CHALMERS
UNIVERSITY OF TECHNOLOGY

Implementing Inland Waterway Transportation in Urban Logistics

Master's Thesis in the International Master´s Programme Maritime Management

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CHALMERS UNIVERSITY OF TECHNOLOGY

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Abstract

Urbanisation puts tremendous stress on road infrastructure. Consequently, innovative solutions to cater for the growing population and subsequent need for increased transport of goods and waste in urban areas need to be explored. A modal shift from road transportation to inland waterway transportation can be beneficial for several reasons such as less pollution, traffic congestion, accidents and noise. This study analyses the necessary conditions for a successful implementation of a combined goods and waste transportation system on inland waterways based on the case of an urban planning project in the City of Gothenburg. Therefore, semi-structured interviews with stakeholders from the local urban supply chain, field trips and work group meetings have been conducted, attended and analysed. It was found that economic and operational factors, behavioural change, policy and regulations represent strong barriers for the implementation of such a transportation system. As weak drivers, public interest, environmental drivers, political incentives, regulations and technical development were identified. To overcome strong barriers, weak drivers need to be strengthened. More emphasis needs to be put on policy and regulations as those have strong power to influence the actions of stakeholders in the urban supply chain and thus, bring forward sustainable transportation. It is concluded, that building trust represents a core element in the implementation process of a new transportation system. Consequently, new systems need to prove their applicability and reliability on a small scale in the short run. In the long run, these new systems need to serve more areas, thus achieving economies of scale and profitability.

Key words: (inland waterway transportation, modal shift, sustainability, sustainable transportation, urban logistics)

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1 Introduction

European cities are facing trends of urbanisation. Despite a stagnating population growth, the number of habitants in urban areas will increase substantially. More precisely, by 2025 more than 75%, and by 2050 around 84% of the population will live in urban areas (MDS Transmodal, 2012). The increased number of citizens implies higher consumption of goods and production of waste locally. Thus, the need for transportation into and out of urban areas increases and puts tremendous stress on the transportation network and related infrastructure. This results in raised negative impacts of freight transport connected to sustainability issues consisting of environmental, social and economic impacts, while emissions to air and use of non-renewable natural resources relate to environmental impacts, influence of emissions to public health, injuries and fatalities from traffic accidents, visual intrusion and vibration point to social aspects and economic impacts consist of the inefficient use and waste of resources, congestion, decreased journey reliability and delivery punctuality (Quak, 2008).

Consumers tend to source goods from smaller stores in near proximity rather than from large shopping centres outside the city as the latter option is too time consuming and not suitable for personalised service. In the set up with decentralized large shopping centres, high fill rates of heavy trucks were contributing to high transport efficiency. As local authorities introduced regulations in several cities to ban heavy trucks from city centres in order to reduce the negative impacts of freight transport, other ways of transportation into the centres need to be considered replacing heavy trucks (MDS Transmodal, 2012). Deciding on the suitable mode of transportation such as air, road, rail and water depends on requirements on time, network availability and total logistics cost (Rhodes, et al., 2012).

In order to reduce the negative impacts of freight transport and to avoid limitations from local regulations on road traffic a modal shift to inland waterway transportation can be beneficial. Janjevic and Ndiaye (2014) present inland waterway transport concepts that were implemented in several European cities to substitute and reduce heavy traffic in dense urban areas. The concepts aimed to transport palletized and containerized goods, deliver parcels, transport to local shops and restaurants as well as to carry waste and recycled material. The projects show that environmental and social benefits are achievable. However, Janjevic and Ndiaye highlight the importance of the accessibility and structure of the network of inland waterways and that this mode of transportation only covers a limited part of the total urban freight volume. What is more, local authorities and bodies play a substantial role in the implementation process by providing financial aid in the starting process of the projects. Lindholm (2012) highlights the importance of authorities´ influence when making sustainable development of urban freight transport possible. In many cases authorities do not understand their role and their significant power to bring sustainable development of the urban freight sector forward. Allocation of resources and information exchange plays an important role in this context. However, as urban freight transport represents only a small part in the whole supply chain, its relevance is recognized by the European Union as subordinate. In order to promote the implementation of sustainable development of urban freight transport it is recommended to introduce legislation, which encourages the private sector to increase its efficiency and lower the negative impacts (MDS Transmodal, 2012).

1.1 Purpose/Research Question

Inland waterway transportation can be a suitable mode of transportation in dense urban areas and has proved to achieve environmental and social benefits, while the implemented projects focused on goods and waste transportation separately (e.g. Flipo, 2013; BESTFACT, 2014; Janjevic & Ndiaye, 2014; BESTFACT, 2015; BESTFACT, 2016). Implementing inland waterway transportation, which combines the transportation of goods and waste, can improve the transport system efficiency as empty haulage can be avoided. Furthermore, it provides huge potential to lower the negative impacts of urban freight transport.

This study aims at identifying the necessary conditions to enable a modal shift from road transportation to inland waterway transportation where the transportation of goods and waste can be combined. Therefore, the research question addressed in this thesis is formulated as follows:

How can a combined goods and waste transportation system be implemented in urban supply chains utilizing waterway transportation?

The focus of this research question lies on the process of the implementation of a new transportation system. Answering the research question is intended to provide an understanding of which barriers to overcome and which drivers to make use of as central parts of a successful implementation process. The research project is carried out in close connection to an urban develpment project in the City of Gothenburg.

The findings of this study can not only be used for existing city development projects in Gothenburg, but in urban freight transport planning in several cities, in which urban space is scarce and which have access to an inland waterway network, which is not fully utilized. It should provide clarification of which aspects have influence on the successful implementation of an inland waterway transportation system.

1.2 Challenge Lab

The Challenge Lab was established in 2014 as an initiative within Chalmers University of Technology, in which Master´s students write their theses in a collaborative way in close connection to the triple helix, which consists of academia, society and industry. Contemporary challenges are faced and analysed by using the backcasting methodology, which has an unbiased view envisioning a future regardless from current trends. For the transformative and integrative opportunities to intervene in the system, the triple helix combined with the student as a fairly neutral person is the focus of the Challenge Lab.

Within the university the students connect the areas of research, innovation and education, known as the knowledge triangle (Holmberg, 2014) and connect it with the triple helix (see Figure 1). By standing in between academia, the public and the private sector, the Challenge Lab provides a neutral space to bring these three areas closer together.

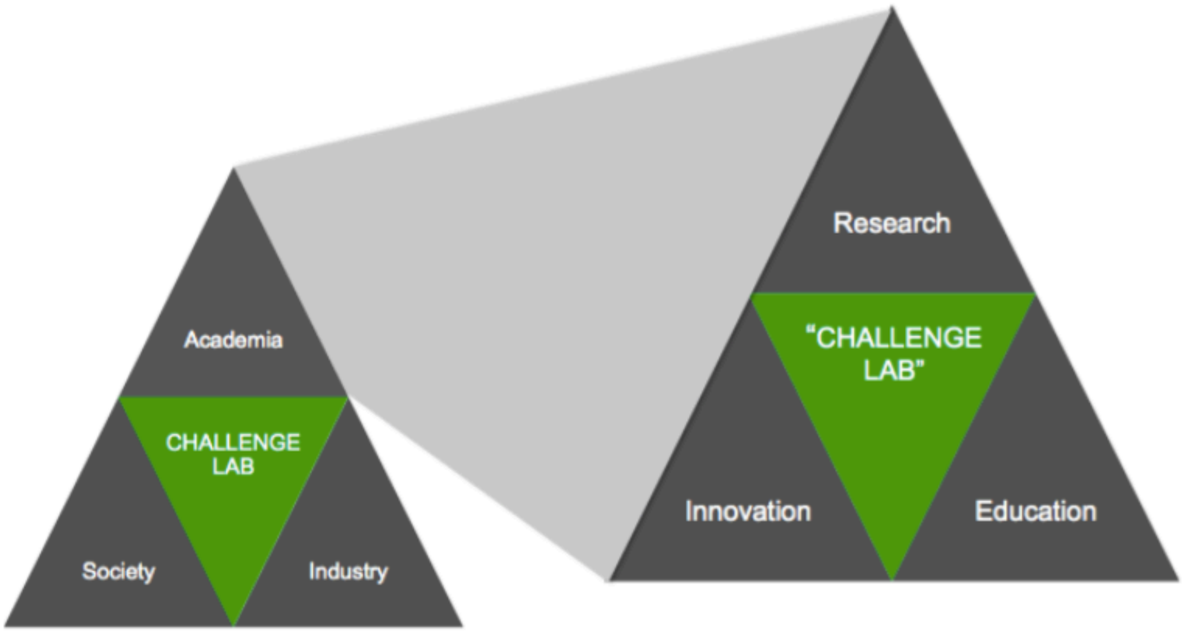

Figure 1: The Knowledge Triangle as part of the Triple Helix, (Andersson, Holmberg, & Larsson, 2015)

Writing their Master´s thesis in the Challenge Lab, the students work as change agents closely with the stakeholders from the three different sectors enabling and enhancing rich dialogue which can result in increased quality of collaboration and possibilities in finding leverage points to bring transitions in complex socio-technical systems (Andersson, Holmberg, & Larsson, 2015). As a student does not represent any institution, regulator or private company stakeholders are claimed to be more open in the dialogues and to bring up own ideas without restrictions (Holmberg, 2014).

In the last study term before starting their Master´s thesis project the majority of the students participating in the Challenge Lab took the course "Leadership in sustainability transitions" as a preparation to the Challenge Lab. The overarching theme was to envision a sustainable campus at Chalmers, which resulted in projects on urban mobility, sharing economy, the Chalmers vision, food on campus and social integration.

In this year, 2016, the Challenge Lab students consists of 14 students under the guidance of the Challenge Lab team; the examiner, a professor in Physical Resource Theory, a tutor, two project leaders and an assistant. The highly diverse group of students from nine different countries on four continents shares their interest in sustainability while coming from a great variety of Master´s programmes, i.e. Communication Engineering, Design and Construction Project Management, Environmental Science, Industrial Design Engineering, Industrial Ecology, Infrastructure and Environmental Engineering, Maritime Management, Sustainability, Economics and Management and lastly Sustainable Energy Systems. In this variety of educational and cultural backgrounds a unique learning and working experience can be observed where exchange of information, knowledge and work experience takes place on a daily basis providing new views and ways of problem solving in relation to the different Master´s thesis projects.

1.3 Scope and Limitations

The preparation and process of defining the research project within the Challenge Lab represented the first two month on the five-month Master´s thesis timeline. As to the limited time of the research project, only one round of interviews was performed. Stakeholders were chosen from the urban supply chain in Gothenburg. Therefore, a bias originating from geographically local thinking of the interviewees might occur.

Carrying out the research project, does not aim to present a final technical solution on how the urban supply chain could look like. It intends to describe factors of importance for a successful implementation of an innovative transportation system introducing combined goods and waste transportation on inland waterways in urban logistics. Furthermore, this thesis does not provide a technical solution on solving the problem of connecting inland waterway transportation with the last mile delivery solution in the distribution to the receiver.

1.4 Outline

The thesis is divided into two phases. The first phase relates to the Challenge Lab process with the aim of defining a research question; the second Phase contains the research project.

In the first phase, in Chapter 2, process tools and methods used in the Challenge Lab are presented. A description of the methodology used in the first phase follows in Chapter 3. Thereafter, the results from the Challenge Lab proceedings are described in Chapter 4, which lead to the research project, which is approached in the second phase.

In the second phase, the theoretical framework is described in Chapter 5 and elements of urban logistics, transport regulations in the City of Gothenburg, urban waterway projects in Europe and the socio-technical system are presented. The methodology is described in Chapter 6 followed by the results and subsequent analysis of the research project in Chapter 7. In Chapter 8, the results of the research project are discussed. The thesis ends with a conclusion in Chapter 9.

Phase 1 – The Challenge Lab Process

The first phase of this thesis focuses on the theoretical background and the proceedings in the Challenge Lab towards finding a research project. Strongly influenced by the backcasting methodology, the students work in a co-creative environment from global understanding of sustainability to solving sustainability challenges in the local system. The road to finding individual research topics for the students in the Challenge Lab is described by presenting the theoretical framework in Chapter 2, the methodology in the Challenge Lab in Chapter 3 and the results in Chapter 4.

2 Frame of Reference

This chapter portrays the theoretical framework of the first phase of the Master´s thesis within the Challenge Lab. First inside-out and outside-in tools and methods are described followed by a presentation of the design thinking method. Lastly, the central methodology in the Challenge Lab, backcasting, is depicted.

2.1 Inside-Out Perspective

The inside-out perspective relates to the identification of own values, strengths and visions through the application of knowledge, methods and tools to understand ones individual position in a greater system. Furthermore, it relates to the interaction of those individuals in that system (Holmberg, 2014). In the following the inside-out tools self-leadership, active listening, guidelines for dialogue and dialogic leadership are presented.

2.1.1 Self-Leadership

Through self-leadership individuals can identify their own values, strengths and visions (Holmberg, 2014). For the identification of an individual’s motivation and engagement Ryan and Deci (2000) differentiate four types of extrinsic motivation with a perceived locus of causality reaching from external to internal. First, caused externally, the motivation of action lies in complying with external regulations. Second, somewhat caused externally, the motivation is based on introjected regulation relating to internal rewards and self-control. Third, caused slightly internally, the motivation of action lies in self-identified regulation resulting from identifying matters of personal importance and conscious valuing, thus, finding a sense of meaning. And last, caused internally, the value of congruence and awareness shows, that the motivation is based on the individual’s personal values and beliefs. This level, where the motivation comes from the deep inside of an individual, is the desired level for leaders to transform complex systems.

2.1.2 Active Listening and Guidelines for Dialogue

Listening to and involving stakeholders are important leadership abilities, where trust and active listening are central contents. Sandow and Allen (2005) describe a circle of reinforcing trust as a basis for collaboration. The circle shows the interrelation of listening, understanding, trusting and collaborating. In a system, where everyone in an organization is accepted and works towards the same goal, everyone should have a voice. Listening to this voice, irrespective that level in hierarchy the person represents, is central. Interrupting and shutting off any voice hinders the understanding and disturbs the trust building process. If the voice is listened to and understood, trust can emerge in the teller, as this person knows, his idea or contribution is relevant, thought over and respected by the others, thus, leading to collaboration. Reflection of processes in performing collaboration results back in listening, closing the circular relationship (Sandow & Allen, 2005).

Similarly, Isaacs (1993) provides basic recommendations for a successful dialogue. Therefore, following actions must be taken. Firstly, assumptions and certainties shall be suspended, secondly, observers shall be observed, thirdly, one shall listen to ones listening, fourthly, one shall slow down the inquiry, fifthly, one shall be aware of thought and lastly polarization shall be befriended.

2.1.3 Dialogic Leadership

A strong tool in communication is to understand the power of dialogue, as “Human beings create, refine, and share knowledge through conversation.” (Isaacs, 1999, p. 2). In his four-player model Isaacs defines four different parties in a conversation (see Figure 2). The first one moves and brings forward new ideas, the second one follows and carries out, what is said. The third player opposes and brings about criticism, challenges the mover and states different views. The fourth and last player in this model is a bystander, observing what is happening and providing a perspective.

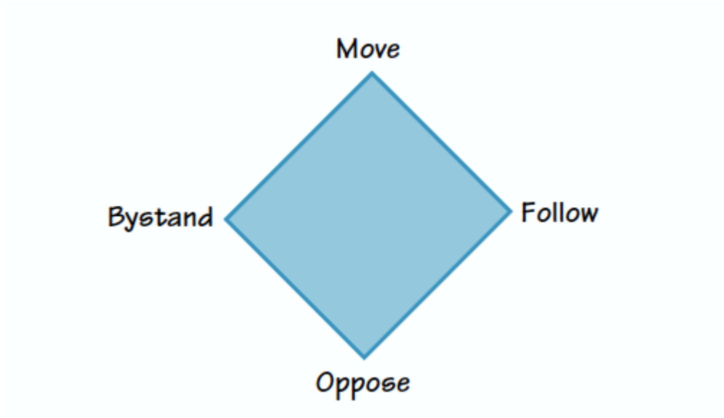

Figure 2: Dialogic Leadership – 4 players model, (Isaacs, 1999)

A leader has to track the action in a conversation and has to balance advocacy and inquiry. Therefore, to advocate well, he “must move and oppose well” and to inquire he “must bystand and follow” (Isaacs, 1999, p. 3). A person who opposes, but does not move - i.e. does not bring in new ideas - is not effectively taking part in the conversation. The same happens, when a follower does what others say, but never develops an own view for a better understanding of the task.

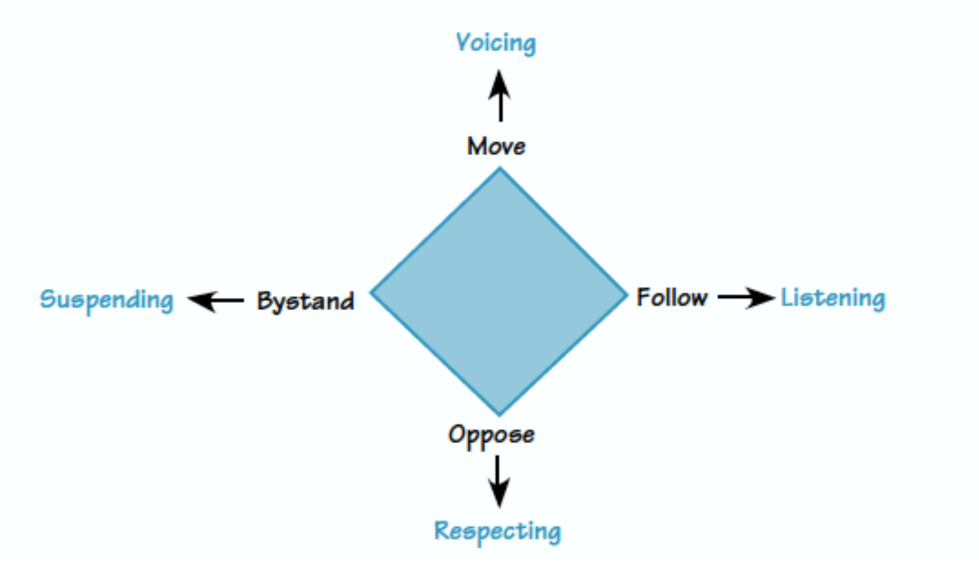

Figure 3: Four practices for dialogic leadership, (Isaacs, 1999)

By extending the four-player model (see Figure 3), four practices for dialogic leadership are described, which can positively influence the quality of a conversation, where balanced action is essential. Following means to listen carefully, without criticising in order to understand the essence of what is told. Listening is difficult, because one always processes own thoughts on the topic, which can cause a blockade in really understanding, what the other wants to say. When opposing, respecting that the opposite has a coherent, different view is important in order to efficiently discourse. Bystanding means to suspend the own views accepting that others have different ones. Finally, stating own views and opinions and encouraging others in the same manner, i.e. voicing, relates to moving in the four-player model. Using these four dimensions of listening, suspending, respecting and voicing can significantly increase the quality of dialogues. Therefore, leaders should incorporate these dimensions into their understanding of dialogues (Isaacs, 1999).

2.2 Outside-In Perspective

The outside-in perspective provides means of analysis to understand how global sustainability influences global and local systems. Outside-in tools and methods are: Systems thinking, to identify leverage points from where to intervene in locked systems (Meadows, 1997), the multi level perspective (Geels, 2004), to understand on which level to intervene, and design thinking (Söderberg, 2014), as an iterative process to improve a product.

2.2.1 Systems Thinking

Motivated by economic growth, socio-economic systems are often steered in the wrong direction. To enable considerable change in a system, the right leverage points need to be identified. Meadows (1997) describes nine leverage points to enable change in a system, which are stated in reverse order and from short leverage to long leverage:

9. Numbers (subsidies, taxes, standards).
8. Material stocks and flows.
7. Regulating negative feedback loops.
6. Driving positive feedback loops.
5. Information flows.
4. The rules of the system (incentives, punishment, constraints).
3. The power of self-organization.
2. The goals of the system.
1. The mindset or paradigm out of which the goals, rules, feedback structure arise.

Figure 4 illustrates how leverage points can have a different level of influence on changing a system, depending on the length of the leverage.

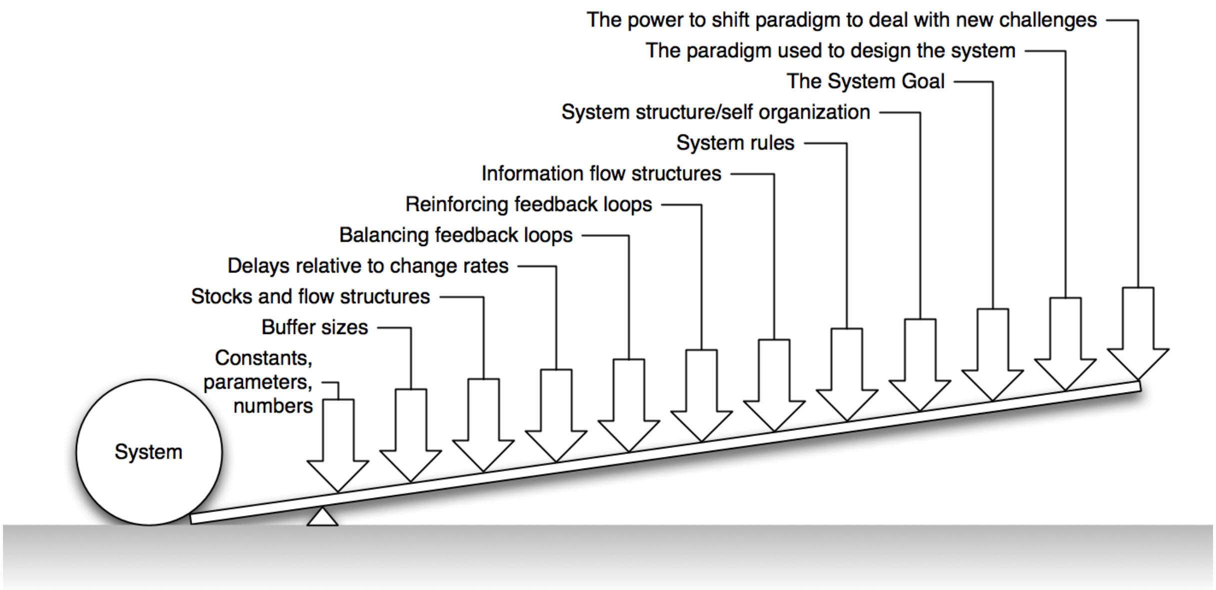

Figure 4: Leverage points to intervene in a system, (Meadows, 1997)

2.2.2 Transition Management: Multi-Level Perspective

Change in socio-technical systems happens on three different levels of society (see Figure 5); on niche, regime and landscape level (Geels, 2002). The niche-level relates to small markets, which are relatively separated from regular markets, while the regime relates to areas where regulations allow and limit activities within communities through lock-in mechanism such as business as usual activities. At regime level, the elements are relatively stable, because they are interconnected through the alignment and organization of the different actors. The landscape refers to broader, non-technologic factors, such as oil prices, economic growth, wars, emigration, broad political coalitions, cultural and normative values, environmental problems (Geels, 2002). Because of the separateness of the niches, they are able to reveal radical change, whereas change in regimes is typically generated incrementally and more slowly because of the existing lock-in mechanisms. The landscape is even harder to change, which is rooted in the fact, that it cannot be changed directly by any actor. Therefore, change happens very slowly in the landscape.

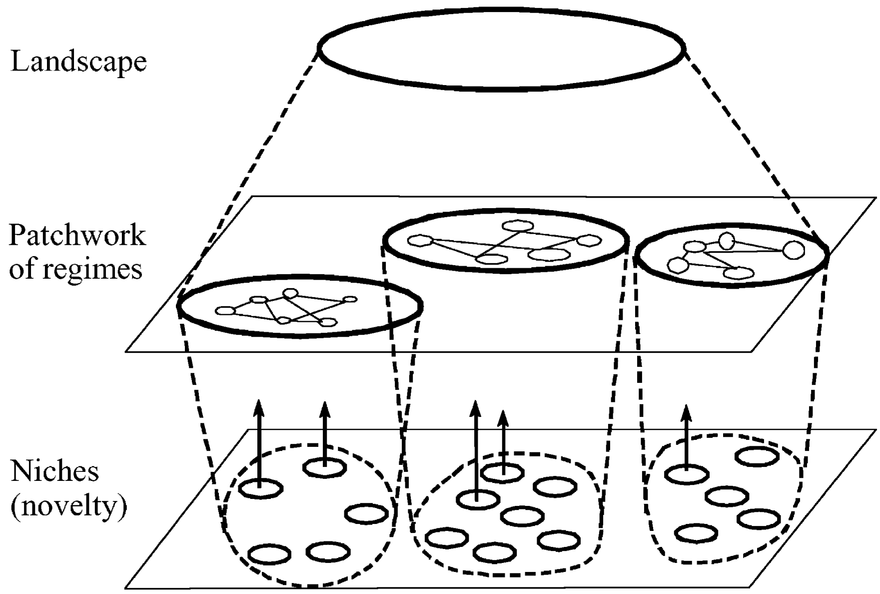

Figure 5: The Multi-Level Perspective, (Geels, 2002)

2.3 Design Thinking

Design thinking is a non-linear concept for planning a product. It consists of three overlapping stages; the pre study, development and verification (see Figure 6). The pre study comprises the knowledge of the group working on the project, identifying a challenge, creating or choosing a system and formulating the needs and requirements. The development phase consists of formulating the needs and requirements, functions and ideas and finally coming up with a concept. The verification phase includes the idea, concept, visualization and prototyping of the design. In between all stages it is necessary to do iterations to improve the quality of each stage. When designing a product, it can be noticed, that the contractor and client have a different range of iterations going through the different processes. Figure 6 displays this disparity of the design thinking range in between client and contractor. While the client, who wants the final design as a product, expects iterations from the contractor only within the development and verification phases based on his own thoughts, the contractor, however, is advised to even go into the pre study phase to question the system in order to improve the quality of the design (Söderberg, 2014).

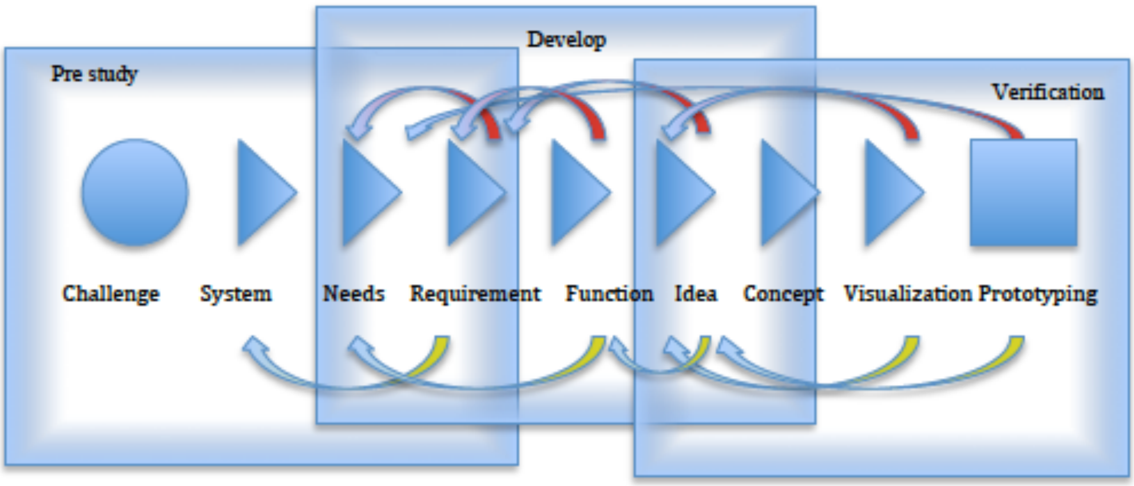

Figure 6: Iterations in the design thinking process, (Söderberg 2014)

2.4 Backcasting

In this chapter, the dimensions of sustainability and system conditions are presented, which are used as a background for the backcasting process, which is described thereafter.

2.4.1 Dimensions of Sustainability

As to the United Nations (1987, p. 41) sustainable development is defined as follows: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." These needs can be described as to have different dimensions. Atkisson and Hatcher (2001) invented a tool named "The Compass Index of Sustainability" which gathers indicators for sustainability in four quadrants similar to the compass:

N - Nature:	Relating to ecosystems, bio-geo-physical cycles and natural resources
E – Economy:	Relating to effective and efficient use of resources in human activities
S – Society:	Relating to government, social and family systems
W – Well-being:	Relating to health and fulfilment of every individuals needs

By using the compass as a way to present the four dimensions an easily comprehensible framework is created to ensure that these four dimensions are always considered in any undertaking related to sustainability.

Holmberg (2015) describes these four dimensions, which were mentioned in the Compass Index of Sustainability, in the way, that nature is the foundation for the social and economical dimension, on which the dimension of well-being is built on (see Figure 7).

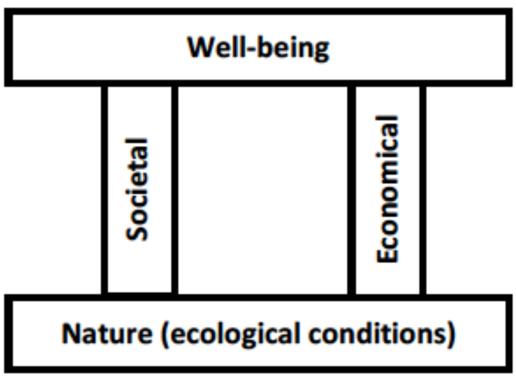

Figure 7: Dimensions of Sustainability, (Holmberg 2015)

2.4.2 System Conditions

Together with Robert, Holmberg (2000) elaborated on the tremendous impact of humans on the life-enabling surroundings. Regarding negative impacts, they defined four principles as "system conditions" on what humans should refrain in order to enable earth to sustain human kind and keep earths functions and biodiversity as the foundation for the other sustainability dimensions.

Firstly, "In order for society to be sustainable, nature´s functions and diversity are not systematically subject to increasing concentrations of substances extracted from the Earth´s crust" (Holmberg & Robert, 2000, p. 298). This means, that materials taken from the lithosphere should not accumulate in the atmosphere and hydrosphere, such as carbon in form of coal, oil and natural gas taken from the lithosphere and accumulated as carbon dioxide in the atmosphere as a result of burning and processing of these materials. An accumulation takes place, when the earth cannot absorb as much material as emitted. What is more, materials should be used keeping in mind the time, which is necessary for nature to reproduce them. The same applies to any other chemicals taken from the lithosphere.

Secondly, there shall not be "increasing concentrations of substances produced by society" (Holmberg & Robert, 2000, p. 298). This system condition relates to all artificially, chemically produced substances, which do normally not exist in nature and do not follow natural cycles, or - even worse - negatively affect natural cycles, as example given fluorochlorinated hydrocarbons, which were used in spray cans and refrigerators and drive forward ozone layer depletion.

Thirdly, the system condition "nature´s functions and diversity are not systematically impoverished by over-harvesting or other forms of ecosystem manipulation" (Holmberg & Robert, 2000, p. 298) sheds light on for instance deforestation of rainforests, which is carried out in order to grow other plants, motivated by economic benefits as well as the exploitation of soil in agriculture, in the way that it cannot be used afterwards or needs excessive time to recover before being able to enable new plant growth.

Fourthly and finally Holmberg and Robert (2000, p. 298) state that "resources are used fairly and efficiently in order to meet basic human needs world wide." With this system condition Holmberg and Robert highlight, that society should make sure, that wealth and resources should be distributed equitably in order to enable every human being all over the world to meet their basic human needs.

2.4.3 The Backcasting Process

For transitions it is necessary to analyse a situation and to understand that there is a need for change. Backcasting is a suitable tool for transformative transitions, as it does not follow trends or is biased by trends, but envisions a future according to relevant criteria. The concept is divided into four steps as illustrated in Figure 8 (Holmberg, 1998).

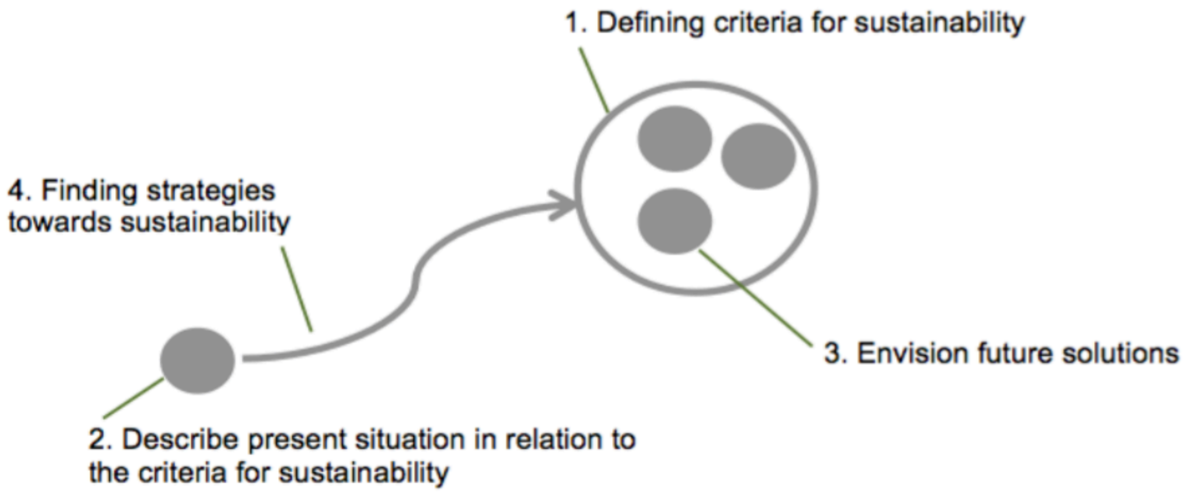

Figure 8: The four steps in Backcasting, (Holmberg, 1998)

1. First, criteria for the four dimensions of sustainability are defined for a future situation.
2. In the second step, the present situation is described in relation to the formulated criteria in step one.
3. Solutions for a future according to the pre-set criteria are envisioned in the following, while not being biased by trends of the present situation.
4. The last step consists of identifying the gap in between the envisioned future and the present situation and finding sustainable strategies to minimize or erase the gap, thus creating a transition towards sustainability (Holmberg, 1998).

3 Methodology

The purpose of the methodology in the Challenge Lab it to go from broad sustainability challenges into formulating the research question for a Master´s thesis project focussing on challenges in the Gothenburg region. The application of the backcasting methodology in this undertaking is suitable as it is used for solving long-term complex challenges, concerning society, technological innovations and change (Dreborg, 1996). Following the four steps of the backcasting methodology as presented by Holmberg (1998) the first phase in the Challenge lab was divided into four weeks; 1. Defining criteria for sustainability, 2. Describe the present situation, 3. Envision future solutions, 4. Finding strategies for sustainability. Further tools helped during the process, such as inside-out and outside-in perspective tools and design thinking.

3.1 Backcasting Step 1 – Defining Criteria

In the first week the students in the Challenge Lab started with presenting each other and identifying personal strengths in a self-leadership workshop (Inside-out) and concentrated on defining criteria for sustainability (Outside-in).

Inside-Out Perspective

To get a better understanding of the diversity of the group of students in the Challenge Lab and identifying personal strength, two inside-out tools were used: Coat of Arms and a Self-Leadership workshop. In the latter part of the first phase, the results of this step were used to choose partners for writing the thesis.

One of the first activities in the Challenge Lab was, that the students present themselves to the others in order to understand each others´ motivations related to the participation in the Challenge Lab and to get to know each other more personally. Therefore, everyone had time to paint a *coat of arms* with the four sections:

1. This is me
2. This makes me concerned
3. Why I chose Challenge Lab
4. This makes me happy

In groups of four, the students presented themselves to the others, whereas later in the group of all students, one had to present another person to the group in order to make everyone more acquainted as well as generating openness and trust.

In a *workshop* guided by the institution *SelfLeaders* the students were introduced to concepts of intrinsic motivation, being value-driven and leadership ability using the inside-out perspective in order to relate the inner values to the outer world and to give each other a better understanding on personal views. As a preparation for that, two surveys had to be done. One survey, in which personal values had to be graded in comparison to others, and another survey, in which personal strength were ranked.

Given the individual results from this survey on personal values, further group work in teams of three students was done. The task was to present some of the values by defining each one of it and then motivating why this value was chosen, while one person was sitting quietly listening actively. The third person was a questioner, guiding the presenter towards sticking to the rules of the presentation.

The results from the survey on personal strength were used to analyse in which category of leaders each individual student falls. As students in the Challenge Lab mostly write their thesis in groups of two, this is an important tool to understand the students' differences and how to find a team partner who could complement the other, instead of having the same strength.

Outside-in Perspective

In the first week the Challenge Lab team introduced several concepts and theories to the students such as the backcasting methodology (Holmberg, 1998) and the four dimensions of sustainability (Holmberg, 2015). To define the criteria for sustainability, the students were divided into four groups, each representing one of the four dimensions; ecological, economical, societal and well-being. In each group, one person facilitated a discussion, which was based on the literature, which was given to the students beforehand. To not only discuss one dimension, the students changed with their group to other discussions of dimensions, while the facilitator of each dimension stayed the same in order to gather all discussion contents and to be able to present those to the next discussion group. After the groups discussed on all four dimensions they returned to the dimension they first discussed on and focussed on defining criteria for this dimension.

3.2 Backcasting Step 2 – Present Situation

To describe the present situation, the second step in the Challenge Lab focussed on identifying current sustainability challenges in the Gothenburg region using tools from the inside-out and outside-in perspectives.

Outside-in Perspective

In order to describe the present situation in the Gothenburg region, the Multi-Level Perspective as of Geels (2002) was applied to enable an analysis of the system on a landscape, regime and niche level. Furthermore, leverage points to intervene in a system as of Meadows (1997) were investigated in, consisting of current projects in the Gothenburg region. Adding to that, the Challenge Lab team presented current trends, which put pressure on the current system, consisting of an increasing number of population, economic growth and material and energy intensity as well as scarcity of resources, assimilation capacity and decreasing land area (Holmberg, 1998). Additional literature review, group discussions and group presentations on different topics were held to bring everyone up to the same level of insight into the topic of the present situation.

Inside-out Perspective

The findings from the outside-in approach were then used as a basis for getting the inside-out perspective. Therefore, four stakeholder dialogues were organized in order to get insight from specialists in the four areas Mobility and Urban Development, Sustainability Driven Innovation for Urban Development, Area of Advance – Energy and Integration and Social Innovation. In each dialogue up to ten stakeholders preferably from all three sectors academia, the public and the private sector, took part in a dialogue on different topics. For that, a fishbowl setup was used, which consists of two circles of chairs, an outer and an inner circle. In the inner circle, the students from the Challenge Lab leaded the dialogue with the stakeholders through two facilitators and four questioners. The questioners had been preparing a list of questions to bring up during the dialogue with the stakeholders. In the outer circle, the rest of the Challenge Lab students and other spectators were listening to the dialogue and taking notes without active involvement in the dialogue. In short breaks of the dialogue, the students from the inner and outer circle were exchanging ideas and checking, whether all topics and questions on challenges were covered and how to improve the dialogue. At the end of every dialogue, all participants in the inner circle were asked to give feedback about the held dialogue. After the dialogue sessions, the Challenge Lab students gathered together to sum up the findings and reflect on what could be improved in the next session.

3.3 Backcasting Step 3 – Envision Future Solutions

Through the application of the Multi-Level Perspective and the stakeholder dialogues in the second step in the Challenge Lab methodology, three topics for further investigation were identified. Those three topics, namely Urban Mobility, Urban Development and Bio Innovation and Energy were then analysed by using the Design Thinking method as presented in Figure 6. Therefore, the Challenge Lab students worked in groups on one of the three topics regarding personal interest. For each three topics, on-going projects were searched for to identify visions on solutions. The scope of each area of interest was widened by adding identified projects and narrowed down by dividing those projects in categories or discarding some. After that, the categories were even more narrowed down fewer hot topics. Those hot topics went through an analysis using the following guideline:

1. Who are the stakeholders?
2. What are the dimensions of sustainable development?
3. Is it transformative?
4. Is it integrative?
5. What are the socio-technical aspects?
6. Where can one intervene in the system (Multi-level Perspective)?
7. In which phase or process of the value chain can one intervene?

Through group discussions and reflections on the different topics future solutions were identified as a possible basis to work on as research projects.

3.4 Backcasting Step 4 – Finding Strategies for a Sustainable Future

The aim of the last step in the Challenge Lab methodology was to find strategies to transform the present situation into the desired future state. This is done by the formulation of the research question and therefore working on a research project. As a Master´s thesis in the Challenge Lab is generally written in a group of two students, finding a research project meant to form groups. In several discussions and conversations the students in the Challenge Lab decided on areas of interest, which were identified in the third step. Each student proposed his or her area of interest and what kind of research was intended. Then, personal interest, study backgrounds and personal strength as identified in the first week were matched to find a suitable thesis partner. In the groups of two, and for those who decided to work individually, research questions were formulated.

4 Results

In this section the results from the first phase are presented, following the four steps of backcasting and finally resulting in the formulation of the research question for the individual research project.

4.1 Backcasting Step 1 – Definition of Criteria

With the help of the inside-out and outside-in perspective the Challenge Lab students defined criteria for sustainability and an overall vision for the Challenge Lab as the first step of backcasting.

Inside-Out Perspective

Relating to the inside-out perspective, the workshops held during the first week in the Challenge Lab concentrated on identifying the personalities of the Challenge Lab students. First, the presentation of the interests and background of the students with the help of the coat of arms helped to better understand each other and the motivation, why they intended to write their Master´s thesis in the Challenge Lab. The self-leadership workshop resulted in the visualisation and categorization of the personal strength, which was later used to match the strength of the students, to form groups in which the individual strength in a group complement each other.

Outside-In Perspective

After several time-consuming discussions and redefinitions of the self-formulated vision of the Challenge Lab students, which should overarch the whole process during the thesis writing, it was decided to stick to the vision, which was used in the Challenge Lab in the previous year. It would not only contain the intended visions of the current students, but also provide consistency to the Challenge Lab.

"We envision a sustainable future where we, approximately 10 billion people, are able to meet our own needs within the planetary boundaries without compromising the ability of our future generations to meet theirs" (Challenge Lab 2015)

Furthermore, this decision provided more time to the students to concentrate on defining criteria for sustainability, which were later used as a foundation for the individual thesis. In the following the ecological, economic, societal and well-being criteria of the students from the Challenge Lab year 2016 are presented.

Ecological Criteria

Human activities affecting nature's function and diversity are done in such a way that they:

- Do not increase the concentration of substances from the lithosphere in the ecosphere;
- Do not increase concentration of human made substances in the ecosphere;
- Do not systematically deteriorate the resource base; such as fresh water, fertile land, and biodiversity through manipulation, mismanagement, or over-exploitation.

Adopted and inspired by Holmberg et al. (1996)*, Holmberg and Robert* (2000)*, United Nations* (2016)*, Criteria from Challenge Lab* (2015)

Economic Criteria

The economic system is an instrument that enables individuals to meet the other criteria (society, wellbeing, nature) efficiently and effectively, as such:

- The function of the economic system is driven by the other criteria and not the other way around;
- It enables further use of resources and avoids dissipative use of materials;
- It assures an equitable distribution of resources;
- It has an inherent mechanism of maintaining and serving societal infrastructure and institutions that permits human wellbeing to be met over time;
- It has the ability to change and to adapt when facing shocks and disturbances.

Adopted and inspired by Anand and Sen (2000)*, Simmie and Martin* (2010)*, United Nations* (2016)*, Criteria from Challenge Lab* (2015)

Societal Criteria

The societal system is an instrument for individuals to live together with the other criteria with respect to the following conditions:

- It enables the well-being, empowerment and productiveness of every individual while adhering to the ecological principles by:
    - Equitable accessibility to education and health care;
    - Gender equity, social equity, political voice;
    - Equal human rights;
- Its governing mechanisms are built on transparency, accountability, mutual trust adaptability and recognition of diversity.

Adopted and inspired by Raworth (2012)*, Pisano* (2012)*, United Nations* (2016)*, Criteria from Challenge Lab* (2015)

Well-being Criteria

First the basics for survival and then components supporting self-fulfilment and self-realisation are presented.

The goal of the society and economy, lying on the nature as its fundament, is to serve the human wellbeing, where:

- Everyone has the right to access human basic needs; health, security, future security, food, water, sanitation, recreation, shelter, energy;
- Human life includes: subsistence, protection, affection, understanding, participation, idleness, creation, identity, freedom;
- Everyone should have access to the same opportunity and the freedom to build a meaningful life;
- Everyone should have access to the same opportunity and freedom to explore and express your ”inner self” and to life according to one´s values without limiting others' freedoms or harming others;
- Social and economic inequalities are not justified unless they are to the greatest benefit to the least-advantaged members of society.

Adopted and inspired by Rawls (1971)*, International Wellbeing Group* (2013)*, Cruz et al.* (2009)*, United Nations* (2016)*, Criteria from Challenge Lab* (2015)

4.2 Backcasting Step 2 – Description of Present Situation

In the following the results of the second step in backcasting, the description of the present situation, are presented from an inside-out and an outside-in perspective.

Inside-Out Perspective

Through literature review solutions for sustainability challenges on a regional level in the Gothenburg area were investigated in. This resulted in the identification of four overarching topics for further research, which the Challenge Lab team decided on together with the students:

- Mobility and Urban Development
- Sustainability Driven Innovation for Urban Development
- Area of Advance – Energy
- Integration and Social Innovation

Outside-In Perspective

Within these four topics, stakeholder dialogues were carried out, to gain an outside-in perspective of current projects, which are focussing on sustainability challenges in the Gothenburg area. The stakeholder dialogues provided the students with a broad insight into the complex structure of the current systems, leverage points and aims of current projects. As the background of the author of this thesis lies within the transportation sector, a focus on Mobility and Urban Development was decided. The dialogue session brought up several relevant challenges within the transportation sector such as zero-emission mobility, behavioural lock-in, creating a denser city, social inclusion, car dependency, sharing economy, low use of inland waterways, cooperation and coordination of city planners and the transportation sector and waste management.

4.3 Backcasting Step 3 – Envisioning Future Solutions

After understanding the present situation in the previous step, the students identified several hot topics in the Gothenburg region to work on future solutions for sustainability challenges. These were:

- Scaling up electromobility
- Smart grid
- Traffic strategy
- Traffic reduction
- Logistics
- Fossil free strategy
- DenCity
- Value chain of material use
- Sustainable criteria for housing
- Inclusive communities

Using the design thinking method, these topics were broadened and narrowed down in several group work sessions to find similarities of topics and formulate a stronger focus. Together with applying different perspectives in the socio-technical system, this resulted in the formulation of the three hot topics, in which the Master´s theses of the Challenge Lab should do in-depth research:

- Transport strategy
- DenCity
- Value chain and materials

The transportation strategy relates to a fossil-free and car-free city, scaling up electromobility within the Gothenburg region and introducing a 0.1 parking norm. The DenCity project is an undertaking of several stakeholders within the private, public sector and academia focussing on creating a sustainable dense city in the Frihamnen area of the City of Gothenburg. The third topic relates to the value chain and use of materials in the construction industry. In the following, the students worked on each of the topics, gathering answers to the questions stated in Chapter 3.3 during group discussions to find a focus for their individual thesis project.

4.4 Backcasting Step 4 – Strategies for a Sustainable Future

To identify possible group constellations, the students stated their interest in the different topics and what to focus on. In more group sessions, it was tried to find a partner for writing a thesis. Where research interests could be merged, groups of two were formed. For those, who could not find a partner, individual projects were chosen. Finally, in a consultation with the examiner the focus of the individual project was put under scrutiny and whether it is a suitable theme within the Challenge Lab.

As to the maritime background of the author, he registered his interest in writing the thesis on part of the DenCity project, as the project had a relation to waterway transportation. Because of the focus on waterway transportation, interest from students within the Challenge Lab could not be found, even if there were two more projects focussing on the DenCity project, but within other research areas; therefore, an individual project was chosen. The research question and scope of the resulting project – this thesis - are stated in Chapter 1.1 and 1.3. The formulation of the research question concludes the first phase of the Challenge Lab and lays a foundation for the second phase, which is presented in the following.

Phase 2 – Implementing Inland Waterway Transportation

This part of the report contains the elaboration on the research project, which represents the second phase in the Challenge Lab process. In the pursuit of answering the research question "*how can a combined goods and waste transportation system be implemented in urban supply chains utilizing waterway transportation?"* the frame of reference is presented in Chapter 5 followed by the methodology in Chapter 6 and results and analysis in Chapter 7. After a discussion of the findings of this report in Chapter 8 the report ends with the conclusion in Chapter 9.

5 Frame of Reference

This section of the report provides the theoretical background for the research project. For a better understanding of the topic, it starts with a description of the elements of urban logistics. Thereafter follow a presentation of local regulations on road traffic in the City of Gothenburg and a display of urban waterway projects, which have been implemented in European cities, where the city centres are connected to inland waterway networks. Last, the socio-technical system is presented as a framework to comprehend the interrelatedness of stakeholders within different dimensions.

5.1 Elements of Urban Logistics

To provide an understanding of urban logistics, firstly, the actors in urban logistics are presented. Secondly, the distribution system and efficiency are depicted followed by a definition of delivery service elements. Lastly, the role of sustainable transportation in logistics is described.

5.1.1 Actors in Urban Logistics

Actors in urban logistics can be divided into the three groups, i.e. supply chain, infrastructure and public authorities. Shippers, transport operators, receivers and end consumers represent the actors in the supply chain. Infrastructure can be owned, operated and provided. Companies offering theses services represent the second group. Public authorities consist of the regulatory institutions on local, regional, national and international level (MDS Transmodal, 2012).

5.1.2 Distribution System and Efficiency

The purpose of a distribution system is to move goods over geographically far reaching areas. Environmental impacts of the distribution system can be decreased by lowering the total need for transportation, changing to other modes of transport, which are more environmental friendly or by utilizing the chosen mode of transport more efficiently.

In a distribution system, transport system efficiency relates to better operating the transport system in a way, that a lower number of transportations is necessary. Fixing time delivery days contributes to transport system efficiency by predefining the number of deliveries and therefore gathering more cargo as the delivery covers more cargo than for every day deliveries. What is more, it eases transport planning. By consolidating cargo from different shippers for the distribution to different receivers the transport system efficiency can be increased. In this case, a receiver gets shipments from different suppliers in one consolidated delivery achieving higher fill rates of the transport unit than in single supplier deliveries. In transport system efficiency reverse logistics play an important role. If the transportation of cargo into an area is higher than the outflow, return flows can provide a balance by increasing the fill rate for the transportation out of the area by transporting cargo, that would be transported out of that area in a different way, thus, decreasing the entire transport kilometres of the distribution system. With the help of, often computer backed, route and load planning, routes and load rates can be optimized, which can lead to use of smaller vehicles and a lower number of total transport kilometres. IT systems contribute to transport system efficiency by supporting transport planning and the execution and reception of orders increasing the information flow in between logistics providers, goods shippers and receivers. Lastly, vehicle design influences transport system efficiency enabling utilization of higher transport volumes and therefore decreasing the total transport kilometres of the delivery.

In logistics a terminal plays an important role to bring producers and consumers closer together. It is a place to which products are transported, consolidated and split up into different deliveries. Furthermore, value can be added to the product by processing the product, which is then prepared for further transportation to recipients, while the terminal can serve as an intermediary place for storage. Central activities in a terminal are sorting, repacking into smaller or bigger units, storing as well as preparing the goods for transportation on another mode (Jonsson, 2008).

5.1.3 Delivery Service Elements

The service in a transportation system, which normally takes place in between the order and delivery, is depicted as the delivery service. Its quality can be described by several elements, which differ from situation to situation and mostly consist of inventory service level, delivery precision, delivery reliability, delivery time and delivery flexibility.

The inventory service level refers to the ability to which degree customer orders can be delivered straight from stock.

Delivery precision is related to the ability to deliver within the time span, which was previously agreed on in the transportation contract. It can be measured and expressed by the number of deliveries, which were made within the defined time span in relation to the total number of deliveries.

Delivery reliability describes the amount of deliveries of the right product in the right quantity and quality. It is an important measure to lower the workload on reception facilities of customers. The delivery reliability quantifies the relation of deliveries of the right products, quantities and qualities compared to the number of successfully delivered orders.

The delivery time is the time, which passes from the reception of the order to having carried out the delivery. It contains administration, processing, dispatch and transport times. When a product is manufactured, manufacturing or engineering time add to and increase delivery time. Delivery time is mostly stated as weeks or days. A long delivery time inheres negative consequences such as high capital lock up, lower flexibility and increased response time.

Delivery flexibility alludes to the ability to adjust to and conform to changes in client necessities in concurred and continuous requests. Issues may arise from changes in delivery times, order quantities or content and quality of the delivered items. It is distinguished between delivery flexibility before and during the order. Before the order, the flexibility refers to the ability to deviate from the normal terms of conditions such as delivery times, minimum and maximum quantities and product requirements. During the order, the flexibility relates to ability to react and conform to changes in quantities and qualities resulting from client requests (Jonsson, 2008).

A responsive supply chain has various abilities. It can respond to wide ranges of order amounts, meet short lead times, handle a large variety of items, fabricate highly innovative products, meet a high service level and cope with supply uncertainty. The more of those abilities a supply chain has, the more responsive it is (Chopra & Meindl, 2014).

5.1.4 Sustainable Transportation

Sustainable development is defined as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987, p. 41). This definition highlights the impact of actions of contemporary society on the planet limiting the achievability of meeting present and future needs. Elkington (1998) relates to the sustainable impact of organizations as the triple bottom line. Besides the economic responsibility, an organization has social and environmental responsibilities.

In a logistics system, demand puts great pressure on the logistics providers. Besides economic factors, environmental factors gain importance as aspects of a logistics service. To keep the service level and customer satisfaction high, logistics providers offer services with lower negative impacts to the environment as these measures partly influence the customers´ environmental impact. To keep delivery times short, fast transportation is used rather than prioritizing environmental friendlier slower transportation. States as regulators have the power to influence market behaviour by policies and therefore to influence the environmental impacts of logistics.

Several different factors refer to environmental adaption of logistics, such as the supply chains´ influence on ecological, financial, technological and social conditions. Adapting logistics to ecological factors relates to the minimization of environmental impacts. The financial adaption is connected to investments for the reduction of the environmental impact while the business shall stay profitable. In terms of technological conditions, the logistics system makes use of the latest technological developments to reduce environmental impacts. With social conditions the influence of logistics on the maintenance of material and psychological welfare is described. Furthermore, the influence on the structure of society and trust in the political system are part of the social factors in a logistics system.

Resulting from the need of transport, logistics has several negative impacts on the environment such as emissions, congestion, tyre wear and load on infrastructure. From the combustion engines of vehicles nitrogen oxides, carbon monoxide, carbon dioxide, sulphur oxides, hydrocarbons and particles are emitted to the air. This leads to an increased greenhouse effect with impact on the climate, acidification of land and sea, over-fertilisation, depletion of the ozone layer, ground-level ozone and broken biological cycles. Adding to that, the use of non-renewable energy resources such as oil contributes to the negative environmental impact of logistics. Furthermore, transportation emits noise to the environment and contributes to congestion in highly dense traffic areas.

In order to control and limit the environmental impact of the transportation system, policy and regulations can be introduced. Governmental institutions can put pressure on the logistics providers by introducing emission standards, which limit the emissions of vehicles to defined amounts. Vehicle charges and tolls for those vehicles, which do not comply with the regulations are financial means of control as well as a congestion charge, which is required to be paid in certain traffic areas, sometimes limited to the times during rush hours. Setting up environmental zones, in which only vehicles with specific environmental classifications can be used for transportation are further matters of governmental control (Jonsson, 2008).

5.2 City of Gothenburg – Transport regulations

The city of Gothenburg has introduced low emission zones and road tolls for road traffic in 2015 in the central part of the city.

The low emission zone applies to all heavy, diesel-powered lorries and buses in the marked area in Figure 9. It allows all vehicles to entre until six years after their first registration – for vehicles of the Euro 3 norm this period was extended to eight years. However, the latest a Euro 3 norm vehicle could enter the low emission zone was 2015. All vehicles with a norm lower then Euro 2 were banned from the low emission zones. Vehicles with Euro 4 norm could be driven until 2016 and those of Euro 5 norm and enhanced environmentally friendly vehicles are allowed until 2020 irrespective of their year of first registration (EU, 2015).

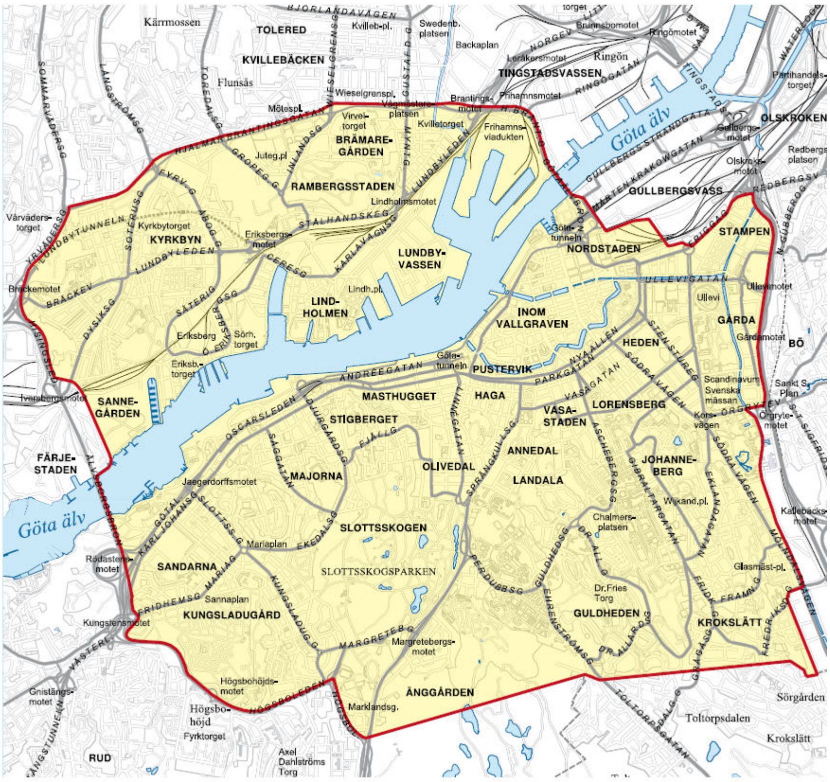

Figure 9: City of Gothenburg – Low Emission Zone, (EU, 2015)

Road tolls as a congestion charge have to be paid in the marked zone as seen in Figure 10. They apply to all vehicles entering the area, while the vehicles with allowed total weight of more than 3,5 tons are charged double the amount of vehicles with a total weight of lower than 3,5 tons. The amount charged varies from the different times of the day but is only charged in between 06.00 hrs to 18.29 hrs (EU, 2015).

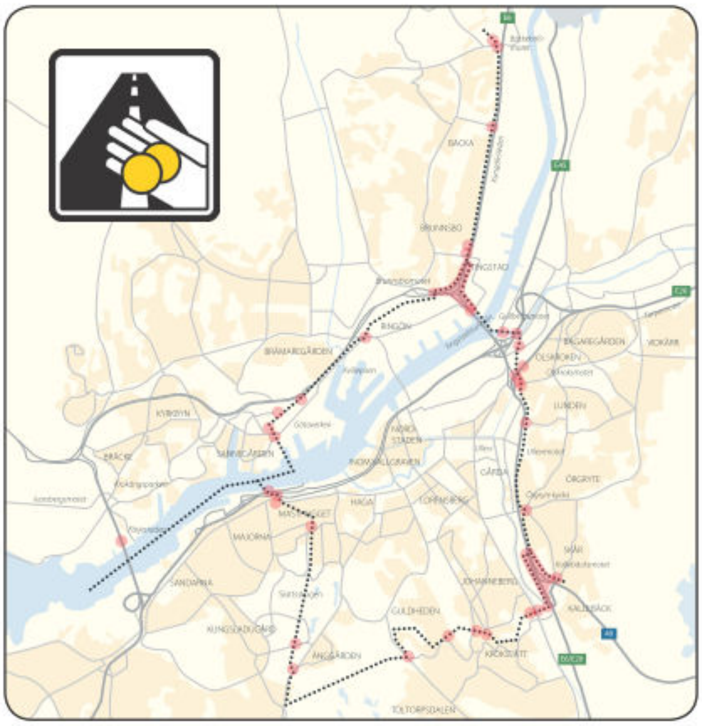

Figure 10: City of Gothenburg - Road tolls, (EU, 2015)

5.3 Urban Waterway Projects

In cities where dense traffic and local regulations put tremendous stress on the transportation system on roads, several European projects focussed on a modal shift from road traffic towards utilizing urban waterways. Hyard (2014) points out, that in the starting phase of most projects in the urban transport system markets and the potential benefits are limited in relation to total urban freight flows. Nevertheless, the implementation of these projects play a crucial role in bringing forward sustainable urban transport with high potential benefits originating from the use of new technologies and practices.

In the following, examples of transport solutions in European cities are presented, where city centres have dense canal networks or river connectivity. At the end of this chapter the factors contributing to the successful implementation of the different transport solutions are consolidated in Table 1.

5.3.1 Franprix Paris – Containers on Barge

In Paris there is a multi-modal urban logistics project from the supermarket chain Franprix that was initiated in 2012 resulting out of the cooperation of numerous entities, such as the supermarket company, a logistics provider, the city, the region, legislating authorities a cooperation project and others. The idea behind this project was to supply several supermarkets situated in the centre of Paris with a more sustainable transport solution where the increasing density of urban areas and the problems in common space of commercial players and locals put tremendous stress on the transportation system. Facing strict regulations in urban logistics related to emissions of air and noise, Franprix wanted to go one step ahead (Flipo, 2013).

On a daily basis, 450 pallets of consumer goods, food and non-food products in 24-feet and 27-feet containers leave a distribution centre around 50 kilometres outside the city centre of Paris. With this size of the containers, two containers can be transported by one truck complying with French transportation law carrying up to 26 tons. From the distribution centre, four truck drivers manage the transportation to the inland waterway port located at the river Seine from 09.00 hrs to 18.00 hrs in seven dedicated trucks (Flipo, 2013).

At the inland waterway port reach stackers unload the trucks. From 14.30 hrs to 18.00 hrs the reach stackers are used to load a barge, which has a capacity of maximum 48 containers stacked with maximum two layers of containers in order to be able to pass low bridges. A pusher navigates the barge through two floodgates of the Seine 20 km into the centre of Paris from 18.00 hrs to 21.00 hrs (Flipo, 2013).

Berthed at the quay in the city centre the barge waits for the commencement of cargo activities, which last from 05.15 hrs to 11.00 hrs until it sails back to the inland waterway port from 11.30 hrs to 14.30 hrs. The final delivery of the containers to around 100 shops in the centre of Paris takes place from 06.00 hrs to 12.30 hrs and is carried out by seven trucks, while delivery hours of the shops do not have to be changed. As of the short distances to the shops, the truck needs just ten minutes to reach their destination (Flipo, 2013). After the cargo operations on the quayside in the city centre are finished, the quay is opened for public to be used as a promenade along the river, utilizing the quay for industrial as well as recreational purposes (Lantz, 2016).

Resulting from the modal shift from road to water, based on a full load of the barge with 48 containers, road traffic could be reduced by 450.000 kilometres, taking 3.874 trucks from the roads, avoiding 35 accidents and saving 88.500 litres of gasoil annually. The reduced emissions to air could account to 234 tons less CO_2, 23% less NO_X, 46% less CO and 43% less hydrocarbures. Furthermore, society savings were calculated to one million Euros. In 2012, Franprix transported 26 containers daily, accounting to 113.000 pallets per year (Flipo, 2013).

This endeavour required certain investments and functioning cooperation to reach success. The road logistics operator invested in 73 specific containers and 14 trucks. The Port of Paris invested 1,6 mio. Euro in reconditioning the Parisian wharf. A close connection within the partnering parties, political and financial support from the region, operational helps from the French legislation and working in small teams enabling quick decisions were claimed to backing the success of the project. Further success factors were the location of the distribution centre and the inland waterway port, the dense distribution of the shops within the centre of

Paris and high volumes to cover fixed costs (Flipo, 2013). However, this solution is still more expensive compared to the utilization of solely road transportation (Tribillon, 2016).

5.3.2 Vert chez Vous – Floating Distribution Centre

Another Parisian project implemented river transportation in their intermodal distribution system for parcel deliveries. In its system the company "Vert chez Vous", sends a barge on the river Seine to serve as a moving distribution centre. Goods are transported from the warehouse by natural gas and electric powered trucks from the warehouse to the quay, where they are loaded in bulk on the barge at 07.00 hrs in the mornings (see Figure 11).

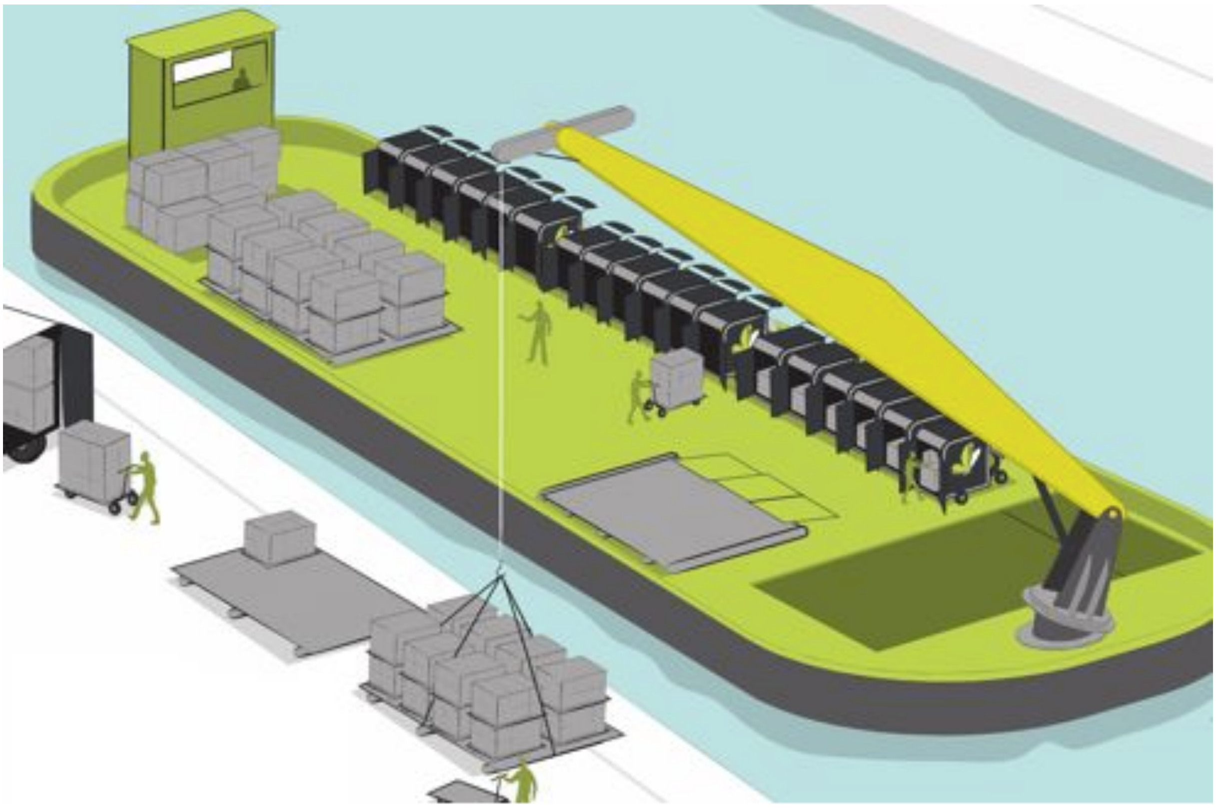

Figure 11: The barge as a floating distribution centre, (Fluvialnet, 2012)

On board, the parcels are packed on electric bikes while the barge sails around eight kilometres downriver. Within this route, the barge stops five times to send out the bike deliveries. A delivery round of a bike is calculated to take one and a half hours. After this round, the bikes return to the barge two stops further on. Around noontime the barge turns around and sails the eight kilometres back upriver repeating the sorting operations on board and delivery operations at the five berthing points (BESTFACT, 2014). Daily numbers of parcels account to in between 2000 to 3000 parcels per day, measuring in total 144 cubic meters with an average total weight of 14 metric tons. The utilization of this kind of delivery system takes away 15 heave duty vehicles from the roads reducing CO_2 emissions by 207,9 kilogram per day, resulting in an annual reduction of 51 tons of CO_2 (Flipo, 2013).

Several factors contributed to the success of this project such as that Vert chez Vous was able to steer around a heavy goods eco-tax which applies to transportation units on road above 3,5 tons, air priority action zones, urban tolls, low speed zones and limitation on delivery times for conventionally fuelled vehicles (BESTFACT, 2014). Furthermore, the inland waterway administration gave financial aids for installing a crane on the barge and granted further upgrades (Flipo, 2013).

5.3.3 The Beer Boat – Electric Barge Utrecht

In Utrecht a fully electric barge is used to carry out the last mile deliveries for several breweries and a catering industry wholesaler to customers, which are densely situated in the historical centre of Utrecht. The problem in the historical centre of Utrecht is, that the delivery of goods on the roads put tremendeous stress on the road infrastructure in terms of congestion, space occupancy and wear. Therefore, axle load weight was restricted to two tons and time windows for deliveries were determined. This led to the transfer of goods to the water already in 1996. Since 2010, the barge in use is fully electric and can sail for around eight to nine hours. Its length over all is 18,8 metres, it is 4,2 metres wide and can carry up to 18 tons. The barge is fitted with an electric hydraulic crane for the cargo handling and can store 40 to 48 containers. Using this transport solution for the last mile deliveries resulted in annually reduced CO_2 emissions by 17 tons, NO_X by 35 kilograms and 2 kilograms particulate matter. (BESTFACT, 2015).

Because of its success, the project invested into another zero-emission barge in 2012 to carry greater amounts and other type of cargoes, such as waste. The use of this transport solution enables to avoid the two-tons axle restriction, time windows and small roads with mainly one-way traffic while being cost- and time-efficient. Because of being publicly subsidised, the transportation costs for the customer are kept low (BESTFACT, 2015).

5.3.4 Mokum Mariteam - Electric Barge Amsterdam

In Amsterdam, where narrow streets around the dense network of canals restrict road traffic, a project about transportation on an electric driven barge resulted out of the cooperation of five different local companies with backgrounds in waste collection, cargo transportation and canal cruises. The service contains the transportation of different goods, such as books, refrigerated products, food, beverages and building material for various customers such as supermarkets, shops, hotels, healthcare facilities and hospitals. Furthermore, the barge is utilized for waste collection. To avoid traffic in the centre of the city, goods are consolidated at a hub outside the city centre and transhipped onto the barge (Janjevic & Ndiaye, 2014). For this project, a new electric driven barge was designed with a length overall of 20,00 metres and a beam of 4,25 metres being able to carry about 85 cubic meters, which is equivalent to four full truck loads. The barge has an own crane for cargo handling and is able to carry existing transport units such as rolling containers, pallets and mesh containers (BESTFACT, 2016).

By this project, the costs for the transportation of bulk goods, number of road accidents and transport emissions are reduced. What is more, the barge is not restricted to delivery times such as conventional road transportation. With the electric barge, a better use of the available infrastructure is achieved reducing the number of trucks in the city centre and combines the transportation of goods and waste at the same time (BESTFACT, 2016).

Table 1: Factors contributing to successful implementation of waterway projects

Project	Factors
Franprix Paris Containers on Barge	Close cooperation of stakeholders Short lines of communication Financial support from the region Legislation providing foundation for operational help Location of distribution centre and inland waterway port Dense distribution of shops in city centre High volumes to cover fixed costs
Vert chez Vous Floating Distribution Centre	Avoidance of eco tax for heavy vehicles Avoidance urban tolls Compliance to limitations in air priority zones Financial support from inland waterway administration Extended time to enter city centre for deliveries
The Beer Boat Electric Barge Utrecht	Avoidance of two-tons axle restriction Extended time to enter city centre for deliveries Avoidance of congestion Avoidance of one way traffic Public subsidies
Mokum Mariteam Electric Barge Amsterdam	Extended time to enter city centre for deliveries Applicability of reverse logistics

5.4 Socio-Technical Systems

Geels (2012) describes a socio-technical system as a configuration of elements comprising technology, policy, markets, consumer practices, infrastructure, cultural meaning and scientific knowledge in which changes within the system are referred to as socio-technical transitions. The different elements are mentioned to be relatively independent from each other. However, as there are links in between the different elements, they are interdepending. Maintenance, reproduction and changes in the socio-technical system are influenced by the commitments of the actors, but then again they provide a framework for actions as well (Geels, 2004). Actors in a socio-technical system (as shown in Figure 12) are firms and industries, policy makers and politicians, consumers, civil society, engineers and researchers (Geels, 2012).

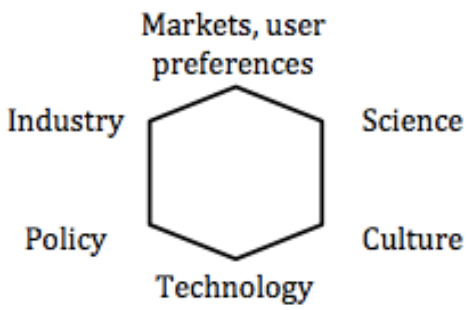

Figure 12: The Socio-technical System, (Geels, 2012)

6 Methodology

This chapter presents the methodology, which is used in the second phase of the thesis for the research project. First, the research design is depicted followed by the presentation of the case study and the case. Finally, data collection methods are described.

6.1 Research Design

There is qualitative and quantitative research. According to De Vaus (2001) qualitative research aims to describe a problem in detail, where the data is in the form of words, pictures or objects and the researcher is the data gathering instrument. Furthermore, qualitative research focuses mostly on one phenomenon, case or subject during a certain period of time (Benz & Newman, 1998). In qualitative research theories are constructed based on the observation on the phenomenon, what is referred to as the *inductive* research approach (De Vaus, 2001).

Quantitative research requires a quantitative measure on a research problem (Bernhard, 2011) and has the objective to generalize from a sample to a population (Benz & Newman, 1998). Benz and Newman (1998) point out, that in a combined qualitative and quantitative research, the qualitative part often represents starting points and initial schemes trailed by quantitative methodologies. In quantitative research, analyses are made based on theories. Those theories lead the researcher in the direction, which observations to make. This approach is referred to as the *deductive* research approach (De Vaus, 2001).

6.2 Case Study

A case study represents a typical research methodology, when carrying out qualitative research. In a case study, the case as an object is put under scrutiny. In doing so, one tries to understand the case in complete. However, it is important to differentiate between the case as a whole and the several levels of the case. A school, as an example of a case, consists of students of different years, teachers with different educational level and expertise, parents, administrative staff and many levels more. Furthermore, a school can be distinguished by its characteristics related to size, type of school, structure, strengths and weaknesses. Therefore, to have a full understanding of the case, all the different levels have to be included in the analysis. A broader picture is obtained analysing more levels of a case, as the information extracted from the numerous entities may vary significantly (De Vaus, 2001).

For the purpose of finding out which factors influence the design how an urban waterway supply chain should look like, a qualitative research design, focusing on descriptive research was chosen. Within the urban water supply chain a case was identified and put under scrutiny as elaborated on below.

In its “Samrådshandling” Göteborg Stad (2015), the City of Gothenburg, describes the endeavour of developing the industrial area of the former free port called “Frihamnen” into a sustainable neighbourhood containing a great mix of public space, residences, shops, companies, culture and service industries, where a strong focus lies on public space. The original shape of the harbour shall be kept in order to preserve the industrial heritage of the city, which has a long shipbuilding and marine shipping history. Within this neighbourhood, goods and waste handling shall be sustainable and in a small scale, while being easily accessible. The whole development process shall be supported by co-creation.

In close connection to the plans of Göteborg Stad, Vinnova, a Swedish government agency with the mission to promote sustainable growth within Sweden, finances a project called "DenCity", over a period of two years, which started in December 2015 and is coordinated by the Lindholmen Science Park AB, Gothenburg. In this project, a consortium with representatives of the three dimensions of the triple helix is brought together, to use Frihamnen as a testbed to introduce innovations in urban planning and urban logistics with the goal of creating a sustainable functioning city district.

The DenCity project is divided into seven work packages with different focuses:

Work package 1	Zero emission deliveries
Work package 2	Urban waterways
Work package 3	Enabling infrastructure for dense neighbourhoods
Work package 4	Urban services and deliveries
Work package 5	System integration evaluation
Work package 6	Project leadership
Work package 7	Diffusion and communication

The work package related to urban logistics and urban waterway transportation is work package 2. Its goal is to assess the possibilities of utilizing urban waterways for a combined transportation of significant amounts of goods and waste into and from Frihamnen through a demonstrator project, stimulating the development of future solutions in urban waterways. Participants of this work package are Älvstranden Utveckling AB, a landowner and urban development company owned by the City of Gothenburg, Kretslopp och Vatten, Gothenburg´s municipal administration for water and waste management, SSPA Sweden AB, a maritime consulting company and Trafikkontoret, the urban transport administration of the City of Gothenburg (Vinnova, 2015).

Within the DenCity project the work package 2 was found suitable to serve as a case study, as the setting seemed beneficial for data collection purposes, where interview partners with deep insight could easily be identified and contacted. What is more, observations in group meetings and workshops of the DenCity project were expected to give more insight into topic based problem identification and problem solving as well as revealing further ideas. As the DenCity project comprises entities from the three dimensions of the triple helix, it can be expected, that the overall findings will not be biased in a single direction and may provide good data on the different factors shaping the design of the urban supply chain.

6.3 Data Collection Methods

In qualitative research, interviews are considered the most common and powerful tool for data collection. There are structured and unstructured interviews. Both, the structured and the unstructured interview need preparation. While the structured interview follows a strict written arrangement, which exists as a hard or soft copy, the unstructured interview follows the structure, which the interviewer constantly monitors in his mind to not deviate from the topic. Combining the structured and unstructured approach results in the semi-structured interview, which follows an interview guide that should be made available to the interviewee prior to the interview. It provides questions in a certain structure and allows space for deviating from the topic, revealing additional information and personal views from the interviewee. Here it is in the power of the interviewer to allow to which extent the deviation may reach. Furthermore, by knowing the content of the interview guide, the interviewee understands the scope of the undertaking and recognizes the preparedness of the interviewer (Bernhard, 2011). As an interview can be full of unexpected situations the interviewer has to prepare the interview questions carefully. Czarniawska (2004) describes an interview as an interaction between one ore more people, which is taped. One has to be alerted, when an interviewee seems to be interested in the interviewers opinion, he just waits to point out his own views after the interviewer has finished. Furthermore, interviewees can answer questions in an unexpected way. When involved in an interview with more than one person, dialogic listening is important, as not following a conversation and asking questions about another topic can hinder the dialogic flow (Helin, 2013).

As the main goal of the case study is to understand the different ways, in which various stakeholders in urban logistics in Gothenburg describe drivers and barriers of a combined goods and waste transportation system in Gothenburg for the district of Frihamnen, the most important data comes from interviews. Therefore, semi-structured interviews and the participation in seminars, workshops as well as project group meetings serve as sources for the primary data collection. Furthermore, site visits contribute to the latter. As a preparation for those methods secondary data is gathered through literature review.

The background knowledge in the secondary data gathering on inland waterway transportation was found in scientific papers, companies' websites, internal reports and presentations from governmental institutions and consulting parties.

For the interviews, an interview guide (see Appendix 1) was prepared, which slightly varied from interviewee to interviewee depending on their background. Before carrying out the interviews, this guide was sent to the interviewees to give them time to understand the purpose and content of the interview. Interviewees, which were related to urban logistics were chosen from all three dimensions of the triple helix. Three interviews were conducted with organizations from the public sector, eight with representatives of the private sector and one with an organization related to academia. Table 2 shortly presents the individual background of the interviewees.

Table 2: Background of Interviewees

Interviewee	Sector	Type of Business / Organization	Position / Role
A	Public	Waste and water management administration	Head of Unit, Household Waste Management Projects
B		Urban Transport Administration	Project Manager Development of Innovation Projects
C		Urban Transport Administration	Project Manager Development City Distribution
D	Private	City owned real estate company	Head of Sustainability and Innovation
E		City owned real estate company	Project Manager City Development
F		State owned logistics provider	Product Manager
G		Logistics Provider	Branch Manager
H		Logistics Consulting	CEO
I		Business Consulting	Port Development Manager
K		Business Consulting	Head of Port Development
L		Logistics and Waste Handling	Terminal Contact Person
M		Supermarket Chain	Project Manager
N	Academia	Transport Research, Development and Innovation	Project Manager

The interviewed organizations from the public sector were a local waste and water management administration and an urban transport administration. The representative of the waste and water management administration is occupied as a head of unit working on waste management projects related to household waste. In earlier employment, the interviewee worked in a private waste management company and has a chemical engineering background. One of the two interviewees from the urban transport administration has been working as a project manager on development of innovation projects related to urban freight and city logistics in the administration for the last three years. Before that, the interviewee has been a director of logistics in a private waste management company for eight years. The second interviewee from the urban transport administration has been occupied as a project manager for the last ten years focussing on project development in city distribution logistics related to freight and goods flows.

The persons representing private companies were working for a city owned real estate company, several logistics providing and logistics consulting companies, a logistics and waste management company and a supermarket chain, thus, all entities connected to urban logistics and urban development. One of the two persons from the city owned real estate company has been employed for thirteen years as a city developer, with the last position as the head of sustainability and innovation. The other interviewee from that organization has been working as a project manager in city development for the last 15 years and is now strongly involved in the development of the Frihamnen area. Stating the view of a logistics provider, a product manager of a state owned logistics company, which is involved in the aforementioned DenCity project, was interviewed, who had been occupied in that position for three years after having worked 14 years in the telecommunication industry. From another logistics providing company, which is also involved in the DenCity project, a branch manager was interviewed, who had been in the company for the last twelve years. From a logistics consulting company, the CEO was questioned, who has a 30 years background in shipping and logistics with a strong focus on Swedish inland waterway transportation and was appointed CEO one year ago. Two persons from a business consulting company, which mainly focuses on port infrastructure projects, were interviewed, who had both more than thirty years working experience in port planning and development. Furthermore, the contact person of a logistics and waste handling company, which is responsible for the last mile distribution of goods and the waste collection, except food waste, for several customers within one district was interviewed giving insight into an innovative last mile distribution solution. Finally, representing the goods receiver, a supermarket chain project manager took part in an interview.

Representing academia, a researcher with main focus on city logistics and freight transport was interviewed, who is employed as a project manager in a consortium concentrating on research, development and innovation for efficient transportation.

7 Results & Analysis

This section of the thesis comprises the findings of the primary data collection originating from carrying out interviews accompanied by observations from taking part in work group meetings and workshops. At first it is elaborated how interviewees describe the success factors of a delivery system to show the reader, that there can be several different facets seen as important. To achieve what is needed for the implementation of a delivery system with such success factors, barriers and drivers were formulated by the interviewees, which are presented in the following sections.

7.1 Success Factors of Delivery Systems

When the different interviewees were asked to describe from their point of view what made a delivery system a successful delivery system, be it e.g. relating to time, costs and negative impacts, they argued for a wide spectrum of factors. As central factors environmental impact, time and service level were mentioned.

Table 3: Central success factors mentioned by interviewees

Factors	Interviewees
Environmental impacts and sustainability	A, B, C, D, G, H, I, K, L, N
Time	B, C, G, H, I, K, M, N
Service level	A, B, C, H, L, N

Table 4: Sub factors of success factors in a delivery system

Success factors	Sub factors
Environmental impacts and sustainability	Sustainable energy for propulsion of transportation
	Low congestion in road traffic
	Low emission of pollutants incl. noise
	Low visual intrusion
	Low cost for society
Time	On time delivery
	Extended time windows for deliveries
	Being responsive
	Quick transportation
	Low transhipment time
	High predictability
	Next day delivery
Service level	Easy handling for customer
	Meeting delivery agreements and quality
Further mentioned factors	Capability of high volumes
	High load factor
	Decent costs for stakeholders
	Reliability

Environmental impacts and sustainability as success factors in a delivery system were referred to by nine interviewees (see Table 3 and Table 4). This category included use of sustainable energy sources for the propulsion of transportation, low congestion through reduced number of trucks on the road resulting from the modal shift, low emission of pollutants and noise as well as low visual intrusion for the same reason. With visual intrusion the interviewees related to heavy trucks disturbing the view in the city when parked, stuck in traffic as well as on their way to the customer. Interviewee D indicated, that the cost for society should be low, relating to the long-term impacts of the mentioned environmental factors.

Eight interviewees (see Table 3) stated time related factors influencing the quality of a delivery system. These consisted of on time deliveries, being able to deliver and receive shipments in certain and extended time windows as well as being responsive (see Table 4). Especially Interviewees I and K pointed out, that the transportation time should be quick and times for transhipment held as low as possible. Interviewee G made clear, that it is of high importance to be able to predict transportation times, thus a system is necessary where experience and reliable data are available. Furthermore, it shall be possible that goods can reach the point of destination within a certain distance one day after ordering the transportation.

Six interviewees recognised the service level as a success factor, which relates to easy handling for the customer, meeting delivery agreements and quality, the service being precise and having a high predictability.

Further mentioned factors were capability of high volumes, efficiency relating to a high load factor, minimizing storage, decent costs for stakeholders and reliability (see Table 4). Relating to the capability of high volumes interviewee H stated, that a shipment on the river could consolidate ten to 15 truckloads, which reduces the pressure on the environment by the reduction of the number of trucks on the road. Interviewee G described it as a success factor, when cargo units are used efficiently, in particular, when the capacity of the unit is utilized to its maximum. Interviewees I and K elaborated on minimized storage as one of the advantages of just in time deliveries, where goods are delivered, when they are needed instead of storing huge amounts in a warehouse until utilization. With decent costs for stakeholders interviewee C linked to reasonable pricing for services connected to transportation for all involved parties.

7.2 Barriers

To understand the difficulties of implementing combined goods and waste transportation on inland waterways in urban logistics, the interviewees were asked to give their opinion on barriers, which could hinder the implementation process They mentioned economic factors, operational factors, behavioural change and policy and regulations as central barriers.

Table 5: Central barriers mentioned by interviewees

Barriers	Interviewees
Economic factors	A, B, D, F, G, H, I, K, M, N
Operational factors	A, B, C, F, G, H, I, K, M
Behavioural change	B, C, H, I, K, M, N
Policy and regulations	A, C, D, F, M

Table 6: Sub factors of Barriers

Barriers	Sub factors
Economic factors	Low cost for road transport
	Economic feasibility
	Financing of infrastructure
	Allocating financial responsibility
	Ownership of infrastructure
	Financial risk of logistics companies
	Transhipment cost
Operational factors	Consolidation
	Nature of goods
	Weather conditions
	Ownership and operation of infrastructure
	Location
	Accessibility
	Decision making
Behavioural change	Receiver wants low cost and fast delivery
	Willingness to pay for sustainable delivery
	Road transport culture
Policy and Regulations	Allocating financial responsibility
	Low political support
	No strict regulations on road traffic
	Low bridges planned

All interviewees except Interviewee C and L mentioned economic factors as barriers (see Table 5 and Table 6). First of all, the cost for the transportation service containing waterway transportation was not seen as competitive to the cost of truck transportation, which is already part of a well functioning logistics system relying on experience and continuous improvement. The economic feasibility of waterway transportation was one central point of discussion. What is more, it was brought up, that the financing of the not yet sufficiently existing infrastructure for the connection of waterway and road transportation inheres many problems.

While interviewee D claimed that infrastructure cost are all paid by the city another view was observed during workshop meetings. In those meetings it was mentioned from a representative of a real estate company, that the financing of the infrastructure and recreational areas related to the Frihamnen district posed several questions for discussion. The city wanted land buyers to cover parts of the costs for parks and transportation infrastructure. However, those refused to pay as they claimed, that it is accessible for the whole public, therefore, it should not be binding to be paid from local private entities. Furthermore, the land buyers have the opinion that with the amount paid for the land, the city should be able to cover the expenses for the parks and transportation infrastructure. It was mentioned, that this is an on-going discussion and has not yet led to final agreements.

Adding to this, interviewee D highlighted, that there could be problems in allocating responsibilities related to infrastructure costs covered by the public sector, whether costs are paid locally by the city, municipality or the country. Moreover, it was questioned whether the infrastructure is owned publicly or privately. In the case of private ownership, the interviewees mentioned high investment cost for this undertaking. To be able to provide a transportation service on water, logistics companies have to invest into transportation units suitable for this mode. As a consequence, Interviewee H argued, in a new waterway transportation system the logistics provider bares substantial financial risk. Another cost factor mentioned by Interviewees M and N was transhipment cost, which relates to the cost, which arises when transferring goods or waste from one to another mode of transportation.

Nine interviewees declared several operational factors as barriers (see Table 5 and Table 6). Firstly, consolidation was described as difficult. According to Interviewee A, household and company waste are treated differently and therefore not consolidated. On the goods side, interviewee F mentioned that the compatibility of consolidation is highly dependent on the recipient's requirements on the transportation. Furthermore the interviewee stated troubles of consolidation regarding revenue streams and allocating shared cost in a collective last mile distribution as well as the problem, that logistics providers have already established their own delivery systems and distribution hubs. Secondly, Interviewees F, H and M added, that requirements to the nature of the goods, i.e. whether they need heating or cooling, which is highly energy consuming, or whether they are bulky and heavy, are very complex and it is therefore challenging finding a suitable and sustainable transportation solution that fits all the different goods and waste. Thirdly, as to Interviewee C and G weather conditions could put extra stress on the operability of waterway transportation in form of ice, snow, hail, wind and rain which could harm the transported goods if not covered properly and influence safe navigation on the water. Fourthly, the ownership of infrastructure such as of the quay was tackled as a problem. Here it was questioned whether it was operated publicly or privately. And fifth, finding the right location of the reception facility in Frihamnen as well as the consolidation hub outside the city centre was described as a barrier by Interviewees B, I and K. Inside the Frihamnen area the location, where waterway transportation is connected to the land should not be disturbing in terms of reducing the living quality around it. The accessibility both by water and land transportation of the locations outside the Frihamnen area, where goods are consolidated in a hub and waste collected in the waste facilities was considered high importance. Further, deciding on the right location was seen as challenging as well. In a workgroup meeting it was brought up, that the barge, which could transport bulky household waste should have a scheduled trip to different areas, which have connection to water, in order that the public can have access to it, but therefore, locations have to be decided on.

Behavioural change of the public as the recipients of goods was seen as a barrier by seven interviewees (see Table 5 and Table 6). It was described, that the receiver mostly cares about receiving the shipment as fast as possible and to the lowest cost, where, as to Interviewee M, cost is the decision making factor. Willingness to pay for a more sustainable transportation service plays an important role. Furthermore, interviewee D stated that logistics costs lack transparency. Because of that, the receiver has no insight into what logistics costs the purchase include, e.g. when shipping is advertised to be free. Adding to that, a culture based on road transportation is prevalent hindering the implementation of waterway transportation as a change from a functioning system to an unknown system could be conceived as prone to causing problems.

In bringing forward waterway transportation five interviewees (see Table 5 and Table 6) identified barriers in policy and regulations. As mentioned before, allocating responsibilities related to infrastructure costs in between different authorities is one of them. Interviewee N mentioned the problem, that sustainable transportation plays a subordinate role for politicians. Thus, it is difficult to get strong political support. Furthermore it was recognized, that no strict regulations on road traffic apply for the Gothenburg urban transportation system, which could make the market and industry change to other modes of transportation. What is more, according to Interviewee H and N, the fact that the bridges planned for construction in Gothenburg are significantly low is contradictive to promoting waterway transportation.

In the market, Interviewee B pointed out, that companies are locked in into their existing well functioning transportation system. A change towards new ways of transportation was seen as a too extensive challenge. Furthermore, Interviewee F made clear, that using the same last mile distribution as competing logistics providers would lower the differentiating factor significantly, where the way to deliver is the central competence of a business in logistics.

7.3 Drivers

Opposing the barriers, the interviewees were asked to state drivers, which could bring forward the implementation process. It was found that public interest, environmental drivers, political incentives and technical development are central points of discussion.

Table 7: Central drivers mentioned by interviewees

Drivers	**Interviewees**
Public interest	A, B, D, I, K, M, N
Environmental drivers	A, D, E, G, H, L, N
Political incentives and regulations	A, B, C, F, G, M
Technical development	A, C, F

Seven interviewees mentioned public interest as a driver (see Table 7). In particular, interviewee D referred to Gothenburg with its heritage as a harbour city and putting life on the water would bring this feeling back into the city centre. Interviewee B mentioned a new thinking in the public, where sustainable options are voluntarily taken and therefore sustainable transportation promoted. This is especially found in the younger generation from 20 to 40 years, as Interviewees I, K and N highlight, which can be the driving force on that promotion with high involvement and broad publicity through social media. Interviewee M added, that industry itself cannot drive the change alone and is highly dependent on this new thinking society, which is eager to steer towards their own sustainable future.

Table 8: Sub factors of drivers

Drivers	**Sub factors**
Environmental drivers	Lower congestion
	Lower noise level
	Less road accidents
	Less pollution
	Less visual intrusion
Political incentives	Financial aid
	Coverage of infrastructure costs
	Ban of heavy traffic from city centre
	Low emission zones
	Bonus-malus system

Environmental drivers such as lowered congestion, lower noise level, less road accidents and less pollution as well as less visual intrusion were indicated by seven interviewees (see Table 7 and Table 8). Congestion in urban areas could be lowered as the shifting of cargo from several trucks into one floating unit takes away a significant amount of road traffic. By reducing the number of heavy trucks in the urban road network the noise level and probability of road accidents could be reduced and emission of pollutants lowered at the same time. What is more, as to interviewee D, reduced traffic on the road would even make space for other use of the land, as the space for streets could be minimized.

Several interviewees mentioned, that the implementation of a water based transportation system could benefit from political incentives and regulations (see Table 7 and Table 8). Political incentives were related to financial aid in the planning and starting process of a new waterway based transportation system to cover initial costs for e.g. purchasing equipment such as cranes, ramps and suitable floating transportation units. Furthermore, covering the cost for infrastructure such as quays and their connectivity to the last mile transport solution was found as supporting. For regulations, banning heavy traffic from the city centre and introducing zones with extremely low emission levels were seen as helpful to promote inland waterway transportation. Interviewee M emphasized, that a bonus-malus system would be necessary to significantly bring forward waterway transportation. In this bonus malus-system taxes would be raised for other transportation modes than on waterways and taxes would be lowered for waterway transportation making it economically more interesting shifting transportation in that direction. Interviewee G added, that conversations in between public, private sector and academia formulating a sustainable transportation vision for Gothenburg are on-going and could be supportive in the implementation process of waterway transportation as a sustainable option. Furthermore, interviewee M pointed out, that the river as transport infrastructure is more or less free compared to road infrastructure.

Interviewees A, C and F found that recent technological development could be seen as a driver to promote waterway transportation. The first two brought up, that sustainable transportation on the water in form of electrically driven barges contributes to further waterway transportation. Interviewee F referred to silent transportation solutions for the last mile deliveries taking and bringing goods and waste from the water connection to the receiver and vice versa.

In a field trip it was discovered, that distribution centres of two logistics providers have a direct connection to waterways and that a waste collection centre and combustion plant are both connected to waterways. However, the river near the waste combustion plant is a natural reserve and is naturally limited by the dimensions of the river and related bridges.

8 Discussion

In the following, the findings from this thesis are discussed. First the complexity of the supply chain design is talked over, in order to reveal the difficulties to the reader when choosing a suitable solution for the implementation of a new transportation system. This is followed by an examination of how drivers and barriers affect a successful implementation of such a system. Further, the importance of early planning and collaboration is highlighted which also affects its success. Finally, short-term and long-term goals for the implementation process are presented.

8.1 Complexity of the Supply Chain Design

Results of this paper show that the design of a supply chain is shaped by several factors and stakeholders describe its quality in different ways depending on their role in the supply chain. With the various requirements on the delivery system it is difficult to find the right solution to perfectly fit everyone´s needs while achieving high transport system efficiency. The complex requirements make it challenging to choose one solution, which serves all. Especially deciding which type of goods and waste to transport plays a central role as it defines the technical requirements of the waterway transportation units and the related infrastructure in order to achieve economies of scale. Furthermore, it determines how the supply chain needs to fit the last mile delivery solution to the receiver and the carriage to the intermodal hub, where goods are transhipped to waterway transportation. On one hand, it has to be decided, which types of goods and waste are most suitable for transportation on water. On the other hand, it has to be assessed, not only whether they are suitable for that transportation mode, but also whether the new system actually and significantly contributes to the reduction of road traffic and the negative environmental impacts of urban logistics. The aim of the logistics providers is to avoid a decrease of their service quality. As water transportation is slower than road transportation, the total transportation time might increase. What is more, transhipping cargo from one mode to another adds time and cost, thus, reducing the transportation quality. However, the quality can be increased by the reduction of emissions to air, noise pollution and visual intrusion offering a more sustainable transport solution resulting from the modal shift to inland waterway transportation. The question here is, whether the overall quality of the transportation service experiences an increase, decrease or stays at the same level. This assessment highly depends on the point of view and the requirements of the different stakeholders on the service.

Another important aspect is the location of the hubs for transhipment of the cargo, as it strongly influences the land use planning and therefore the space efficiency of the urban area. Firstly, it has to be easily reachable by different kinds of modes of transport. Secondly, it should fit into the surrounding area and not cause noise and visual intrusion. A combination of industrial and recreational use of infrastructure such as the quay is therefore desirable.

As mentioned before, providing a final technical solution is not the aim of this thesis, but aforementioned factors need to be taken into account in order to plan the implementation process of an innovative sustainable transportation system.

8.2 Strong Barriers vs. Weak Drivers – The Importance of Policy

In the case of the City of Gothenburg as an example of bringing forward sustainable transportation, the interviewees described the implementation of waterway transportation in urban logistics as facing strong barriers. These consisted of economic factors relating to the ownership and financing of infrastructure, investment costs and increased logistics cost through transhipment of cargo from one to another mode. Adding to that, weak policies, lock-ins into the existing transportation system and market demands were described as hindering factors of the implementation. Furthermore, operational factors were seen as inhering problems when finding the right location, adapting to goods requirements and consolidating cargo from different logistics providers. Additionally, consolidating cargo from different operators and then carrying out one transportation service was described to reduce the unique characteristic of the service of a logistics provider. It is questionable, if logistics providers see a barrier in the change of their roles in the supply chain.

From the presented cases of implemented waterway solutions in city logistics in Chapter 5.3 it can be seen that policy played a central role for a successful implementation. In these cases, policy was related to financial support in the starting phase, legislation for operational support, extended time windows to carry out deliveries in the urban area and avoidance of weight restrictions and costs such as heavy traffic taxes and urban tolls. As stated in Chapter 5.2 transport regulations already exist for the City of Gothenburg. However, as presented in the results of this report in Chapter 7, the interviewees state that policy in the City of Gothenburg is not supportive enough for the application of waterway transportation for services in the Frihamnen area. It provides a framework, as tolls and low emission zones apply for exactly that area (see Figure 9 and Figure 10), but the incentives are not strong enough to motivate a change of the mode of transportation.

The problem is, that the benefits of sustainable transportation, which were described as drivers for an implementation, such as the reduction of congestion and emissions, are on one hand relevant to all stakeholders in the supply chain, but on the other hand, they are somehow outside the business model. The quantification of the negative impact of the transportation service and its evaluation in the way that a lower negative impact is rewarded economically would be helpful. With these measures, transportation services could be benchmarked and they therefore promote sustainable transportation. Thereby, the economic and environmental savings could be made more tangible for all stakeholders in the supply chain. Establishing this approach by policy in the industry could influence the whole socio-technical system. The industry would adjust to the regulatory requirements. Then, the market is required to follow and change its behaviour, thus, increasing the importance of technology and science in that area. The overall goal should be to introduce drivers, which overcome and surpass the above-mentioned strong barriers for such an implementation. Therefore, more emphasis needs to be put on policy to make this change possible and the importance of policy needs to be understood by the regulatory institutions, which introduce them.

8.3 Early Planning and Collaboration

Another aspect for a successful implementation process is early planning. In the cases shown in Chapter 5.3 it is found, that early planning and inclusion of various stakeholders contributed to the success of the projects. This can also be observed in the Frihamnen area in the City of Gothenburg where different stakeholders are discussing to find urban logistics solutions. It is determined who pays how for which part of the infrastructure and how to design logistics services.

During the planning process it is important to include various stakeholders in order to understand the different views and goals, which motivate their actions. Including them in an early stage of a project, contributes to the identification of potential problems early in a phase, in which changes do not considerably delay the project. Solutions of those problems can be discussed together. Therefore, a platform has to be created, in which close collaboration in between the stakeholders in the urban supply chain is possible. Within this framework stakeholders should continuously update each other in meetings and workshops. Especially in projects, in which completely new districts are built, early planning inheres many opportunities. The shape of the district does not have to be adapted to the surroundings. Space can rather be created with a great freedom of choice.

8.4 Short-term vs. long-term Goals

For a successful implementation of a new transportation system clear goals need to be defined and communicated in the close collaboration within the stakeholders in the urban supply chain. Regulatory authorities, which have the greatest influence within the socio-technical system relating to transportation, should introduce policies, which promote such new, more sustainable transportation options. These goals should be divided into short-term and long-term goals. Transport operators carrying out transportation services for freight forwarders should therefore include waterway transportation in their service portfolio making use of incentives of the newly introduced transport policies. The whole supply chain could experience an improvement e.g. by reducing the carbon footprint of transportation, by using a more sustainable way of transportation, which is highly valued by customers. But this only works, when there is trust in the new transportation system.

The short-term goals are a small start with an enhancement of trust in the system. In the interviews it was mentioned, that trust is highly important when introducing something new. Therefore, inland waterway transport operators need to show that the new, more sustainable transportation system is reliable, thus, increasing the interest of freight forwarders to include inland waterway transportation into their service portfolio and gaining trust in the market. In the short-run, as the focus on trust building, services transporting only waste or goods should be offered in a designated location range to show that this mode of transportation works and to avoid problems, which might occur in consolidated transportation. However, as this system is only focused on one type of goods, it might not show to be economically feasible, but serve as the basis for the long-term goals.

The long-term goal is the expansion of this new system´s capacities and capabilities. In the long run, when the system has shown to be reliable it should be scaled up. Firstly, the transportation of goods and waste can be combined. Secondly, the service can cater more locations. With the combination of the transportation of goods and waste empty haulage could be reduced. Offering services to more than one district would make it more likely to achieve economies of scale to finally provide an economically feasible transportation service.

In the case of the Gothenburg´s Frihamnen area, which has a direct connection to the river Göta älv, the short-term goal should be an establishment of a logistics service in another area within the City of Gothenburg. As the construction of the Frihamnen area is projected to finalize in more than a decade the new transportation system could be tested and improved in other areas during that period demonstrating its applicability and workability. The cases presented in Chapter 5.3 show that comparable new systems are accepted but still struggling to become economically sustainable. However, they show tremendous potential, when scaled up. For the long-term, the service in the City of Gothenburg can be scaled up to cover more areas including the Frihamnen district combining the transport of goods and waste, thus reducing empty haulage and increasing the transport system´s efficiency.

9 Conclusion

The challenges induced through urbanisation increase the need for innovative solutions to urban logistics. This study draws the attention to inland waterway transportation and highlights that an implementation of combined transportation of goods and waste on inland waterways can bring forward sustainable transportation in urban logistics lowering road traffic in urban areas. However, the path to a successful implementation is lined with several obstacles. First of all, the design of the supply chain is dependent on various complex factors such as the type of goods and waste, compatibility of transportation modes, impacts on the environment and service level requirements. Additionally, strong barriers have been identified which hinder the implementation process, consisting of economic and operational factors, behavioural change, policy and regulations. It was discovered that the existing drivers such as public interest, environmental drivers, political incentives and regulations as well as technical development just have a marginal impact. Therefore, more emphasis has to be put on policy to considerably bring forward sustainable inland waterway transportation while close collaboration of policy makers with all stakeholders in the urban supply chain is needed to even out problems early in the planning phases. Besides that, cooperation of stakeholders in the urban supply chain is necessary to enable consolidation of goods and waste flows.

Consequently, short-term and long-term goals for a successful implementation were formulated. In the short-run, transportation systems have to be initiated on a small-scale to ensure trust in the new transportation through applicability and reliability of these new systems. In the long run, systems need to be scaled up in order to serve more areas and achieve economies of scale.

The findings from this research are used in an urban planning project in the City of Gothenburg for a demonstrator project, which aims to assess the applicability of combined goods and waste transportation on inland waterways in the region of Gothenburg, especially in the district of Frihamnen.

Furthermore, this thesis can be used as a basis for additional research in the area of urban logistics. In particular research on the marginal relevance of inland waterway transportation in areas with waterway connection as well as the use of inland waterway transportation for large-scale construction projects provide promising avenues of further research to contribute to academic discourse on urban logistics.

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Appendix

1 Interview Guide

A modal shift in goods transportation into urban areas from road to waterway transport can be beneficial for several reasons, such as less pollution, less traffic congestion, less accidents and less noise. Also, utilising the same vessels to transport waste away from the city avoiding empty haulage can be beneficial for the same reasons. However, designing the urban waterways transport system is complicated as there are many different design parameters such as which goods to transport (e.g. household deliveries, perishable and refrigerated goods to different types of receivers), which waste to transport (e.g. bulk waste, scraps of food, metal scrap, hazardous waste), which barge/ship to use and which load carriers to use.

Furthermore, there are a number of different stakeholders that have different views of what constitutes an effective and efficient urban waterway transport system. The different views of the actors and their perception of barriers, drivers, cornerstones and success factors need to be understood. Furthermore, the different actors' operations need to be understood (in terms of the amount of goods that can be transported, from where it is transported, which infrastructure is required etc.).

All these factors shape the design of the urban waterway transport system. Therefore, this study aims to find out, what is necessary to enable a shift from road transportation to inland waterway transportation in urban logistics in order to reduce road traffic in urban areas. The context is the DenCity project, which deals with the construction of the Frihamnen area. The research question is phrased as "How do different factors influence the shape of combined goods and waste transportation in urban waterway supply chains?" or alternatively "How can a combined urban waterway supply chain be designed". The following interview guide is used (slightly modified depending on which actor is being interviewed) to collect data from 10-15 stakeholders/actors/experts on urban waterway transport.

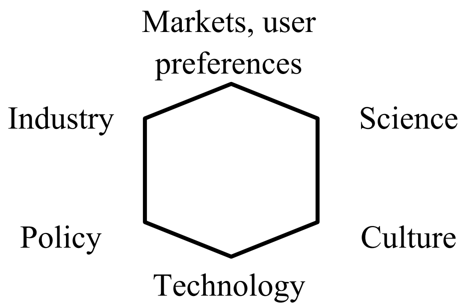
Introduction

- Please introduce yourself elaborating on your background and experience.
- Please shortly describe your company/institution, your field of work and your role.
- What is the companies´/institutions´ role in the urban logistics supply chain?
- What is your role in the DenCity project (if applicable)?

Goods and waste transportation

- What are the expected volumes of goods and waste for Frihamnen? Are there any limits?
- What type of goods do you see as most applicable in this system?
- What are the expected cargo units and its packaging?
- What type of waste do you see as most applicable in this system?

When answering the following questions on “barriers” and “drivers” please refer to the six dimensions of a socio-technical system as seen below:



Barriers

- What do you see as challenging factors implementing waterway transportation into city logistics for Frihamnen?
- What would be hindering an implementation?
- Why is water transportation in Gothenburg not used to a greater extent?

Drivers

- What do you see as driving factors for implementing a new system?
- Who has great influence on driving forward towards a new system?

Prerequisites

- Which prerequisites could lead to a successful implementation of the system in question?
- Who needs to participate in such a system in order to reach success?

Success factors

- Which are the success factors in existing delivery systems?
- Which would be the success factors for a new system?
- Which existing problems do you see as solved by this mode of transport?

Vision

- What is your vision on urban logistics in relation to this research project?