach, this study confirmed that involving problem owners and researchers in the process leads to the application of knowledge and increased research output. The participatory-creative workshops conducted through this approach were highly influential in gathering detailed information and explaining complex concepts. Based on this experience, it was determined that the Action Research approach is particularly suitable for emerging topics with high uncertainty, such as technology-related, and with a diverse group of stakeholders. Section 7.2 outlines the design of the participatory-creative workshop used in this thesis that can guide future research utilising the Action Research approach.

10.3. Future research

After summarising the findings of this thesis and explaining their significance in terms of knowledge and practice, it is essential to evaluate the progress made in this study and propose potential avenues for future research.

The findings of this thesis highlight the multiplicity and diversity of benefits related to the implementation of information and knowledge-sharing systems such as eT&T. This work characterizes the impact of these benefits in an exploratory way. Future research should seek to develop a comprehensive schema to measure their impact.

In section 8.1, a group of constructs was deduced from qualitative data. Future research should focus on validating this theory, potentially through integrating new data sets or using mathematical analysis.

It would be highly desirable for future work to operationalize the causality model (SusInWa). This would increase its predictive capability and both its practical and theoretical value. Due to the complexity of the system, much data should be gathered, and analytics carefully formulated. At any time, the model´s equilibrium should be monitored. Too complex constructions are hard to calibrate and compromise the credibility and transferability of the results.

Through this study, we have discovered that the widespread use of the eT&T system by different IWT players is a significant challenge in ensuring complete chain visibility with reliable transport-related data. Considering technology adoption as a social process, it would be valuable to investigate how new variables could replicate this behaviour, particularly within the context of IW networks. For instance, conditions such as vessels serving as transportation modes and living quarters for the crew and operator could provide intricate influences.

Finally, two last directions for future research could be deduced. The SusInWa causal model suggests that new forms of cooperation could arise in the inland waterways (IW) sector through the increased visibility and transparency provided by eT&T. Given the unique characteristics of IW networks, it would be beneficial to explore these new forms of cooperation and their impact on the overall performance of transport chains. Additionally, it is crucial to address the issue of appropriate business models for implementing and operating eT&T. By examining these two areas, the IW sector can gain valuable insights and innovation to address sector challenges. Notably, the industry is witnessing trends in autonomous vessels and new delivery concepts for city logistics using inland waterways that deserve special attention.

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Appendix A. List of reviewed EU projects

According to their objectives, we classified these reference projects into 5 categories:

1. Greening the IWT and new vessel concepts
2. Traffic management for efficient operations
3. Information systems for transport management
4. Political framework for promoting IWT
5. Modal shift promotion

1. EU projects about greening the IWT and development of new vessel concepts

PROMINENT

The project "Efficient and clean vessels, monitoring emissions performance and qualification of professionals" target is the implementation of advanced concepts for reduction of emissions through several measurements such as: development of an efficient navigation advice tool to support the reduction of vessel fuel consumption; demonstration of performance or standardized retrofit diesel aftertreatment systems; design of certification system for monitoring and evaluation of solution´s emissions behaviour; development of digital and simulation-based tool for vocational training; and formulation of a roadmap and roll-out strategies for the follow-up actions of the project.

CLINISH

"Clean Inland Shipping" developed solutions encompassed: demonstration of effects of NOx and particulate matter (PM) techniques; demonstration of on shore power supply measures to reduce emissions; development of an emissions inventory database, including all relevant ship information under real conditions, test of scenarios to evaluate he expected impact on emissions upon policies and/or incentives; formulation of a monitoring protocol leading to a clean shipping index for financial incentives and development of a decision-making tool to assist ship owners on the selection of techniques for emission reduction.

RIVER

"Non-Carbon River Boat Powered by Combustion Engines" aim to develop new vessel engines to eliminate NOx and to capture and store all CO2 emissions and transform them into a bio-solvent by reducing fuel consumption.

Watertruck+

The project target is the introduction of a small, self-propelled, or un-propelled, standardized barges for the transport of goods on small waterways that can be coupled and decoupled with large or small environmentally friendly push boats in a fast and flexible way.

#IWTS2.0

On “IWT Solutions” 8 small waterway modal shifts will be test as pilots that allows: a quick modal shift, make better use of existing waterways through standard-sized vessels and small barge concepts, modernization of inland waterway education with focus on navigation on smaller waterways; linking smaller waterways to TEN-T corridors.

2. EU projects about traffic management for efficient operations

Rhine-Alpine

“Pilot Implementation of an Upper Rhine Traffic Management Platform” target was the implementation of an innovative ICT traffic management platform at 3 port locations in Basel-Mulhouse-Weil and Rhein with a total of 7 container terminals. On a second stage, a feasibility study for the roll-out of this ICT traffic management platform at 6 other locations was developed and a conceptual design to extend the platform to non-containerized cargo, rail, and truck hinterland traffic.

RIS COMEX

“RIS-enabled Corridor Management Execution” is a very ambitious project with Partners on 13 European countries to develop an overall corridor RIS management concept to provide increased quality and availability of fairway, traffic, and transport information services through the harmonization of data exchange concepts for RIS data. To ensure the sustainable development of the infrastructure and services an agreement on operational arrangements (legal, organizational, financial, technical, and quality) will be defined.

3. EU projects about Information Systems for transport management

Aeolix

On “Architecture for EurOpean Logistics Information eXchange” a solution for connecting logistics information systems of different characteristics, intra- and cross-company, for the real-time exchange of information to support logistics-related decisions will be designed, tested, validated and implemented.

SELIS

"Shared European Logistics Information Space" delivered a distributed common communication platform for pan-European logistics applications that enable logistic communities to link their existing systems through a secure infrastructure and provide shared information and tools for data acquisition and use, according to pre-established cooperation agreements.

ECOLOGISTICS

"Efficient Carbon-reduction and Optimisation of Logistics Operations Generated via Innovative Services, Training and ICT using Cooperative Standards" developed an ICT-based demonstrator based on the EPC-Network European standard, allowing direct connection between people and travelling objects (concept of IoT) to fill the information gap between large companies and SMEs.

e-Freight

"European e-freight capabilities for co-modal transport" aimed to accelerate the development of EU and national single windows to streamline traffic and cargo reporting to authorities. The Next-Generation National Single Window (NGNSW) allows all parties involved in trade and transport to enter information and upload documents on a single-entry point. Further, a single transport document application generates electronic transparent documents.

GET Service

"Service Platform for Green European Transportation" bring already existing transportation and route planning to the next level by aggregation of novel real-time transportation planning algorithms, a subsystem for the transportation control and reconfiguration mechanism and automated real-time information aggregation mechanisms to provide transportation planners and drivers with means to plan, re-plan and control their transportation routes and save CO2 emissions.

RISING

"RIS Services for Improving the Integration of IWTs into intermodal chains" demonstrate 15 new RIS services for transport and logistic companies. During the project, existing RIS performance have being extended with additional intelligent software modules to plan and control transport.

4. EU projects about political framework for promoting IWT

CORE

"Consistently Optimized Resilient Secure Global Supply Chains" proved through 10 demonstrators that safe, secure, timely, efficient and resilient flow of goods in global supply chains can be improved by amount others: combining corridor with supply chain data, visibility and better data in port-hinterland connections, real-time tracking of time-sensitive shipments and advanced security control measures, tracking and tracking solutions based on the European satellite navigation for intermodal transport of dangerous goods.

EMMA

On "Enhancing freight Mobility and logistics in the BSR by strengthening IWW and river sea transport and ProMoting" pilots were used to showcase and demonstrate the potential of IWT and open up new market segments in the Baltic Sea Region (BSR) by running a competitive improvement plan, reducing bureaucratic and regulatory barriers, raising awareness of potentials and giving IWT a stronger voice in policy and society.

GOTRIS

During the "Göta älv River Information System" project a platform was designed to create well-functioning freight traffic over the river to facilitates the expansion of the port of Gothenburg. Objectives of this platform was to minimize waiting time and ship bunker use as well as achieve a minimal city flow interference from bridge openings.

CCP21

"Connecting Citizen Ports 21" brought together 7 major European inland ports to develop tools, invest in infrastructure and communicate activities to optimize the organization of freight logistics and achieve a sustainable spatial development of ports and its cities.

SCALE

"Step Change in Agri-food Logistics Ecosystems" worked across Northwest Europe to deliver new tools and frameworks to improve the efficiency and sustainability of food and drink logistics hampered by the increasing demand of food that leads to rising food prices and fuel costs, extra production and extra CO_2 emissions.

Appendix B. Extract of ethical issues in qualitative, quantitative and mixed methods by (Creswell 2014)

Where in the process of research the ethical issue occurs	Type of ethical issue	How to adress the issue
Prior to conducting the study	• Examine professional association standards. • Seek college/university aproval on campus through an institutional review board (IRB). • Gain local permission from site and participants. • Select a site without a vested interest in outcome of study. • Negotiate authorship for publication.	• Consult the code of ethics for professional association in your area. • Submit proposal for IRB approval. • Identify and go through local approvals; find gatekeepers or key personnel to help. • Select sites that will not raise power issues wih researchers. • Give credit for work done on the project; decide on author order in future publication.
Beginning the study	• Identify a research problem that will benefit participants. • Disclose purpose of the study. • Do not pressure participants into signing consent forms. • Respect norms and charters of indigenous societies. • Be sensitive to needs of vulnerable populations (e.g., children).	• Conduct a needs assessment or informal conversation with participants about their needs. • Contact participants, and inform them of the general purpose of the study. • Tell participants that they do not have to sign form. • Find out about cultural, religious, gender, and other differences that need to be respected. • Obtain appropriate consent (e.g., parents, as well as children).
Collecting data	• Respect the site, and disrupt as little as possible. • Make certain that all participants receive the same treatment. • Avoid deceiving participants. • Respect potential power imbalances and exploitation of participants (e.g., interviewing, observing). • Do not "use" participants by gathering data and leaving site. • Avoid collecting harmful information.	• Built trust, and convey extent of anticipated disruption in gaining access. • Put into place wait list provisions for treatment for controls. • Discuss purpose of the study and how data will be used. • Avoid leading questions. Withhold sharing personal impressions. Avoid disclosing sensitive information. Involve participants as collaborators. • Provide rewards for participating. • Stay to questions stated in an interview protocol.
Analyzing data	• Avoid siding with participants (going native). • Avoid disclosing only positive results. • Respect the privacy and anonymity of participants.	• Report multiple perspectives. • Report contrary findings. • Assign fictious names or aliases; develop composite profiles of participants.
Reporting, sharing, and storing data	• Avoid falsifying authorship, evidence, data, findings, and conclusions. • Do not plagiarize. • Avoid disclosing information that would harm participants. • Communicate in clear, straightforward, appropriate language. • Share data with others. • Keep raw data and other materials (e.g., details of procedures, instruments). • Do not duplicate or piecemeal publications. • Provide complete proof of compliance with ethical issues and lack of conflict of interest, if requested. • State who owns the data from a study.	• Report honestly. • See APA (2010) guidelines for permissions needed to reprint or adapt work of others. • Use composite stories so that individuals cannot be identified. • Use unbiased language appropriate ofr audiences of the research. • Provide copies of report to participants and stakeholders. Share results with other researchers. Consider website distribution. Consider publishing in different languages. • Store data and materials for 5 years (APA, 2010). • Refrain from using the same material for more than one publication. • Disclose funders for research. Disclose who will profit from the research. • Give credit for ownership to researcher, participants, and advisers.

Appendix C. Ethical Framework

The ethical framework for this dissertation is based on four action edges:

1. Ethics in research
2. Ethics in exercise of engineering profession
3. Ethics in qualitative research
4. Ethics related to engineering sciences and T&T technologies

Ethics in research

The attention to ethical issues in research increases progressively. The ethical considerations that need to be anticipated during research are extensive and apply equal to qualitative, quantitative, and mixed methods and to all stages (Creswell, 2014). For this research the author adopts the "*Guidelines for Safeguarding Good Research Practice – Code of Conduct*" from the Association of German Engineers and follows the practical guide of (Creswell) introduced on his last book edition of "Research Design" with a list-assemble of ethical issues that could occurs along the different processes in qualitative, quantitative, and mixed methods research. An extract of this table with ethical issues relevant to this study can be found in Appendix B.

Ethics in exercise of engineering profession

"Provide that science and technology are essential factors on the development of modern life and society for present and future generations, engineers should be aware of their special responsibility." (VDI Association of German Engineers, 2002).

On this action edges, the author as an industrial engineer, examined professional associations standards. Thus, related standards from the Association of German Engineers, the largest technical and scientific association in Germany where revised. Their codex *Ethical Principles of Engineering Profession* (Ethische Grundsätze des Ingenieurberufs) guides the work of the author as an engineer. Further the *Engineering Code of Ethics* of the Institute of Industrial & Systems Engineers (IISE) and the *Code of Ethics for Engineers* from the National Society of Professional Engineers (NSPE), both in United States where revised as extended sources. Table 1-1 provides an overview about the scale of these codes.

Authors	Headquarters	Title	Publication/last revision year	Approx. word count [a]
Association of German Engineers (VDI)	Germany	Ethical Principles of Engineering Profession	2002	630
Institute of Industrial & Systems Engineers (IISE)	USA	Engineering Code of Ethics	2006	1930
National Society of Professional Engineers (NSPE)	USA	Code of Ethics for Engineers	2019	1790

Notes: [a] Excluding preface, preamble, summary and statements

Table 0-1 : Code of ethics for engineering professionals

As important part of this study, the extent of sustainability consideration of the codes mentioned above was probed. Both, the IISE and NSPE closest consideration of sustainability it is encrypted on the common principle “Engineers shall hold paramount the safety, health and welfare of the public” (IISE, 2006) (NPSE, 2019). It can be interpreted that this principle implies sustainability as interests of mankind (public) are regarded. Nevertheless, important elements of sustainability such as securing future generations and environment are not clear-cut. An unambiguous consideration of sustainability is enclosed by the VDI when stipulating “Engineers are conscious of social, economic and ecological contexts when embedding technical systems and respects related criteria during the technology design that also respects the possibilities of future generations: functionality, economy, prosperity, security, health, environmental quality, personal development and social quality” (translation from original text in German) (VDI, 2002).

Even though IISE and NSPE codes publication/last revision is more actual than VDI codes and more detailed (based on the word count) a clear position about the role of engineers on the implementation of sustainable systems is not provided. The VDI code contributes therefore, for the aim of this study, with a more suitability-affinity foundation.

Ethics in qualitative research

Further than revising existing codes for professional and research integrity, special ethical issues related to qualitative research were addressed. According to (Ramos) there are three types of problems that may affect qualitative studies: the relationship between researcher and research´s participants, the researcher´s subjective interpretations of data and the research design itself (Ramos, 1989). Consideration of these possible ethical conflicts should be considered to further the aims of research instead of merely complying with a series of minimal obligations (Bell and Bryman, 2007). Indeed, the researcher will consider more options before making decisions by applying ethics in a study (Kleijnen, 2011), leading to more trustful results and therefore higher study´s acceptance.

The difficulties inherent to qualitative research can be palliate by applying the ethical principles of autonomy, beneficence and justice (Orb et al., 2000). In brief, *autonomy* refers to the protection and respect of participant rights; *beneficence* means doing good for others and preventing harm while *justice* refers to equal share and fairness to avoid exploitation and abuse of participants (Orb et al., 2000). (Bell and Bryman) provides a more extended list of ethical principles for management research (Bell and Bryman, 2007):

1. Prevent to cause harm to participants
2. Respect dignity of participants and avoid discomfort or anxiety
3. Ensure fully informed consent of participants
4. Protect privacy of research subjects
5. Protect the right of anonymity of individuals and organizations
6. Avoid fraudulent and misleading behaviour through research process
7. Declare any researcher´s professional or personal affiliations that may influence the study
8. Informe all interested parties
9. Struggle to provide results of mutual benefit for researcher and participants
10. Avoid reporting false or biased research findings

In this study, insights from interviews will served for validation of an analytical model for analysing the implementation of enhanced Tracking and Tracing systems. Although a model itself has no morals as an immaterial product, the goal of the model may have ethical implications (Kleijnen, 2011). Further, any model is based on particular assumptions, and the outputs of the model are valid if those assumptions hold. Individuals or organizations looking forward to implementing the model should be aware of these assumptions so that can decide by themselves if the model will yield realistic outputs for their cases. Thus, to minimise the possible negative effects resulting from model´s misuse, the developer should (Kleijnen, 2011):

1. Clearly communicate the model's goals
2. Provide the assumptions upon the model is based
3. Share the process of model´s validation
4. Warm about limitations of the model
5. Warm about either epistemic or aleatory model´s uncertainties should be care about

Generally, it is considered that research risks on other fields such as medicine entails more dramatic risks (Elgesem, 2002). This could be true as well as false for engineering sciences. The research for the development of a massive new destruction mean could be an example for the last one case.

Nevertheless, ethics is about preventing from doing wrong. As a conclusion, reflecting on ethics issues reveals three capital risks for this study:

1. Risk related to the research process
2. Risk related to the protection of study participants
3. Risk related to the utilization of the resulting model

Control measures are applied to reduce the impact of each of this risk through the study.

Ethics related to engineering sciences and T&T technologies

There is a clear gap in existing ethics literature for Information and Communications Technologies (ICT) to provide models or frameworks to balance the trade-offs of such a system (Zhou and Piramuthu, 2013). This is stunning giving the fact that ICT shows a continuous growth on the past decades keeping the same positive trend and its pervasive nature enables virtual processes everywhere, anytime making possible to access, monitored, record and extract large amount of information and therefore being susceptible for unethical practices. Even though, ICT like Tracking and Tracing Systems are well-traceable, measurable, regulatable, and standardizable (Zhou and Piramuthu, 2013) lack of instruments for the implementation of ethical aspects embedding such systems is remarkable. This could be explained by the fact that it is impossible in a natural sense to *program* Ethic, nevertheless, it is possible to algorithmizes ethical rules (Capurro, 2015). A first measure to introduce ethical considerations on ICT is to keep a critical way of think and formulates questions that are not exclusively about technical knowledge (Capurro, 2015). The General Model of Ethics with Technology Selection (GMETS) from (Zhou and Piramuthu) provides a good framework for this reflective exercise.

On this study, it should be considered that there are possible external barriers for considering ethical matters addressing sustainability issues. This reluctance arises from two different paradigms (Harris et al., 2000):

1. Crisis-oriented environmental management: Business should not detract from its fundamental purpose of making money.
2. Cost-oriented environmental management: environmental matters represent only costs for the business.

Appendix D. Summary of information system success measures by category by (DeLone and McLean 1992)

System quality	Information quality	Information use	User satisfaction	Individual impact	Organizational impact
Data accuracy	Importance	Amount of use/ duration of use:	Satisfaction with specifics	Information understanding	Application portfolio:
Data currency	Relevance	-Number of inquiries	Overall satisfaction	Learning	-Range and scope of application
Database contents	Usefulness	-Amount of connect time	Single-item measure	Accurare interpretation	-Number of critical applications
Ease of use	Informativeness	-Number of functions used	Multi-item measure	Information awareness	Operating cost reductions
			Information satisfaction:		
Ease of learning	Usableness	-Number of records accessed	Difference between information needed and received	Information recall	Staff reduction
Convenience of access	Understandability	-Frequency of access	Enjoyment	Problem identification	Overakk productivity gains
Human factors	Readability	-Frequency of report requests	Software satisfaction	Decision effectiveness:	Increased revenues
Realization of user requirments	Clarity	-Number of reports generated	Decision-making satisfaction	-Decision quality	Increased sales
Usefulness of system features and functions	Format	-Charges for system use		-Improved decision analysis	Increased market share
System accuracy	Appearance	-Regularity of use		-Correctness of decision	Increased profits
System flexibility	Content	Use by whom?		-Time to make decision	Return on investment
System reliability	Accuracy	-Direct vs. Chaffeured use		-Confidence in decision	Return on assets
System sophistication	Precision			-Decision-making participation	Ratio of net income to operating expenses
Integration of	Conciseness				
	Sufficiency				
	Completeness				
	Reliability				
	Currency				
	Timeliness				
	Uniqueness				
	Comparability				
	Quantitativeness				
	Freedom from bias				

Appendix E. List of expert interviews, additional meetings, and study visit

Organisation	Interviewee	Place	Date	Player group
DeltaPort	General Manager and Marketing Director	Wesel	12.04.2018	Authorizing
duisport	Authorized signatory and Deputy Head of the Port Authority	Duisburg	02.05.2018	Authorizing
Association of Forwarding and Logistics North Rhine-Westphalia e.V.	Marketing & Sales Manager and Managing director of the committee Inland shipping and maritime forwarding / port management	Düsseldorf	17.05.2018	Lobbying
TanQuid	IT & Future Business	Duisburg	04.06.2018	Physical
Contargo	IT Manager	Duisburg	06.06.2018	Physical
HTAG Port and Transport	Director Tonnage acquisition / Support	Duisburg	28.06.2018	Physical
Haeger & Schmidt Logistics	General Manager, General Manager of the Division Intermodal - Corporate Development	Duisburg	20.08.2018	Physical
Duisburg Water Protection Police	Head of press and Public Relations	Telephone	23.08.2018	Authorizing
DCH Düsseldorf Container Port	General Manager and Administration Assistant	Düsseldorf	28.08.2018	Physical
neska shipping and forwarding office	Distribution Director	Düsseldorf	28.08.2018	Physical
Henkel	Purchasing Manager Air & Sea Europe FP Global Purchasing Logistics	Telephone	30.08.2018	Commercial

Table 0-2 : List of expert interviews

Organisation	Positition	Place	Date	Player group
Association for European Inland Navigation and Waterways	General Manager	Duisburg	13.06.2018	Lobbying
Dialogistik Duisburg	Coordinator	Duisburg	25.06.2019	Lobbying
Development Center for Ship Technology and Transport Systems	Head of Department for Transport Systems and Ship Operations	Duisburg	25.06.2019	Research
Federal Association of German Inland Navigation	Office of Dangerous Goods, Tank Vessels, Bunker and waste disposal companies	Telephone	26.06.2019	Lobbying
Rheincargo	Rheincargo	Telephone	27.06.2019	Physical
Imperial Logistics	Business Process Manager - Business Unit Shipping	Skype	08.07.2019	Physical
Rhenus Inland Shipping Group	General Manager and Director Innovation Unit	Duisburg	09.09.2019	Physical
NPRC	Executive Assistant to Direction	Telephone	31.10.2019	Lobbying
Bargelink	General Manager	Kalkar	25.09.2018	Commercial

Table 0-3 : List of additional meetings

Organisation	Positition	Place	Date	Player group
CTS Container-Terminal GmbH	Assistant to Direction	Cologne	28.09.2019	Physical

Table 0-4 : Information of study visit

Appendix F. Questionnaire-guidelines for expert interviews

Commercial group: Shippers and consignees

Introduction
Greetings and participant´s introduction
Clarification of interview´s objectives

Key Questions Catalog		
Thematic complex	**Nr.**	**Key Questions**
Theme complex 1: Business	1	What is the core business of your company?
	2	Mention the location of company´s offices and functions?
	3	What products do you handle?
	4	Where do your clients are located?
	5	Mention special characteristics of the market you are serving to?
Theme complex 2: Logistics processes	6	What is the different cargo flows you handle? What is their volume?
	7	How are packed the different types of cargo you handle?
	8	How are these products stored and transported?
	9	Who are the suppliers or buyers of these products?
	10	Where are your warehouses and points of delivery located?
	11	How is the delivery frequency and volume of cargo for or from most important clients and suppliers?
		Describe your typical product handle process.
	12	How are the transport of your products organized (partners, processes, others)?
	13	Are you using inland waterway transportation for your flows? Why?
	14	If yes:
		What products are transported by waterways?
	15	How is the organization, execution, and control of this transportation?
	16	What are the specific problems (economic, operational, and managerial) you encountered in your inland waterway transportations?
	17	
	18	How do you evaluate your processes of traceability of transport units?
Theme complex 3: Tracking and Tracing	19	What grade of visibility do you have on the cargo you handled, especially along the waterway transportation section?
	20	What is the level of transport unit that you can trace along your supply chain?
	21	What kind of transaction and traceability information is exchanged with your partners and when?
	22	Which IT-Solutions (software, portals, apps, cloud-services, others) are you using to organize the flow of cargo and the information exchange?
	23	Do you use electronic data format(s) such as XML, EDIFACT, XLS, or other?
	24	Through which channels (EDI messages, e-mail, fax, phone, others) is this data exchanged?
	25	Do you have to re-enter or re-send the same information several times?
	26	What are the challenges such as lack of information, interoperability, or others, do you encounter when tracing transport units and exchanging this data?

Closing part
Declaration of consent for the public acknowledgement of participation and interview results
Authorization to send the protocol or the transcription of the interview Closedown

Physical group: Carriers and freight forwarders

Introduction
Greetings and participant´s introduction Clarification of interview´s objectives

Key Questions Catalog		
Thematic complex	**Nr.**	**Key Questions**
Theme complex 1: Business	1	What is the core business of your company?
	2	Where do your clients are located?
	3	What type of products are transported?
	4	What types of inland shipping vessels/trucks do you use for their transportation?
	5	How big is this fleet?
Theme complex 2: Logistics processes	6	Describe your typical waterway transportation process from point A to point B.
	7	What transport units (containers, pallets, big bags, others) do you use?
	8	Who are the different stakeholders of the logistic chain you are in relation with?
	9	What are the specific problems (economic, operational, and managerial) you encountered in your inland waterway transportations?
	10	How do you evaluate your processes of traceability of transport units?
Theme complex 3: Tracking and Tracing	11	What grade of visibility do you have on your products along the logistic chain, especially along the waterway transportation section?
	12	What is the level of transport unit that you can trace along your supply chain?
	13	What kind of transaction and traceability information is exchanged with your partners and when?
	14	What IT-Solutions (software, portals, apps, cloud-services, others) are you using to organize the flow of cargo and the information exchange on your transports?
	15	Do you use electronic data format(s) such as XML, EDIFACT, XLS, or other?
	16	Through which channels (EDI messages, e-mail, fax, phone, others) is this data exchanged?
	17	Do you have to re-enter or re-send the same information several times?
	18	What are the challenges such as lack of information, interoperability, or others, do you encounter when tracing transport units and exchanging this data?
	19	

Closing part
Declaration of consent for the public acknowledgement of participation and interview results Authorization to send the protocol or the transcription of the interview Closedown

Physical group: Terminal operators

Introduction
Greetings and participant´s introduction
Clarification of interview´s objectives

Key Questions Catalog		
Thematic complex	**Nr.**	**Key Questions**
Theme complex 1: Business	1	What is the core business of your company?
	2	Where do your clients are located?
	3	What equipment (quay crane, forklift, others) do you use for cargo transhipment?
	4	What type of inland shipping vessels your serve to?
	5	What type of products are handled?
Theme complex 2: Logistics processes	6	Describe your typical cargo handle process.
	7	What transport units (containers, pallets, big bags, others) do you handled?
	8	Who are the different stakeholders of the logistic chain you are in relation with?
	9	What are the specific problems (economic, operational, and managerial) you encountered in your inland waterway transportations?
	10	How do you evaluate your processes of traceability of transport units?
Theme complex 3: Tracking and Tracing	11	What grade of visibility do you have on the cargo you handled, especially along the waterway transportation section?
	12	What is the level of transport unit that you can trace along your supply chain?
	13	What kind of transaction and traceability information is exchanged with your partners and when?
	14	What IT-Solutions (software, portals, apps, cloud-services, others) are you using to organize the flow of cargo and the information exchange on your terminals?
	15	Do you use electronic data format(s) such as XML, EDIFACT, XLS, or other?
	16	Through which channels (EDI messages, e-mail, fax, phone, others) is this data exchanged?
	17	Do you have to re-enter or re-send the same information several times?
	18	What are the challenges such as lack of information, interoperability, or others, do you encounter when tracing transport units and exchanging this data?

Closing part
Declaration of consent for the public acknowledgement of participation and interview results
Authorization to send the protocol or the transcription of the interview
Closedown

Authorizing group: Port authorities and inspectors

Introduction
Greetings and participant´s introduction Clarification of interview´s objectives

Key Questions Catalog		
Thematic complex	**Nr.**	**Key Questions**
Theme complex 1: Tasks	1 2 3 4	What are the tasks of your organization? What activities do you perform to comply with these obligations? What is the area your organization is responsible for? Who are your main partners on these tasks?
Theme complex 2: Logistics processes	6 7 8	Who are the different stakeholders in the IW sector you are in relation with? What kind of transactions do you perform with these stakeholders in the IW sector? What are the specific problems (economic, operational, and managerial) you encountered in your inland waterway related operations?
Theme complex 3: Tracking and Tracing	11 12 13 14 15 16 17	What kind of transaction and traceability information is exchanged with your partners and when? What IT-Solutions (software, portals, apps, cloud-services, others) are you using to organize your tasks in the IW sector? Do you use electronic data format(s) such as XML, EDIFACT, XLS, or other? Through which channels (EDI messages, e-mail, fax, phone, others) is this data exchanged? Do you have to re-enter or re-send the same information several times? What are the challenges such as lack of information, interoperability, or others, do you encounter when tracing transport units and exchanging this data? What are the requirements for data security and protocol you should met?

Closing part
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Lobbying and research organizations

Introduction
Greetings and participant´s introduction Clarification of interview´s objectives

Key Questions Catalog		
Thematic complex	**Nr.**	**Key Questions**
Theme complex 1: Tasks	1	What are the tasks of your organization?
	2	What activities do you perform to comply with these obligations?
	3	Who are your main partners on these tasks?
Theme complex 2: Challenges	4	What are the challenges (economic, operational, and managerial) do you consider are they nowadays present in the inland waterway sector?
Theme complex 3: Tracking and Tracing	5	What are the challenges such as lack of information, interoperability, or others, do your IW network encounter when tracing transport units and exchanging data?
	6	Are there are data security and protocol requirements to be met?
	7	What coming trends (technological, political, societal) or changes do you consider would have an impact on the future organization of IW transports especially regarding traceability of cargo?

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Appendix G. Expert interview and study visit reports

Interview Reports

The reports of expert interviews are organized in the following groups using the Wagenaar classification extended on this study:

1. Commercial group
2. Physical group
3. Authorizing group
4. Lobbying and research group

1. Commercial group

In this section interview reports from a company playing the roles of shipper and consignee using waterways for its deliveries is introduced.

1.1. Henkel AG & Co. KGaA

Theme complex: Business / Tasks

Henkel was funded 1876 by Fritz Henkel and operates globally with 53,000 employees. Headquarters of Henkel are in Düsseldorf, Germany 20 minutes to Rhine River´s inland port in Düsseldorf.

The company operates three business units:

1. Adhesive technologies: World´s number one adhesive producer. The company´s produces strong brands for engineered on high-performance adhesive, sealant, and coating solutions with applications on multiple industries such as automotive and transportation, building and construction, electronics and medical. Example of Henkel´s top brand-names products are: Pattex, Loctite, Technomelt and Pritt.

2. Beauty Care: Henkel produces leading brand-name products in the fields of hair colorants, hair styling, hair care, body care, skin care and oral care sold on 150 countries worldwide. Henkel´s top brands are Schwarzkopf, Dial and Syoss.

3. Laundry & Home Care: cornerstone of Henkel's success story. This business sector encompasses a product portfolio on laundry detergents, laundry additives, dishwashing, hard surface cleaners, toilet care, air care and insect control products. Top brands of this business unit are Persil, Purex, and Somat.

Theme complex: Logistics processes / Challenges

Using inland waterways as a transport mode is an important choice for Henkel to comply with its company´s sustainability strategies. The company has a modal split of 60 % IWT and 40 % Train for EU

Import and Export transports to and from Düsseldorf. Henkel works with 2 to 3 freight forwarders for the international import of raw material coming to Düsseldorf and finished products here produced for the non-EU market.

In the case of raw material to be imported; once the company is informed about the arrival time of purchased products to seaport Rotterdam, the company supply their freight forwarders with the cargo data so that they organize the transport, collect it on the announced terminal and delivered it to the communicated destination.

In the case of finished products to be exported; once the company has prepared a cargo, freight forwarders receive a transport order with shipping instructions (terminal destination, sea vessel, time window), cargo specifications and documentation. The freight forwarder organized the complete transport and is responsible to comply with the shipping instructions.

Theme complex: Tracking and Tracing

The transport related data is exchanged with freight forwarders through electronic ways. Alternative this can be as well done through fax.

Henkel mentioned that the three biggest challenges when organizing transports through inland waterways are:

1. Low water levels on the river
2. Trend for larger sea vessels. These large sea vessels call terminals that are far away from the terminals where small inland vessels call. This leads to internal truck-transports on the port facilities between terminals, what brings new risks for shippers.
3. Sea port congestion. Sea ports are so congested that waiting times of up to 2 days for collection of free containers are the rule.

2. Physical group

In this section interview reports from companies that are part of the physical group such as: pre- and post-carrier operator, terminal operator, vessel operator are introduced.

2.1. TanQuid GmbH & Co. KG

Theme complex: Business / Tasks

TanQuid is an independent tank storage terminal with headquarters in Duisburg, Germany that origins date from the foundation of the “Vereinigte Tanklager und Transportmittel GmbH” in 1951. In 2005, TanQuid became an independent business. As an independent tank storage terminal, TanQuid offers storage capacity for its clients. This means that customers can store their products in tanks owned by TanQuid. In addition, the company offers refining, blending as well as additivities. As of now, TanQuid operates about 14 tank-storage-terminals in Germany and Poland and has a workforce of 300. The company stores approximately 70% fuel and 30% chemical products. However, the terminal in Duisburg focuses mainly on chemical products that are stored in 120 tanks. To avoid contaminations, the tanks are designated for specific products. The terminal offers trimodal accessibility to rail, road and water including direct loading from rail to vessel.

Theme complex: Logistics processes / Challenges

Organizing the transportation of products to and from TanQuid tanks is exclusively done by TanQuid's customers. When TanQuid´s storage services should be used, TanQuid is contacted via fax or telephone with information about the arriving volume of products, the specific tank that should be used for storage, the arriving vessel, as well as an estimated time of arrival. Shortly before the vessel arrives, the shipmaster announces the arrival via telephone. The vessel operator carries the bill of lading, analyses, as well as ship's figures. Then, operators unload the vessel and TanQuid stores the products until those are picked up. Upon picking up products, a form must be filled in. Then, the products, as well as the bill of lading are handed over. Regularly, the regional administration receives stock lists.

Measured by the amount of handled cargo at Duisburg, trucks are the most used mode of transportation. The amount of handled cargo transported via rail or water is significantly lower than the amount of handled cargo transported by road.

Theme complex: Tracking and Tracing

Customers can access a web portal with information regarding the volume of stored products. TanQuid offers real-time information via an interface for customers using MPKS / PIDX XML. In addition, customers are provided with a daily auto-report in either PDF or CVS format. This information is provided for customers only, thus not the recipient. However, TanQuid has plans to introduce an interface accessible by senders, forwarders, the tank storage terminal, as well as recipients.

TanQuid experiences problems with forecasting the exact time of arrival of vessels. This is because the company receives information about the ETA once a vessel starts its journey to TanQuid. However, this information is very error prone, as any changes, such as delays due to weather conditions, waiting times at port or locks are not communicated. Therefore, TanQuid uses vessel tracking services to track the position of the vessel as a proactive measure.

Another problem occurs when products from multiple modes of transportation are consolidated, and one mode of transport arrives faster than the other one. For example, a ship that must wait for a train has to pay demurrage charges. On the other hand, a train that must wait for a ship causes problems as track capacities for a waiting train are not available. Thus, reliable information about the arrival time is crucial to ensure that products arrive roughly at the same time. The SAP Cloud Platform Cockpit was mentioned as a possible tool for this purpose.

TanQuid stores liquid products that are subject to evaporation. Thus, a slight decrease of the tank level over time is unavoidable. Likewise, the products evaporate during transport. Therefore, the actual volume of loaded goods might be lower than the volume stated in the accompanying documents. Because of this, TanQuid needs to measure the tank level to detect any differences in the actual and the documented volume of goods that are loaded into the tanks. Similarly, the vessel measures its own tank levels. Any changes in the vessel's tank levels are not communicated to TanQuid. However, this would enable TanQuid to identify evaporated products earlier.

Since TanQuid stores hazardous material, it is crucial to know what actions to take in case of emergencies. For this, regular drills and simulations with the local fire department are organized. In addition, a document with necessary information for the fire department is kept and updated. Non-real-time data about the occupancy of tanks are exchange with rescue units (fire department). This last one assumes tanks are to its full occupancy all time.

2.2. Contargo GmbH & Co. KG

Theme complex: Business / Tasks

Contargo is the leading European container hinterland logistics network, with a workforce of over 900, providing services in Germany, The Netherlands, France, and Belgium. The company operates 24 terminals with a yearly throughput of 2.2 million TEU, which represents a market participation of 31% of western ports hinterland barging activities in 2015 without BeNeLux (Belgium-Netherlands-Luxemburg). Contargo operates container depots and interim storage at the terminals and offers a wide range of container services including local collection and delivery of containers by truck, maintenance, repair, stuffing, and stripping. Measured by the TEU handled in Contargo's terminals, inland waterway transport accounts for 65%, rail transport for 33%, and road transport for 2% of the total transport volume. Contargo aims at reducing the amount of road transport and thus emissions through combined transport. Next to operating terminals, Contargo runs vessel and rail transportation lines. The company operates 33 own inland vessels and works with river transport companies as well as particulars to offer fixed routes and schedules connecting the inland terminals on the Rhine and Main with the western seaports ARA (Antwerp-Rotterdam-Amsterdam). Regarding the rail transport line, Contargo is responsible for the organization of the loading and capacity utilization, but not the actual movement of the train. Trucks are used for hinterland transport. Here, one can differentiate between last mile transport and direct transport, which are both offered by Contargo. Contargo aims at owning 20-30% of the assets involved in the transport activities, such as vessels and trucks.

Theme complex: Logistics processes / Challenges

Dangerous goods are handled in Contargo's terminals, if regulations concerning the classification of dangerous goods are met. The Ludwigshafen terminal and the Frankfurt Höchst terminal offer intermediate storage for this type of cargo.

To plan, organize, execute, and control transports, Contargo uses on market available software when possible, however it has to be open source in order to minimize risks. Standard softwares regularly do not meet all needs of the company. In addition, the company develops open-source solutions in-house itself. As an example, Contargo has developed IMTIS (Intermodal Tariff Information System) where logistics players can calculate transport prices and routes in combined transport via inland vessel, rail and truck and has open sourced its intermodal routing information system, that provides travel times and CO2-calculations based on OpenStreetMap. However, other industry players hesitate to use software developed by Contargo.

A reliable ETA is crucial for synchronising Contargo's follow-up processes. Regarding inland waterway transport, the ETA is relatively reliable once the vessel starts its journey. It was expressed that the ETA of trains is less reliable. This is because very oft trains do not directly enter the terminal upon arrival, e.g., due to inspections that are not communicated to Contargo. Shunting is no. 1 black box. Thus, the synchronization of follow-up processes becomes difficult.

Theme complex: Tracking and Tracing

Containers are the lowest level of tracked logistics units. Therefore, the content of containers is not relevant for Contargo, except for special handling characteristics and dangerous goods. Contargo receives information from seaports about the departure of vessel via EDIFACT. In addition, the approximate position of the containers could be estimated based on the last known transhipment points, as well as the flow rate of the river.

Depending on the customers' preferences, Contargo uses multiple communication channels, such as telephone, e-mail, fax, and EDI. When communicating with other parties involved in the supply chain, Contargo needs to ensure that terms and definitions are clarified. Here, the linguistic competences of other parties need to be considered. To standardise the used terms, the DIN SPEC 91073 was developed by the "Studiengesellschaft für den Kombinierten Verkehr e.V". This norm aims to provide norms for the standardization of data exchange amount all actors in the intermodal chain to ensure an efficient flow of information and sustainable digital communication.

Contargo is willing to use a data exchange platform as an interface between all actors of the supply chain. As this requires transparency and trust, as well as tech-savviness, Contargo expects some customers will prefer not using an electronic data exchange in the closer future. It is expected that direct communication channels with customers/partners (be it “analogue” or digital) will not be eliminated because of the presence of intermediate broker.

From experience, many of Contargo’s customers perceive exchange formats, such as EDIFACT as too complicated and is, therefore, connected to a low acceptance threshold. Thus, Contargo avoids using these kind of exchange formats. Instead, the company uses web services as it is a real integration technology. Contargo prefers small IT-interfaces that are easy to understand and solve the use case rather than overloaded interfaces.

2.3. HTAG Häfen und Transport AG (HTAG Port and Transport)

Theme complex: Business / Tasks

HTAG is a logistics service provider for the transport of bulk and break-bulk cargo. HTAG’s origin is traced back to 1904 with the establishment of a shipping company for the transport of coal by the “Bergbaugesellschaft Harpen”. Nowadays, HTAG is a subsidiary of “Häfen und Güterverkehr Köln AG” that is part of Stadtwerke Köln (public utility company of Cologne, Germany). Services of HTAG include transport, handling, and storage of cargo, as well as contract logistics.

Theme complex: Logistics processes / Challenges

HTAG specializes in bulk shipping of dry goods. For example, HTAG transports coal, building material, grains, and fertilizers to power plants. In addition, HTAG transports general cargo. This includes products for the steel industry, such as coils and slabs, as well as heavy-lift cargo. Depending on customers’ requirements, HTAG offers short- and long-term contracts. Regarding container transports, long-term contracts are rarely signed. The company does not operate container lines but uses existing ones. Part of bulk shipping is the transport of waste that can be divided into hazardous and non-hazardous waste. It was explained that hazardous waste is not equal to dangerous goods. HTAG organizes border-crossing transports mainly from the ARA-region (Antwerp, Rotterdam, Amsterdam), along the river Rhine its tributaries and the Danube. Approximately 1/3 of the transport volume, which is 10 million tonnes per year, is transported by contracted private vessel owners either on tonnes- or rental basis. The remaining transports are carried out by external ship owners. As a subsidiary of HGK, HTAG can use HGK’s private railway for pre-carriage and on-carriage. When road transports, sub-contractors are responsible for.

HTAG operates terminals in Duisburg, Mannheim, Gustavsburg and Karlsruhe for the transhipment of bulk cargo. Containers are not handled. The planning and scheduling of the transports are done in close cooperation with customers or transport partners.

Usually, HTAG communicates with customers via e-mail or telephone. Personal communication is considered important to establish and retain customer loyalty, as well as customer satisfaction. This helps HTAG to solve problems quicker. In addition, the company can pay close attention to customers' individual needs. Ultimately, this creates an advantage over competitors in future freight negotiations.

Via e-mail, customers receive transportation offers and contract confirmations. Additional to this, customers receive data, such as the name of the vessel, transhipment data, the weight, as well as the departure and arrival date. If requested, the current position of the vessel can be shared.

Theme complex. Tracking and Tracing

If requested by the customer, the shipped cargo can be tracked. For this, HTAG communicates with the respective service provider and forwards the information to the customer. The current position of the vessel can either be determined via vessel tracking services, or by contacting the vessel operator via telephone. Regarding bulk shipping, knowing the exact position of the cargo is not as important as receiving a guaranteed arrival notification.

Regardless of whether the transport is organized by HTAG not, arriving vessels must contact the terminal via telephone to plan the handling of cargo. A handling contract regulates the time frame and costs for the handling of cargo, as well as demurrage charges.

HTAG mainly uses software for internal matters, such as statistics, accounting, and billings. Currently, the introduction of a new software is planned that aims at further optimizing and simplifying billing processes.

The exact arrival time of containers is difficult to predict, as delays happen frequently. Reasons for delays include congestions, a delayed sea-going vessel, low water levels or missing customs documents. Delay costs must be bearded by forwarders.

According to HTAG, environmental protection measures (e.g., green ship propulsion technology) provide little to no competitive advantages. The additional costs had to be assumed by customers while transport services from ecological friendly vessels are rated equal to non-ecological ones. Thus, customers are mostly not willing to pay additional costs for environment protection.

Freight portals, such as Bargelink offer private ship owners a space to offer free capacities. This leads to a price increase due to disproportionately high load offers compared to the available transport capacity, for example during low water levels.

The increasing digitalization is seen by HTAG critically. In their opinion, digitalization leads to a more transparent market that led to an increased price sensitivity of customers and private ship owners. This is because the prices of all market players are known. In addition, an increased digitalization limits the personal contact with customers. This makes the establishment of customer loyalty more difficult.

According to HTAG, it is important to differentiate for whom portals are made and who uses those portals. As example, buyers are probably happy to be able to compare prices on the internet and buy the cheapest computer. On the other hand, distributors that must comply with the cheapest market price to sell their goods but decreasing their profits, will see those portals probably more critically. This scenario can be applied to charterers and shipping companies.

2.4. Haeger & Schmidt Logistics GmbH

Theme complex: Business / Tasks

Haeger & Schmidt was founded in 1887 in eleven different locations in Germany, The Netherlands, Belgium, France, and Poland. All locations along the Rhine are active in intermodal activities. The company works with a fleet of about 50 ships (contracted particulier vessels) transporting all kinds of dry goods. Transport of heavy goods is as well part of companies' service-portfolio. Haeger & Schmidt operates as well inland waterway terminals, where services for cargo handling, warehousing (especially steel materials), stuffing and stripping of containers are offered. The intermodal division of the company organizes container transports via waterway, rail, and road. A short sea division offers scheduled services to/from Norway and Great Britain.

Theme complex: Logistics processes / Challenges

According to the experts, railway transport is the least flexible mode of transport. Planning a block train line connection can take up to 8 months. In addition, capacity and weight restrictions possess further difficulties.

Haeger & Schmidt uses the commercial software Modality that allows adding modules based on their individual needs.

Theme complex: Tracking and Tracing

To track vessels, Haeger & Schmidt uses vessel tracking services. Alternative, the company contacts directly the ship via telephone. With regards to road transport, exact tracking is not possible as only the departure time is known. In addition, the truck driver is usually not known what makes contacting via telephone difficult. However, in the Ruhr-Area, transport times between one and two hours are usual. Therefore, exact tracking does not add considerable value for short distances. For long distances, tracking could be used to generate target-performance comparisons. Regarding railway transport, tracking is difficult. Especially, border-crossing transports are not trackable. When using the services of db Schenker, the position of the wagon can be determined. In general, only the mode of transport is tracked, not the loading unit. For example, the exact location of a container within a ship cannot be tracked. This would require RFID trackers, which are quite expensive.

Haeger & Schmidt uses electronic interfaces, more specifically EDIFACT messages for data exchange. Regarding export activities, the terminal receives a container pre notification via COPINO message. After the container is loaded onto the vessel (or unloaded), the terminal receives a CODECO message that includes the time and date of the (un)loading process. Shipping orders are received as IFTMIN message. The confirmation of receipt is then sent as an APERAK message. The status of the shipping order is sent as an IFTSTA message. Regarding depot management, daily depot registrations are sent as COEDOR message. Those inform customers about the number of available containers. To send the freight list for the stowage plan to the vessel operator, the BICS software is used. In general, one can say that Haeger & Schmidt uses electronic interfaces for customers with large transport volumes, while customers with small transport volumes communicate via email and telephone.

Customs documents are stored electronically. Thus, they do not need to physically accompany the vessel. The terminal operators notify the customs of the arrival or transit of containers via port platforms such as Antwerp Port Community System (APCS) in Antwerp. This means that Haeger & Schmidt do not have direct contact with customs.

For Haeger & Schmidt, it would be interesting to know when containers are cleared for import at seaport. Currently, the company is informed when the container arrives. However, as the loading/unloading process can take between two to three days, the arrival time of containers does not help tremendously in planning further activities.

Once the destination of the container is determined it cannot be changed, as this would disrupt all further processes. As containers are stowed according to a stowage plan, every additional move led to additional costs.

A control of the empty containers is performed by the maritime shipping companies that in most of the case are the owners of the containers. This ensures that a location cannot establish a surplus of containers, while other locations have an undersupply of containers.

Skills shortages make hinterland transport increasingly difficult. This concerns ship owners, as well as truck and train drivers.

2.5. DCH Düsseldorfer Container Port GmbH (DCH Düsseldorf Container Port) and neska Schiffahrts-und Speditionskontor GmbH (neska shipping and forwarding office)

Theme complex: Business / Tasks

The DCH Düsseldorf Container Port (DCH) is a terminal operator part of the neska shipping and forwarding office network (neska) comprising seaport locations on Rotterdam and Hamburg, inland locations in Duisburg, Krefeld, Düsseldorf, Dormagen, Cologne, and satellite terminals in Hürth, Bönen and Wustermark. The terminal handles about 500,000 TEU annually and operates as an open common user terminal. This means that external parties can make use of their terminals and services as well as the 10 vessels and 170-180 trucks operated by the neska intermodal network (both via sub-contractors). The terminal can be accessed via water, rail, as well as road (trimodal terminal). There are regular services to the seaports of Rotterdam, Antwerp and Zeebrugge. To Rotterdam, there is a daily rail connection. Road transport is usually used for short distances within a range of 120 to 150 kilometers from DCH. In addition, DCH offers empty depot services that includes storage, maintaining, repairing, and cleaning containers.

Theme complex: Logistics processes / Challenges

Dangerous goods are handled in the terminal, if regulations concerning the classification of dangerous goods are met. As per law, transit of dangerous goods in terminals must be less than 24 hours.

Vessel tracking services are not used for tracking vessels in real time, as they do not provide information about the exact arrival time of the vessel. In other words, the tools show the current position of the vessel, but do not inform about disturbances, such as low water levels or delays at previous terminals Thus, the actual arrival time is difficult to estimate due to imprecise data. To get first-hand information from the vessel, the vessel operator can be contacted directly via telephone. Regarding railway transport, tracking is difficult. Especially, border-crossing transports are not trackable. Due to restrictions on national rail tracks, locomotive change is necessary. In addition, delays e.g., due to driving time restrictions are not communicated. Since the train driver is not known, direct contact is not possible. Not estimated but real time of arriving is high desired by DCH to better allocate resources, perform more efficient operations and be able to better plan and or react.

Theme complex: Tracking and Tracing

Tracking of containers is currently not done. According to DCH, using passive RFID tags for container tracking would be too expensive as they require every terminal to install matching readers. Instead, one could investigate active RFID tags that do not require RFID readers. While the individual tags are more expensive than passive RFID tags, they could only be added to specific containers saving costs.

DCH sends daily stock reports to depot holders. The stock reports include the number of empty containers stored on the premises of DCH, as well as the condition and references of those containers. In case a shipping company orders a container, a reference number is needed. This reference number, which can be limited in time, permits DCH to hand over the container to the shipping company. Shipping companies are using their own portals to administer empty containers.

Due to customs declarations, DCH knows the general description of containers cargo that are handled by the terminal. However, the container content does not affect the business processes, except for special handling characteristics and dangerous goods. Also, the container content is not communicated to external parties. This is especially important to prevent theft.

Depending on the customers' (freight forwarders) preferences, DCH uses different communication channels. Each freight forwarder has its own internal system for the management of their transports what leads to multiple document formats that the terminal should manage daily. DCH hat interfaces with its biggest customers via Electronic Data Interchange, such as IFTMIN and CODECO messages to exchange transport related information and load it on their own system automatically. On the other hand, the communication of transport orders with small freight forwarders is done via email and telephone. DCH estimates that 80 % of the time of their customer service is employed on the manually introduction of this data to their system.

When communicating with other parties involved in the supply chain, DCH needs to ensure that terms and definitions are clarified. 24 hours before arriving at the terminal, customers must pre-notify DCH. This is usually done via email. On this pre-notification DCH confront challenges with the information given from customers to the terminal and the information given to the seaports. Freight forwarders should notify the verified gross mass of the container. They enter this data on the Port Community System (Port Connect in Rotterdam or APCS in Antwerp for example). The same data should be notified to DCH. Anyhow, freight forwarders give this information at latest as possible so that cargo can be still last-minute stuffed on a container an increased use of container capacity. DCH then enters all data manually into its container management system. According to DCH, there is a software on the market that automatically reads emails and fills in the respective forms. However, it is not used. Upon arrival of the vessel, data according to the Bill of Lading must be entered manually.

DCH pointed out that a big challenge on the data exchange between different transport chain players (inland terminals, sea terminals, shipping companies, freight forwarders, etc.) is the missing of standardized and modularized data structure. A cloud working as a master central translator for this multiple data formats to convert on universal data format would be of great value.

3. Authorizing group

In this section, interview reports from companies that are part of the authorizing group such as: port authorities and inspectors are introduced.

3.1. DeltaPort GmbH & Co. KG

Theme complex: Business / Tasks

DeltaPort is a port association with 14 employees, that promotes industrial land development in the Port of Wesel, the Port of Emmelsum and the Rhein-Lippe Port. All relevant facilities are International Ship and Port Security Code (ISPS) certified. The association acts as a landlord for port-related enterprises and administrates the last available port-land resources on the Ruhr area boundaries. In addition, the port areas are located outside of urban agglomerations and connected gridlock. A market of over 60 million people can be reached within three hours' drive from DeltaPort. Cargo handling of loose bulk, break bulk, liquid and heavy cargo, and containers take place on modern facilities with access to inland waterway, high-ways, and train.

In 2017, around 3.5 million metric tonnes of cargo were handled in the three ports (Wesel: 1,2 million tonnes, Emmelsum: 1,8 million tonnes, Rhein-Lippe: 500 thousand tonnes). The Port of Wesel focuses on the handling of loose bulk, such as building material (gravel, sand), animal feed and salt. The Rhein-Lippe Port is considered a multi-purpose port for heavy lift goods and liquid cargo. Break bulk (conventional and containerized) is mainly handled in the trimodal port of Emmelsum.

Since DeltaPort aims at shifting transport to inland waterways, trucks should only be used for last mile transportation.

The main origin/destination ports to/from DeltaPort are the seaports of Rotterdam and Antwerp. 2/3 of all cargo transhipment in DeltaPort move to/from these seaports.

DeltaPort has plans to intensify the development of added-value businesses on their port's facilities.

Theme complex: Logistics processes / Challenges

Dangerous goods (e.g., mineral oils in storage tanks) are handled in the port areas. However, they play a minor role. Companies in the closer port hinterland dealing with chemicals are, among others, ALTANA/BYK-Chemie (chemical company), TanQuid (fuel depot operator) and Garant (mineral oils trading).

Fresh goods are currently not part of the main business in the port areas. However, they are becoming more and more important. In the future, DeltaPort plans to increase the amount of handled goods, that are temperature controlled. For this, the association plans on utilizing the energy produced by a nearby aluminum plant to generate a cooling system. Today, temperature-controlled goods are mainly handled in seaports and shipping lines are not willing to give up Reefer containers as they are very expensive.

Open-top containers are currently not handled in the port areas. These containers can, for example, be used for foundry coke. Neska developed e.g., a just in time delivery concept for coke in standard containers.

Theme complex: Tracking and Tracing

It is important for DeltaPort that only relevant data should be collected. Port Terminals for example only need information about the mode of transport, the volume of cargo and the type of commodity. On an operational level, information about the smallest unit, such as the container, is desired and real-time tracking is necessary for process monitoring.

Three weeks before the ETA is shared, the entire logistics chain is already drafted, and planning information can be accessed by operators/integrators. Before the transport order is closed, a dispatcher checks the plausibility of the complete order. The data exchange happens automated. Data can be divided into cargo-specific data and data regarding the mode of transport. On an operational level, information modules are built that combines the two types of data. Nautical information, such as the position of the vessel, is provided by the automatic identification system (AIS). Based on this, the arrival of the vessel can be estimated, and resources can be planned. Trucks can be tracked with the help of apps already established in the market. Transport information is continuously updated, and operators/dispatchers intervene in the process only when deviations occur. Cargo-specific data, such as weight, can be traced up to the container level. A container management system (CMS) offers real-time, end-to-end movement visibility. Information regarding single packing items is not available for all stakeholders but for the operators/integrators. The integrator manages all the information about the transport (container, packing list, commodity type, etc.) and has a very accurate and transparent data access.

In congested ports, waiting times cause high costs. For example, the average waiting time of a river-vessel in the port of Rotterdam is 72 hours before cargo is available for loading/unloading. Delays can cause penalties. The smaller the consignment, the higher is the time sensitivity. In the Lower Rhine area, advantages due to economies of scale are negligible. Nevertheless, after extraordinary long waiting times, integrators are willing to regain control over the cargo, thus prefer to transport it with the truck.

Customs procedures (e.g., T1 procedure for imports from third countries) are digitalized and can only be accessed by legitimized parties (customs authorities and shippers/skippers). This offers transparency and security for operators, as well as customs. The examination of goods by customs is happening on a random basis or in cases of suspected fraud.

For DeltaPort, as a landlord, data exchange does not offer optimization possibilities. However, operators can benefit from an improved exchange system.

Currently, the stowage plan is maintained by the vessel operator. There is no synchronization between the stowage plan and the planned container handling. This causes re-stowage. A proper synchronization could improve the productivity by 30% according to the expert.

In congestion ports, data exchange could increase productivity by offering better communication between operators.

3.2. Duisburger Hafen AG

Theme complex: Business / Tasks

Duisburger Hafen AG (duisport), which is part of the duisport-group, owns and manages the inland port of the city Duisburg. In total, the duisport-group employs about 1,200 people. This includes the Duisburger Hafen AG, as well as subsidiaries, such as duisport packing logistics, duisport agency, and duisport facility logistics. duisport acts as a landlord for port-related enterprises and does not operate terminals. However, the group maintains minority interests in terminals and provides them with employees through its subsidiary duisport facility logistics. The subsidiary duisport agency, with a workforce of about 40, organizes logistics processes for customers. In total, 4.1 million TEU are handled, and 20,000 ships are entering the port of Duisburg annually. Terminals are certified with ISPS codes.

Theme complex: Logistics processes / Challenges

Transport by rail becomes increasingly important. In 2016, 53.1 million tonnes were transported via waterways, 30.8 million tonnes via rail and 49.2 million tonnes via road per year. An important activity for duisport is the rail connection between China and Germany. 25 trains per week travel nowadays through this connection and big expectations are placed on this new silk road.

The port of Duisburg is home for eight container terminals. Out of these, two terminals are private terminals, one owned by Bertschi and one owned by the shipping lines NYK and CMA CGM. What terminal is used, depends on the planning of the logistics chain by forwarders. Forwarders either decide on an affiliated terminal, or a terminal that corresponds best with the destination. For example, some terminals offer a regular railway connection to Scandinavia. At seaports, shipping lines usually partner with terminal operators and use those terminals exclusively. At duisport, only the shipping lines CMA CGM, and NYK line partner with terminals.

Dangerous goods (e.g., mineral oils in storage tanks) are handled in the port areas according to the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) and 12 berths are available for their storage. Regarding inland waterway transport, dangerous goods in the port area are mostly transported by tank ships.

Vessels that transport dangerous goods are required to announce their arrival to the port master before entering the port area. There is no standardized form of reporting the arrival, instead; data is shared via telephone, email or radio and it is registered manually by the port master. The collected data is used for statistics about traffic in the port area and for safety reason. For example, the number of TEU handled in the port of Duisburg is registered and published internally monthly.

duisport aim to develop an app ("River Port Communication System") that offers a standardized form for reporting duties. In addition, the app could provide added value for users by offering the opportunity to book services electronically, such as a repair and maintenance. The development of the River Port Communication System will be the next step. The current duisport app offers a basic version of announcing port entrance, harbour's plan including harbour numbers, port charges calculator, water level, weather, harbor's contact-numbers, safety instructions, and information about water level and weather. The aim of using a standardized app is the development of an integrated traffic management system with real-time data to improve the interlinking of different transport modes and thus boosting the efficiency of process on the port area.

Theme complex: Tracking and tracing

Data collected by duisport is currently not exchanged with neither terminal operator, VTS centers along the Rhine. This means that vessels must communicate transport-related information to all parties individually, even though the data asked by the parties does not differ tremendously from each other. duisport considers that there is a deep need to improve the data interchange along the supply chain.

An optimised data exchange system could improve the preplanning of processes. Mainly for the calculation of charges for occupying berths, berth planning and documentation in case of accidents. For example, reporting points along the Rhine could forward the collected data to the port, so that amount and time of arriving vessels and kind of cargo e.g., dangerous goods can be estimated. This information could increase process efficiency and optimize resources allocation considerable. Real-time data offers the possibility to make better use of the port infrastructure. However, this effect might be reduced by the fact that terminal operators compete. Further, real-time data exchange can as well improve the flows of cargo to and from port´s facilities, especially road (congestion, truck-parking, emissions).

Customs procedures are primarily done at seaports (at the EU external border) and less so at hinterland ports. At duisport, customs procedures are mostly done for trucks heading abroad.

3.3. Direktion Wasserschutzpolizei (WSP) of the Duisburg police headquarters (River Police Duisburg)

Theme complex: Tasks

The Duisburg Water Protection Police (WSP) monitors a total of around 900 kilometres of navigable waterways in North Rhine-Westphalia, where around 260,000 ship transports move each year. WSP is responsible for the navigable waterways Rhine, Weser, Ems, the Ruhr to Essen and the North German canals and their tasks range from security up to environmental protection of these waters.

Theme complex: Logistics processes / Challenges

The WSP monitors the above-mentioned responsible areas 24 hours a day, 365 days a year, and securely among other things:

1. Regulation of shipping traffic, such as accompanying special transports, shipping barriers, monitoring the loading / unloading of ships
2. Vessel controls for compliance with legally prescribed rest periods and shipping documents such as permits for the transport of certain (dangerous) goods
3. Prevention of vessel accidents
4. Monitoring the transport and handling of dangerous goods
5. Environmental protection

Theme complex: Tracking and tracing

The WSP does not manage any information about the current position, cargo, or orders of the vessels. The WSP monitors rivers and canals with regular tours and intervenes in the case of suspicious events or to clear up claimed accusations. The WSP receives information about the missions on site. There is no information service or electronic communication medium with which such data e.g., with either the district headquarters, customs office, nor inland port, etc. could be exchanged. In the event of vessel accidents (accidents), information such as the location of the accident, the crew of the vessel, transported cargo, vessel type and dimensions were important.

4. Lobbying and research group

In this section, the interview report of an association, part of the lobbying and research group, is introduced.

4.1. Verband Spedition und Logistik Nordrhein-Westfalen e.V. (Association of Forwarding and Logistics North Rhine-Westphalia e.V.)

Theme complex: Tasks / Business Tasks

The Association of Forwarding and Logistics North Rhine-Westphalia e.V. (VSL-NRW) is an association that represents the interest of freight forwarders upon state authorities and other trade associations.

Benefits of becoming a member of VSL-NRW include the provision of information and advice regarding labour and social law matters, among others. In addition, the association supports professional training and development through the Logistik Akademie NRW (founder) and acts as a representative agent for employers.

Theme complex: Logistic processes / Challenges

It was pointed out the considerable risks of water pollution and ecosystem extinction that might result from accidents of vessels transporting dangerous goods through the inland waterway transportation mode. Refineries performing this kind of transport, mostly use own fleets to transports dangerous goods.

Inland waterway transport is ideal for the transportation of loose bulk goods. Nevertheless, high, and mainly low water levels cause the biggest problems in inland waterway transport leading to latencies on the movement of cargo. These latencies must be communicated to customers. The plan of action is regulated in the freight contract. A possibility to counteract the waiting time is transferring the cargo from the vessel onto the truck. However, the transhipment causes additional costs that must be paid by the consignor. Since consignors are usually not willing to bear extra costs, the transhipment of goods onto trucks is not a regular procedure and normally the transport of cargo must wait. In the case of containers with goods belonging to several consignors transported by a vessel, it would be necessary that all owners agreed on the extra cost to overcome the delay. This is almost impossible.

Further challenges on the execution of transportation through inland waterways are the delays caused on congestion of ports and locks.

The forwarder is responsible for the transportation of cargo by inland waterways and document it properly. Mandatory documents are the order request, confirmation of order, consignment note, as well as accompanying documents, such as licenses and permits needed for transporting dangerous goods among others.

Theme complex: Tracking and tracing

VSL-NRW has no information regarding problems connected to data exchange in inland waterway transport. The status of shipped bulk goods (e.g., loaded / not loaded onto vessel) is always known. Stevedores plan the stowage of containers and packing lists give information about the contents of containers.

Technical study visit

For the study visit, a short stay in the inland waterway port CTS Container-Terminal GmbH in Cologne Germany was conducted. The study visit included presentations and local visit to the restricted port facilities where the transhipments take places. The tour was done by foot on working hours and operations were live experienced.

CTS Container-Terminal GmbH

Company introduction

CTS Container-Terminal GmbH (CTS) is the largest trimodal container terminal along the Rhine and currently the largest handling facility of the neska shipping and forwarding office. The assistant of the Director, did the welcome, introduced the port, did a round-tour into the port facilities, and answered questions.

The CTS Terminal operates on the premises of the Hafen und Güterverkehr Koln AG (Port and Freight Transport Cologne) and 60% its shares belong to the neska group. 112 is the workforce of the terminal and together with the neska group more than 400. The terminal is DIN EN ISO 9001:2015 certified, is an Authorized Economic Operator (AEO) and hold the ISPS certification to enhance the security of ships and port facilities.

The neska group is present on another inland waterways (rivers), but the network along the Rhine River is the strongest one with locations on: Alcotrans Rotterdam, RRT Duisburg, KCT Krefeld, DCH Düsseldorf, UCT Dormangen and CTS Cologne. CTS Cologne offers vessel and rail transports to Rotterdam and vessel transports to Antwerpen. The neska network transport in total around 1 million TEU every year. The terminal CTS handles only containers. No bulk, no broken goods, such as pallets, nor big bags, nor similar are here handled. CTS Terminal handles as well dangerous goods on tanks or containers.

Most important business is the transport from containers to and from see ports Rotterdam and Antwerpen. Destination or source of these container flows are customers located on a radius of 150 Km from the terminal. Outside this scope the transport through river is not more competitive and the truck is than preferred. More than 70 per cent of the road traffic volume is processed within a radius of 35 kilometres from the terminal. Besides advantage of cost and reduced traffic jams probabilities for the transport of containers to seaports through the Rhine is the fact that on combined transport, containers can carry 4 Tons more than not-combined transport. In the case delayed containers need to urgently be transported, “direct tracks” are done where the container is loaded into trucks to meet time critical deliveries.

The terminal offers services as well to shipping companies, normally owners of the containers for maintaining, repairing, and cleaning them. Sometimes are vessel transports organized to bring several empty containers to other locations where the shipping companies received better price conditions for storing, repairing or maintenance.

In year 2016, the terminal began implementing a RF-code system via GPS/WLAN for pitch organisation. This is helpful for the organisation of the handling operations of stacker cranes to deliver on board information through screens about next container to pick, location and destination.

Questions and Discussion

After the presentation, the discussion was open for free questions.

How is the registration of vessels currently being carried out in the terminal? What systems are used for this (web portals, apps, etc.)?

The vessel registers their proximity to call the terminal per e-mail, telephone, or radio. Not standardized way is conducted and no apps, no web portals are used for this purpose. In general, the critical moment on the import (seaports to hinterland terminals) is when the vessel finally leaves the seaport with the containers. After this happened, the travel is relatively predictable and terminals operators know from experience when this ship will arrive to the terminal.

Are systems used to track and track consignments in the terminal? What and how do they work?

No T&T system is used to track consignments along the chain. When there is the need to prove the status of a specific container, its container number will be checked on the movement history (loading, unloading lists) and if more information is needed, telephone calls or e-mails will be sent requesting more information.

How are deviations of ETA's Estimated Time of Arrival communicated? Is this information shared with other terminals?

Delays are communicated via telephone or e-mail. This information is not shared with any other terminals downstream.

What are the main challenges the terminal faces about the material and information flow?

Nowadays, the main concern from CTS are the important congestion levels of the seaports. It is not unusual to have delays of up to days for the vessel to get their cleared containers and began the import. On the other hand, the phenomenon is more a routine than the exception, so that hinterland operators began to integrate this time on their transports-time calculations.

What projects is CTS conducting in the theme digitalization?

Nowadays, the terminal is interested on the implementation of Tracking and Tracing Systems for their own truck fleet. This should allow customers to have accurate and real-time data about the location of their containers on the last mile through the region where traffic jams are usual.

Appendix H. Workshop Program

9:15 – 9:30	**Empfang**
9:30 – 9:35	**Begrüßung** Dr. Ansgar Kortenjann - Leitung Verkehr und Logistik Niederrheinische Industrie- und Handelskammer Duisburg-Wesel-Kleve zu Duisburg Prof. Dr.-Ing. Bernd Noche – Leitung Lehrstuhl Transportsysteme und -logistik Universität Duisburg-Essen
9:35 – 9:50	**Vorstellungsrunde**
9:50 – 10:10	**Agenda und Impulsvortrag – Ergebnisse der Interviews in Nord-West Europa „Stand der Datenaustausch in der Binnenschifffahrt"** Melissa Szymiczek – Projektkoordinatorin Universität Duisburg-Essen
10:10 – 11:10	**I Phase des Informationstransfers** Welche Potenziale ergeben sich aus der Einführung eines erweiterten Track- and Trace-Systems zur Sendungsverfolgung in der Binnenschifffahrt?
11:10 – 11:30	**Kaffeepause**
11:30 – 12:10	**II Phase des Informationstransfers** Welche Handlungsempfehlungen lassen sich festlegen für die Einführung eines erweiterten Track- and Trace-Systems zur Sendungsverfolgung in der Binnenschifffahrt?
12:10 – 12:50	**Vorstellung der Ergebnisse und Diskussion**
12:50 – 13:00	**Zusammenfassung und Ausblick auf zukünftige Aktivitäten in ST4W**
13:00	**Mittagsimbiss**

Appendix I. List of workshop participants

Organisation	Workshop participant	Player group
HTAG Port and Transport	Director Tonnage acquisition / Support	Physical group
Association of Forwarding and Logistics North Rhine-Westphalia e.V.	Marketing & Sales Manager	Lobbying organisation
TanQuid	IT & Future Business	Physical group
Haeger & Schmidt Logistics	General Manager of the Division Intermodal - Corporate Development	Physical group
Haeger & Schmidt Logistics	Corporate Development	Physical group
Imperial Logistics	Business Process Manager - Business Unit Shipping	Physical group
Imperial Logistics	Manager Onsite and Barge Service	Physical group
Federal Ministry of Transport and Digital Infrastructure	Unit WS12 - Waterway Infrastructure Technology - Inland Waterway Information Services	Lobbying organisation
Development Center for Ship Technology and Transport Systems	Project Development Coordinator	Research institution
Development Center for Ship Technology and Transport Systems	Scientific Associate - Department Transport systems and ship operations	Research institution
VVWL - Association for Forwarding and Logistics	Managing Director - Düsseldorf	Lobbying organisation
Multitel	Project Manager	Research institution
Universität Duisburg-Essen	Head of Department Transport Systems and Logistics	Research institution
Universität Duisburg-Essen	Project Coordinator - Department Transport Systems and Logistics	Research institution
Universität Duisburg-Essen	IT Developer - Department Transport Systems and Logistics	Research institution
Universität Duisburg-Essen	Researcher - Department Transport Systems and Logistics	Research institution

Appendix J. Workshop Organizational Aspects

Below, the organizational aspects such as logistics for the event, venue selection and workspace arrangement, catering, contingency plans and debriefing for the workshop are presented.

Logistics

A good preparation of the workshop allows the organizer to stay focused on the day and work efficiently. For the venue, the author got the support from the Lower Rhine Chamber of Commerce and Industry Duisburg - Wesel – Kleve that facilitated two conference rooms with furniture, equipment, and a space for the catering in their premises. The Lower Rhine Chamber of Commerce and Industry Duisburg - Wesel – Kleve hat a convenient location in the city centre of Duisburg with a walking distance from the main train station and very convenient access per public transport and car. The Lower Rhine Chamber of Commerce and Industry Duisburg has a dynamic and neutral reputation among the companies in the industry, trade and services sectors and is therefore a perfect host for the workshop.

The workshop took place on Tuesday 2nd April 2019 from 9:15 to 13:00 o´clock under the title "Intelligent track and trace systems in inland navigation". Two days before the event a remembering e-mail was sent to the participants with relevant practical information about contact details, directions, name of workshop room, access modes and parking areas to reach the venue. Signage for the workshop rooms were displayed to help participants to find their way on the building.

Workshop material (cards, pin board and markers, attendance list, moderation guidelines) and technical equipment (laptop, beamer) were arranged on advance.

On the workshop day, the author arrived early to the venue for informal exchange with participants and meet new ones so that all know the organizer, could poses questions, and feel comfortable with the organization. This made participants feel confident as someone take care of them letting them feel they are important. This gives the opportunity as well to evaluate the participants mood and identify early possible sceptical attitudes. To the best knowledge of the author, all participants were eager to participate in the workshop and take part on the discussion as the theme was innovative.

The workshop began with a welcoming word from the Head of Traffic and Logistics Unit of the Lower Rhine Chamber of Commerce and Industry Duisburg - Wesel – Kleve and the Head of the Department Transport Systems and Logistics of the University Duisburg-Essen. The agenda was introduced with information about the workshop methodology, pauses and catering offer. This made participants confident about workflow and free times available where they could take care of calls or read e-mails (they will then wait for this moment). The exchange began with a round presentation. First the organizer introduced herself sharing her background and communicating her role on the workshop and rapporteurs helping. After this, each participant introduced himself with name, position, company, motivation, and expectations for participation. As next point in the agenda, the impulse presentation was done beginning with an introduction on the workshop theme and objectives to make sure that they are understood by all participants. This help to unify the direction of the discussion. Followed, the results of interviews were presented about the state of the art, challenges, and expectations to enhanced Tracking and Tracing systems with an open discussion at the end.

Participants were then invited to move to the next room with enough space for free movement where workstations were built. Material and instructions how the results should be presented for the phases of information transfer and questions to develop in team on each workstation were explained. These instructions included type of dynamic, time for working the questions and format to present the results so that all groups work using the same format. Participants distributed themselves very proportional to the number of workstations. At the end of each transfer phase, participants of all workstations are called to bring their pin boards (now ideas poster) to form a circle to share in the open round the results of each workstation. In this way participants can do comments to the findings of other workstations and enrich results

This movement between the seating (impulse presentation), standing (workstations) and walking (phase transfer result presentations) activities made the workshop lively and influence as energizer. Writing the results of workstations into cards allowed the participants to share the discussion findings with other participants as well as the rapid writing of ideas, sorting into categories and quickly modification in the case of re-considerations by only re-writing or re-sorting the single card. It allows as well to use key words that express full messages without the necessity to write long texts. Further, the ideas poster kept a visual recording of discussion results.

After all participants worked dynamically on their ideas poster during the phases of information transfer, a wrap-up of workshop results summarized the participants what was achieved with their time and contributions. This allow the organizer to conclude if new perspectives should be explored.

Right away follow-up activities were communicated such as sharing of workshops minutes, impulse presentation, and ideas poster´s pictures. Finally, the author communicated future steps on her research studies, thanks participants for their time and inputs and invite them to join the lunch snack.

Space

For organizing the space for the workshop, special attention was taken to select the kind of room that would best suit the groups' needs in terms of work dynamic, comfort, and environment. As two types of dynamic were necessary for the workshop (seating for impulse presentation and standing/walking for the phases of information transfer), two different room configurations were needed. Not to lose time with the reconfiguration of the room, two separate rooms were arranged. They were adjacent rooms to save time while changing rooms.

For the welcoming, participant self-introduction and impulse presentation, a room with seats and tables in a hollow U arrangement was set up. In contrast to other configuration types (classroom, fishbone banquet, table threes) the hollow U seating allow eye contact between participants for better public cohesion and discussion; at the same time optimize the visual access for the impulse presentation. When one participant intervene, can be good heard by all participants what facilitates discussion as acoustic, visibility, and comfort are optimal. Figure 0-1 is a graphical representation of the implemented room configuration for welcoming, participant self-introduction and impulse presentation.

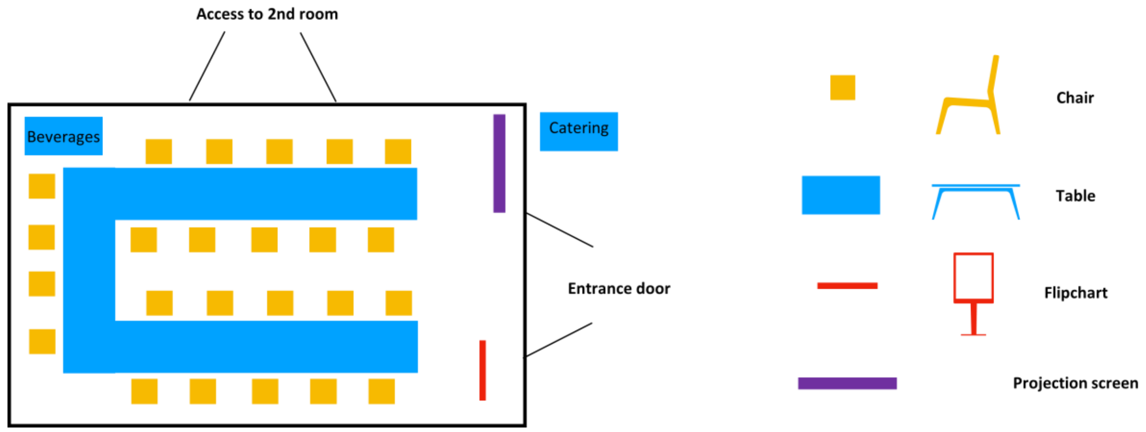


Figure 0-1 : Room configuration for welcoming, participant self-introduction and impulse presentation

For the phases of information transfer it was important to have a flexible room where configuration of workstations with pin boards and standing tables allowed people to easily move themselves and move the ideas posters in the middle of the room for an open round discussion. As 4 questions per phase of information transfer were going to be worked parallel, 4 workstations were configurated. Each workstation was provided with one pin board 1.2 x 1.5 m and a standing round table of 800 mm diameter. Enough markers, cards and pins were available at each table. The standing tables make it possible for the participants to easily work on the pin board, have eye contact during the discussions without too much distance between them but enough surface for taking notes and set up beverages.

The size of the room was sufficiently so that there was enough distance between workstations and groups don´t hear each other when working. Figure 0-2 is a graphical representation of the implemented room configuration for the phases of information transfer.

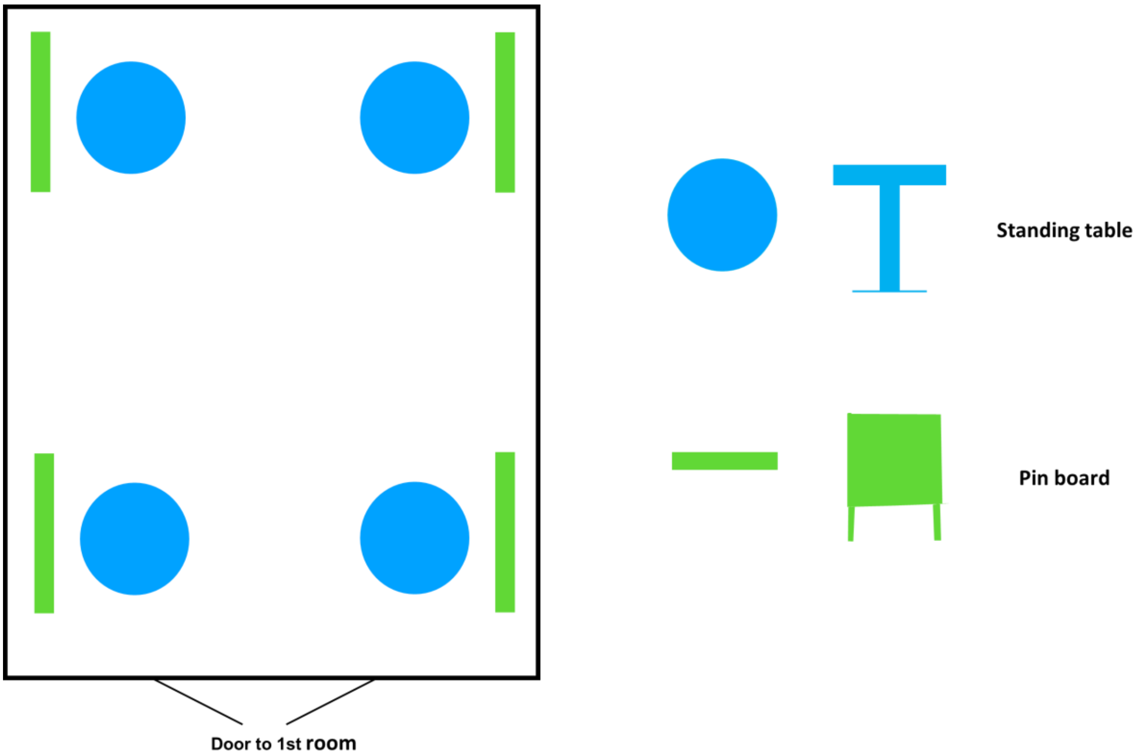


Figure 0-2 : Room configuration for the phases of information transfer

Catering

As the workshop should last hours, Catering is a fundamental part to take care of participants and a key element in creating an environment favourable for collaboration and creativity. A table with beverages (coffee, water, and juice) was to the disposition of the participants all times. A coffee break was as well organized to provide free time for participants to go the bathroom, walk, talk with each other, or attend calls/e-mails. This help for collecting new energy for the second phase of information transfer.

A lunch snack at the end of the workshop was offered as an attention for participants who shared their time and ideas. It was as well a very important moment for networking among participants, extend ideas of the workshop. Additionally, with a lunch snack, participants could right away joint their obligations once back at their offices.

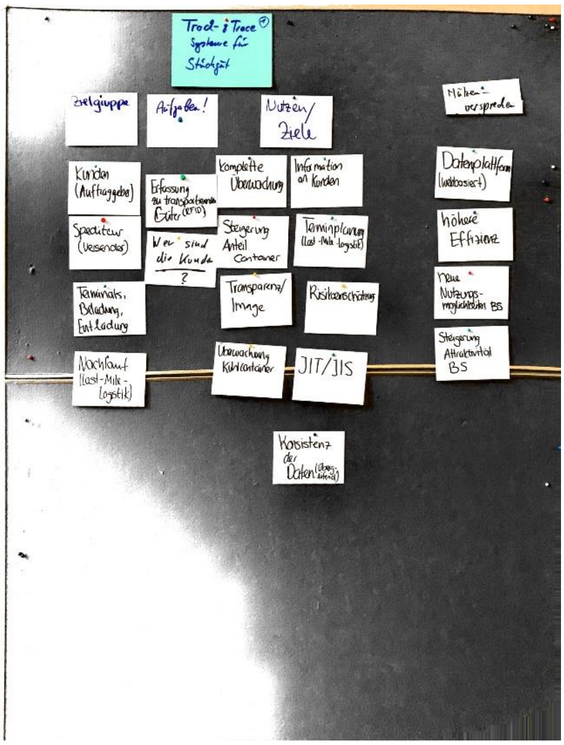
Contingency plans

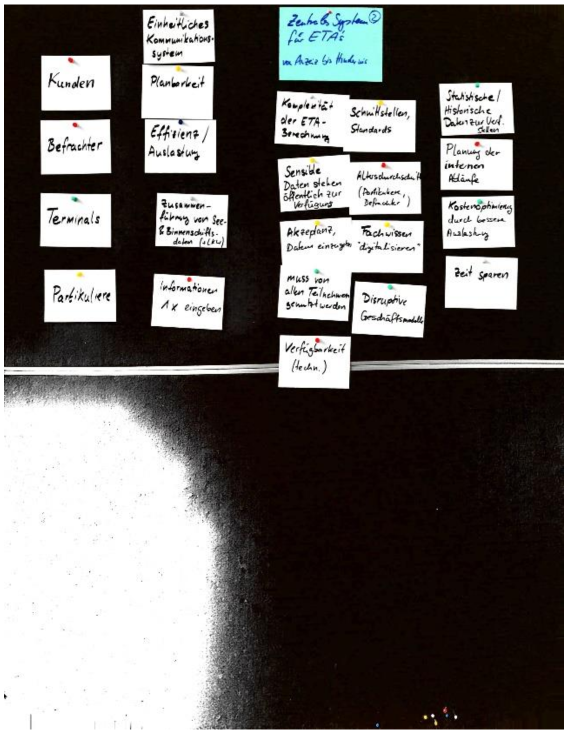
Even if the complete workshop is perfectly organized one should think about possible contingency plans in case some unexpected circumstances take place. For this purpose, this study closely follows the useful instructions offered by Chapter 17 “Troubleshooting” from Manual “Build-A-Workshop” from Oberholzer (pages 24 to 25).

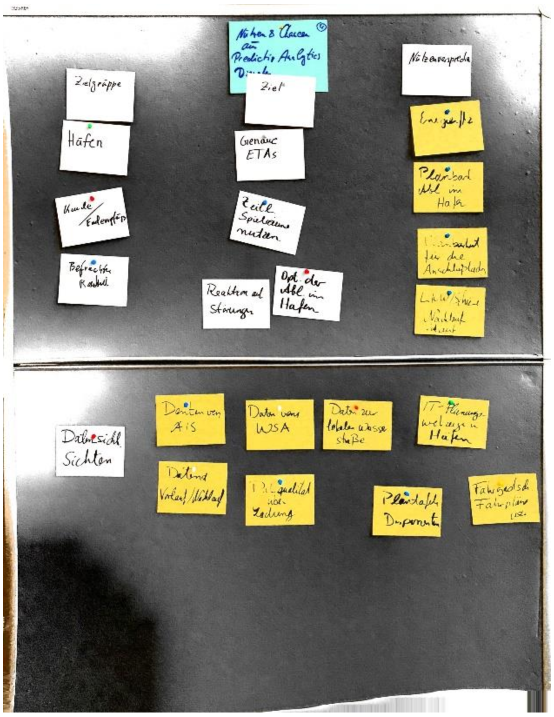
Debriefing

After the workshop, the author conducts a personal debriefing to evaluate workshop success. Main questions were: Were the objectives of the workshop achieved? Was the planned agenda good for the achievement of the objectives? Do each transfer phase hat enough time? Was the workshop methodology the correct one? Where participants motivated, was the discussion rich? Does the results of each workstation were good? Where the strategies for the documentation of the workshop correct and does where they fully followed? Was any appreciation that the participant composition, place, time, agenda, and dynamic affected in a positive or a negative way the results? Was the atmosphere creative and collaborative? Did any participant provide disturbances that could affect the workshop results?

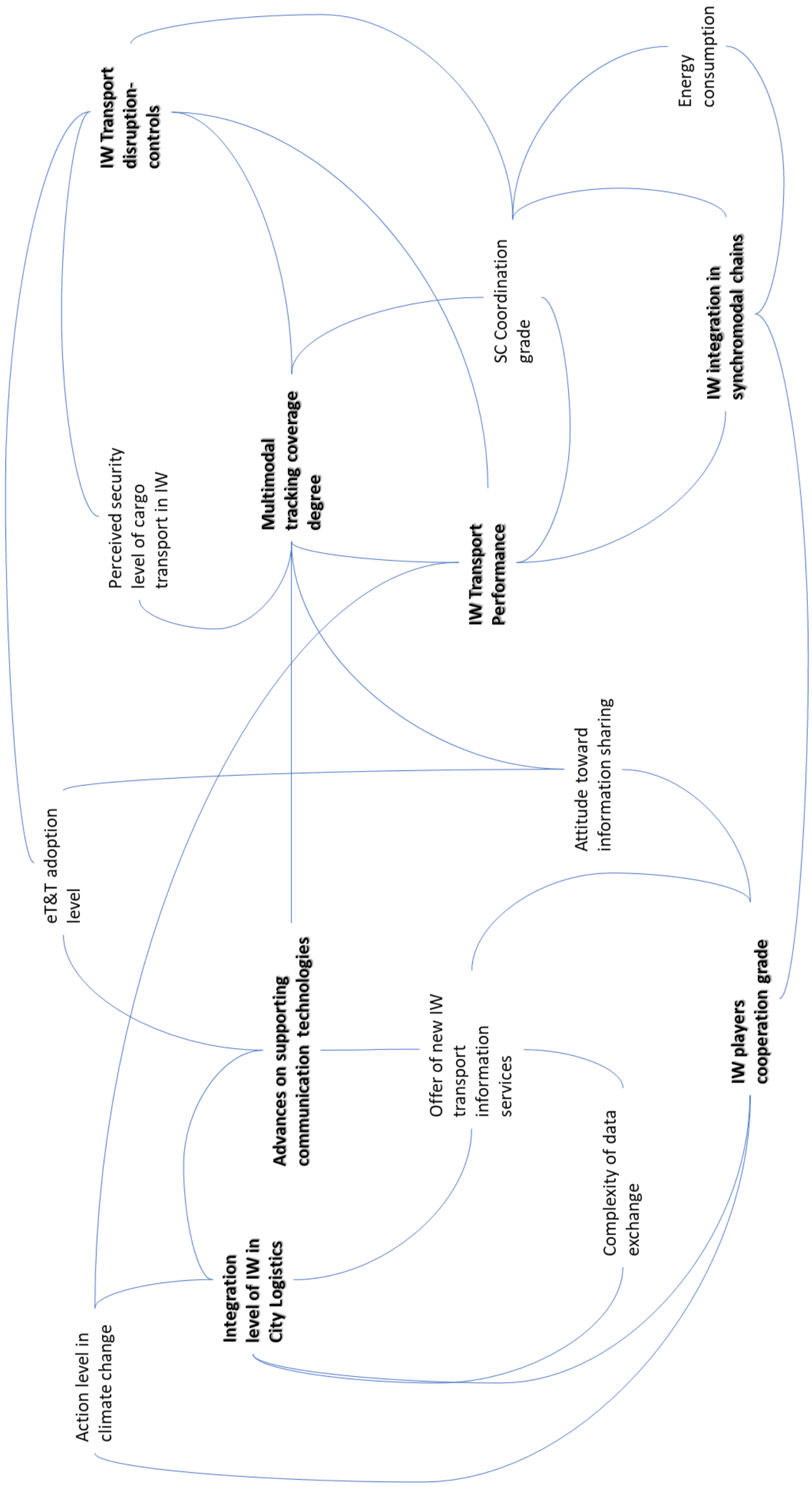
Appendix K. Workshop ideas posters







Appendix L. SusInWa Granularity Level 1



Appendix M. SusInWa Granularity Level 3

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