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Sustainability criteria for urban freight systems

A case study of DenCity

Master's thesis in Infrastructure and Environmental engineering

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Abstract

The concept of sustainable development has failed to make radical changes in today's behavior. This concept has not been incorporated into the engineering practices. Change over time is certain what those changes would be is uncertain. Lock-ins in existing socio-technical system are strong barriers against radical changes. Unsustainable trends are deeply established and rooted in all the elements. Urban freight system, a system to transport goods in an urban unit, is an inevitable system needed for any society. The major challenge identified was to evaluate relative sustainability of different scenarios in the field of urban freight system. A proactive approach is necessary from municipalities not only to integrate urban freight system in their decision-making processes but to also incorporate sustainability into this system. Sustainability criteria are a set of factors to evaluate the relative sustainability of a set of alternatives. These criteria help to ask relevant questions within a project to see whether or not this project move the society towards the desired future. Inclusion, providing equitable opportunities, flexibility, ability to adopt and resource efficiency are among the most important requirements that have been tried to be covered. These criteria are operational, non-prescriptive and comprehensive by considering the future generation needs and unsustainability impacts of today's activities.

Keywords: Urban freight systems, sustainable development, Sustainability criteria, socio-technical systems.

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Writing this thesis in Challenge Lab was quite a new experience for me. I have learnt a lot both about the world and about myself. I want to take this opportunity to thank those who have directly or indirectly contributed to this research. I need to thank all the students involved in Challenge Lab 2016 for providing a safe and inclusive environment to empower my inner values. This group would not be available without the team behind Challenge lab including: John Holmberg, Örjan Söderberg, David Andersson, Daniela Mendoza, and Johan Larsson.

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Aako Raoofi
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Table of Contents

1 Introduction

This study has been formed by two distinctive phases. The first phase is about developing the research question by identifying the unsustainable activities in today's world. The second phase is the actual thesis project which aims to answer the research question developed in the phase 1.

Chalmers aims to work closely with business and public sector in the region. This collaboration – academia, business and public – is needed to address the complex challenges (Holmberg, 2014). In order to achieve that, each of these units have to understand their own roles and also the role of the other units. University as the most stable unit among the others, have the binding bond role. This has been achieved in Chalmers by bringing together the stakeholders from different sectors to address complex challenges.

1.1 What is Challenge lab?

Challenge Lab is an organization within Chalmers University of technology which aims to bring together the actors of the triple helix, see Figure 1. This has been done by building trust in the system through students. Challenge Lab as the bonding agent, aims for collaboration and co-creation in this process. In the other world, challenge lab is a ''student-driven transition arena'' where students have the opportunity to interact closely with the stakeholders and try to work on the leverage points and initiate the necessary changes. Backcasting methodology is the method used in Challenge Lab to help the students to de-attach themselves from the unsustainable trends in today's society and to start from a desired future. The students are called the ''change agent'' which by their unthreatening role they can trigger the leverage points in the systems.

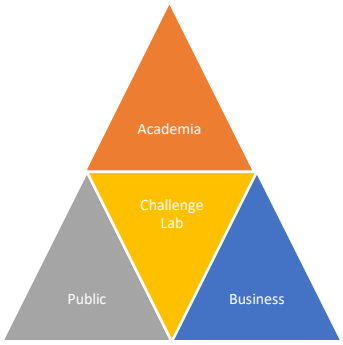


Figure 1 - Challenge lab and the triple helix

13 students from 9 different countries with various study backgrounds have formed the 2016 challenge lab student team. These students are brought together with a shared vision and objectives. These objectives are (Holmberg, 2014, p. 97):

- ''Strengthen the educational dimension in the knowledge triangle within the Areas of advance.
- Provide a natural hub for the triple helix actors within the five regional knowledge clusters, where all parties are drawn because of the students, as they all have a stake in the students.
- Build trust within the cluster through students. A defining feature of students is they are simultaneously non-threatening and challenging, a feature crucial to the kind of change society greatly needs, positioning the students to be powerful change agents.
- Give the students the opportunity to develop unique skills in working across disciplines and from a challenge-driven perspective.''

Challenge lab methodology has formed the basis for the research question of this study. By applying Backcasting to unsustainable trends in todays' society the research question of this study has been evolved.

1.2 Research question

It can be readily said that different actors in a project have different demands and often different frameworks. This makes the collaboration between different sectors a challenging issue. In particular urban freight systems usually are being involved in the finishing phase of developing plans. Municipalities often consider logistic as a matter of business which it will solve its problem (Quak & Joannes, 2008). But it has been argued that urban freight should be considered in the early phase of the developing plan which will lead to a more sustainable freight system and as a result a sustainable district. The lack of trustful environment had always triggered the tension between different sectors – Academia, business and public -, it has led to unproductive dialogues between the actors. Usually the strategic planners have the top-down perspective when it comes to define the visions, which has made the collaboration a very challenging process. On the other hand, future cannot be known which it makes the process of decision-making a rather challenging process. The Lack of an evaluating method for alternative scenarios for a potential future and to see which scenario will move the world closer to a sustainable future has caused severe problems in today unsustainable world.

The purpose of this study is to form a framework for planning a sustainable urban freight system for an urban district. It correlates with the first step of the Backcasting methodology which is to co-create the criteria for a sustainable urban freight system with the stakeholders involved. The result of this study could be a starting point for the work-package 5 of the DenCity[1] project. It aims to emphasize the need of understanding and collaboration between the stakeholders. The main goal is to go deeper in the definitions and to develop a new framework by envisioning a sustainable future and defining the criteria for that.

In particular, this paper aims to identify the sustainability criteria for urban freight system. In order to achieve that questions presented below need to be answered:

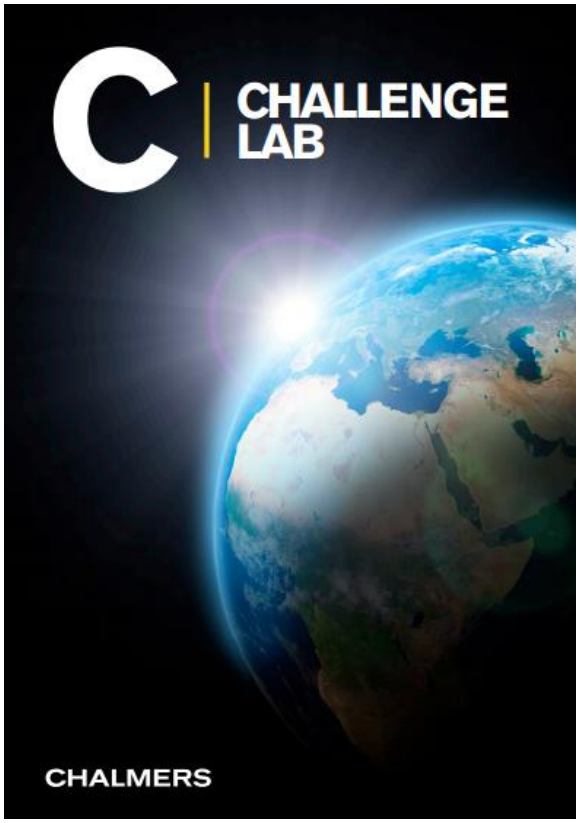
- What are the sustainability criteria for urban freight system?
- What are the applications of these criteria?

1.3 Outline

Chapter 2 – 4 (phase 1) present the process of formulating the research question which has been done in challenge lab together with the other students and the Challenge Lab team. All the process and the theories are thoroughly presented. Research question is evolved during this phase and is presented in Chapter 7.

Chapter 5 - 11 (phase 2) Present the actual aim of this project which is to define sustainability criteria for an urban freight system and to discuss how sustainability criteria could be the framework towards a sustainable future.

[1] Dencity is an ongoing project in the city of Gothenburg which is used as the case study used in this research. The aim of the DenCity project is to provide a livable community in the city of Gothenburg.



''IDENTIFYING THE UN-SUSTAINBALE ACTIVITIES''

The process of formulating the research question

Aako Raoofi

Phase 1

The aim of this phase is to find the leverage points in the development plans of the City of Gothenburg. Then a research question will be formed based on the findings in this phase. This has been done by applying Backcasting. This phase has been started by 13 other students and the challenge Lab team by defining the criteria for a sustainable future (step 1 of Backcasting), continued by several sets of dialogues to investigate the today's situation (step 2 of Backcasting). By comparing findings of the first and second step, potential future scenarios have been developed (step 3 of Backcasting) and the research question has been formed.

2 Theory

In this chapter, the theory behind Backcasting and the tools that have been used in this study are presented.

2.1 Inside out perspective

Inside-out perspective will not only help to understand and to connect student's own values, vision and strength but also to understand the interaction between different stakeholders within a system. In order to implement this perspective into the projects, different tools and methodologies have been used. A self-leadership workshop to understand the inner values and a series of dialogues with stakeholders have been used in this study.

According to Isaacs (1993), dialogue can be defined as '' a sustained collective inquiry into the processes, assumptions and certainties that compose everyday experiences''. This shows how this definitions differs from the common perception of dialogue. It criticizes the common opinion where the participant only tend to defend themselves against each other rather than to seek the reasons for the existence of the disagreements.

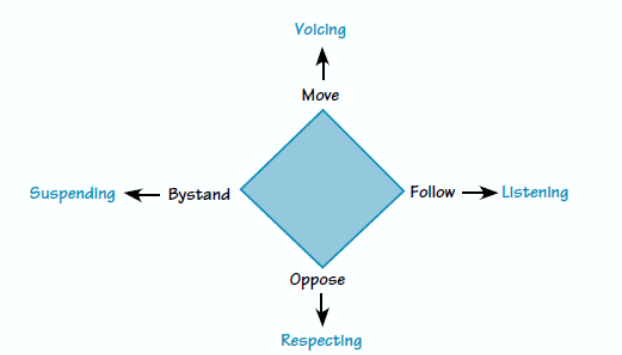


Figure 2 - four player model in dialogues. Movers (directions), Followers (Completions), Opposers (Correction), Bystanders (perspective). Source: Isaacs, 1999.

Four different roles in each dialogues are presented in the Figure 2. It emphasizes the importance of each role in a dialogue (Isaacs, 1999). Movers usually have the higher voice in a dialogue which form the direction of the dialogue. Followers are those who assist to finalize and to complete a discussion. Opposers are those who criticize and correct the direction when it is needed. And bystanders add a perspective to the dialogue and help to open up the lock-ins.

2.2 Outside-in perspective

According to Holmberg (2014) outside-in perspective will particularly help to understand the ''requirements global sustainability will put on the system''. Outside-in perspective can be analogized to looking at a fish bowl to understand the relations, causes and impacts and the different functions within the bowl. As an observer a thorough understanding of the system will be achieved. Different tools and methods can be used to implement this concept.

2.2.1 System thinking

System thinking is a concept that helps to understand and to analyse the connection between patterns which are seemed to be isolated (Haraldsson, 2004). It involves holistic and system thinking when it comes to understand the patterns. System thinking insists to look through system as a whole. It focuses on the fact that everything is strongly interrelated to everything else (Flood, 1998).

In general it can be said that system thinking is the skill of structuring the logic (Haraldsson, 2004). System thinking assists to understand the causes and effects in a system which will lead to a better understanding of the system. It transforms the traditional linear reasoning process to a circular one where the feedbacks or effects of a cause are also effecting the initial cause, see Figure 3.

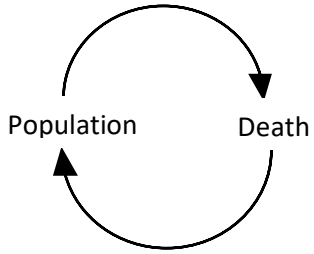


Figure 3 - Example of causal loop. Growth in population will lead to growth in death and growth in dead will lead to population reduction

2.2.2 Multi-level perspective

Multi-level perspective (MLP) is a method that divides a system into three analytical levels. This helps the process of investigating the system to have a thorough understanding of the system (Geels, 2005), see Figure 4.

Niches level is the place where radical novelties take place. It acts as incubation rooms for innovation that protects these novelties from mainstream markets. Niches provide the opportunity for the learning process in different dimensions in a system and it also helps to form strong networks where there is a potential.

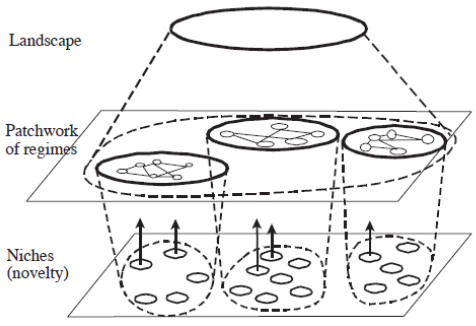


Figure 4 - Multi-level perspective conceptual model. Source: (Geels, 2002)

Regimes are formed by the rule-sets of a system and it can be analogized to the grammars embedded in a system. Another component of the regimes is the cognitive routines. These are the rules that are embedded in the minds of engineers and it is more knowledge based. The

other component of the regimes are the social groups that form a society. This shows the complexity of a system. Several different groups, routines and rules are contributing to the existence of a regime either independently or interdependently.

Landscape represents a wider environment which influence the socio-technical developments. The term landscape emphasizes the hardness characteristic of this level (Geels, 2005). Landscape also includes the special arrangements of cities, infrastructures and materials for example. It needs to be stated that landscape cannot be directly influenced.

By having a broader perspective to these levels, the relations between each level can be understood. Niches are embedded within regimes and regimes are embedded within the landscapes. Innovations which are taking place in the niche level are aiming to influence the regimes and to even modify them. This provides the basis for changes. But it is a very complex process since existing regimes are rooted down into all the aspects of a society.

2.3 Backcasting methodology

Backcasting is a method where the desired condition for the future are envisioned and then several steps are identified to achieve those conditions (Robinson, 1990). Backcasting as a methodology particularly assists to address the complex problems when: a major change is needed, externalities are the major contributors to the problems, existing trends are part of the problems and the scope and time perspective is wide enough (Dreborg, 1996). The following steps are included in a Backcasting approach, see Figure 5:

1. Defining the criteria for sustainability
2. Describe the current situation in relation to the criteria
3. Envisaging and discussing the future
4. Finding strategies for a sustainable future

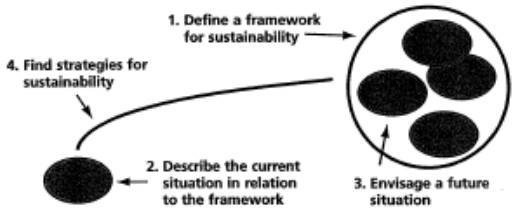


Figure 5 - Backcasting methodology steps. Source: (Holmberg, 1998)

As it is shown above the first step of Backcasting is to define the criteria for sustainability. These criteria will form a framework for sustainability. This will help to have a reference throughout the whole process and to question the process to see whether or not it moves us closer to the desired future.

2.3.1 Defining the Criteria for a sustainable future

The criteria for a desired sustainable future works as framework and as guidance for today's measures (Holmberg, 1998). Ordinary approaches to solve a problem is to focus on the currents trends while in Backcasting firstly the criteria for a sustainable future will be defined regardless of the current trends.

According to Brundtland report (1987) sustainable development is defined as ''development that meets the needs of the present without compromising the ability of future generations to meet their own needs''. This definition is the basis of the four principles of sustainable development defined by Holmberg (Holmberg, 1998):

"Nature's functions and diversity must not be systematically:

1. Subject to increasing concentration of substances extracted from the earth's crust.
2. Subject to increasing concentration of substances produced by the society.
3. Impoverished by over-harvesting or other forms ecosystem manipulation.

And

4. Resources must be used fairly and efficiently in order to meet basic human needs worldwide."

In order to fulfil the requirements of sustainable development and to guarantee the well-being and the human needs, these four principles should be seen as the boundaries which should not be crossed. In the other words these four principles are the core for the three dimensions of sustainable development – social, ecology and economic - and have been being further developed in each dimension. The first three principles are the conditions for the ecological dimension. The fourth principle has been developed in the other two dimensions, societal and economic. Figure 6 represents the four dimensions of sustainability – ecological, societal, economics and well-beings. The criteria within these four dimensions had to be defined based on the four principles presented above.

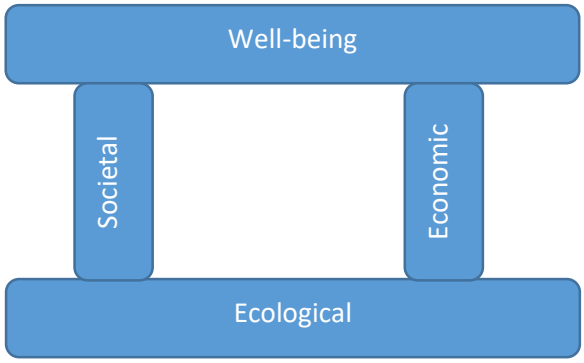


Figure 6 – Four dimension of sustainability

2.3.2 Describing the current situation

This step of Backcasting plays a key role for the third and fourth steps. In order to have a realistic strategic plan for the future, a thorough understanding of the today's situation is needed (Holmberg, 1998). The defined criteria in the previous step have been used as a reference for a comparison between the desired sustainable future and today's situations. As it is mentioned before the aim of this step is to identify the non-sustainable activities in the current world. System thinking, multi-level perspective and dialogue are the tools and methodologies that have been used in this step. By comparing the envisioned future with today's situation the existing gap between these two states will be identified.

2.3.3 Envisaging the future

Potential solutions or scenarios have been formed in this step (Holmberg, 1998). This has been done according to the defined criteria for a sustainable future (step 1) and also based on the today's situation (step 2). It is not necessary – or even needed – to come up with a specific solution or a detail future image. The main goal is to envisage future scenarios in a broader perspective which will open new horizons. The

essential aspect of this step is to decouple the mindsets from the current trends or regimes and to open up the minds for future alternatives.

2.3.4 Finding strategies for sustainability

To link the future sustainable situation which was envisaged in the previous step to the current situation, strategies have to be identified (Holmberg, 1998). These strategies should be defined in a way that they move the society towards the desired future. In order to achieve that the strategies should be flexible, has sufficient pace and scale for the society, and does not have too many losses for today's generation.

3 Methodology

In order to go through the Backcasting steps, several tools which are explained before, have been used. Outside in perspective assist the student to understand the current systems and to define the desired sustainable future. In the other words, outside in perspective has been used to understand today's system in a global perspective to understand the challenges and the relations between the components. Inside out perspective has helped the students to analyze and to understand their inner values and to find the relation between the inner and outer systems (inner system refers to individual in depth values and outer system is the world as a whole). This has been done by a self-leadership workshop where the strength and weaknesses of students have been analyzed.

3.1 Backcasting and the criteria for sustainability (Backcasting step 1)

The first two weeks of challenge Lab were focused on the criteria for a sustainable future which is the first step in the Backcasting methodology. This has been done by having outside-in perspective. The students were divided into 4 different groups each representing one principles of sustainability:

- Well-being
- Social
- Economic
- Ecology.

The main aim of the first week was to have a deep understanding about each principle and to be prepared for the next task which was to define the criteria. A desired sustainable future is defined by starting from a global perspective. After a week of literature review, several mini-dialogues were hold. The aim of these dialogues was to discuss further each principle and try to cover all the perspectives regarding a specific principle, and then define the criteria. This has been done by rotating the members of each dialogue group. So all the students were involved in the discussion for all the principles, see Figure 7. Thanks to this approach, different backgrounds and different perspectives could be involved in the developed criteria.

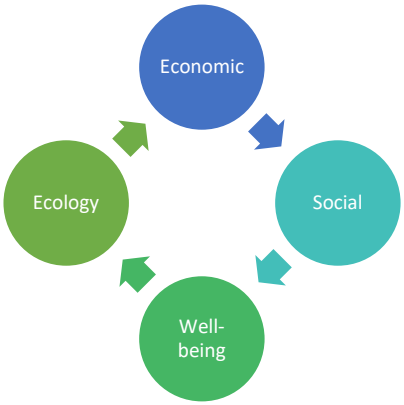


Figure 7 - - Mini-dialogue set-up for defining the criteria for the sustainability principles. The arrows between the circles show that that the students have been rotated continuously to be involved the dialogues for each principle.

By the end of the second week the criteria for a sustainable future were defined. These criteria were formed firstly by literature review and the UN post-15 sustainable development goals, see Appendix I, and secondly extensive dialogues between the students and Challenge Lab team. These principles and criteria form a framework for transition to a sustainable future.

The vision for a sustainable future is taken from challenge team 2015 which is quite comprehensive and includes the definition of sustainable development by Brundtland.

A self-leadership workshop has been held during the first week. This workshop particularly helped the students to go deeper in theirselves and to investigate their strength and weaknesses. This was also a starting point for students to get to know each other and to start the team formation process.

3.2 Today's situation (Backcasting step 2)

This tool perfectly shows the path that today's societies are following. The increasing rate of population and over-extracting the resources are leading the worlds to a suppress stage. This has been analogize to the functionality of a funnel, see Figure 8.

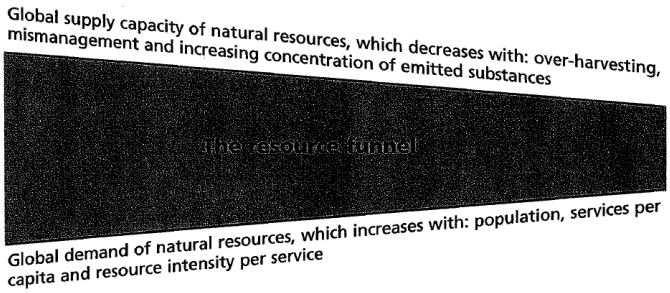


Figure 8 - The resource funnel. Source: (Holmberg, 1998)

As it can be clearly seen in the picture above, if the current trends are going to be continuously followed, the boundaries will become narrow and narrower (Holmberg, 1998). This leads to sever impacts, for example, increasing cost of resources, increasing rate of pollution and stricter legislations. The resource funnel tool has helped the students to understand the complexity and the urgency of the today's situation.

Increasing rate of population and the over-usage of resources will move the universe to a point that all the needed resources will be scarce and development as it is known today will be stopped.

By defining the criteria of sustainability, a framework has been formed. This helped the students to always have a reference point when they want to analyze today's situation and to investigate the strength and weaknesses of the current systems. At the end of the week two, it was the time to analyze the current projects in the city of Gothenburg and to investigate the Strategic plans for the city. In order to have a better understanding of today's situation, several tools and methodologies have been used. Multi-level perspective has been introduced to give a system perspective to the students and to understand how today's societal systems are working. This emphasizes the importance of system thinking and a need of transformative action. This was the time that students could distinguish between the trends and single problems (regime and niche in the Multi-level perspective methodology).

Students were divided into several groups based on their background and interest and they start to dig deep into the available information about the projects. This was the preparation for the dialogues in the third and fourth week. Since the participant of the dialogues were already known, it was easy to focus on the projects and topic which could be related to the participants' expertise. This week finished with a clear vision and a defined set-up for the dialogues.

3.2.1 Transition dialogues (Backcasting step 2)

Main purpose of the dialogue is to bring together the pillars of a society to analyze today's situation by involving different perspectives in the discussions. Dialogue as a tool helps to analyze the impact of each speaker on the other(s) (Isaacs, 1999). It helped the students to ask the questions that have not been answered in the reports and to explore the uncertainties. It was intended to provide a safe environment for a collective thinking both for the stakeholders and the students. Representative from different sectors in a society were invited to these dialogues and a Fish bowl set-up was chosen to be the set-up for these dialogues, see Figure 9.

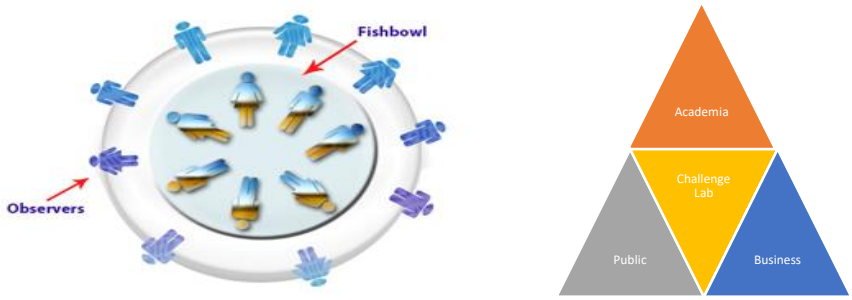


Figure 9 - left picture represents the dialogues set-up. Right picture represents the position of challenge lab in today's society

The fish bowl set-up was formed by a group of stakeholders, questioners, facilitators and observers. The latest three were formed by the students. Each dialogue took 3 hours and the stakeholders were

questioned by the questioners. Observers had the responsibility to analyze the dialogues with another perspective. Five dialogues were planned for The Challenge lab 2016:

1. Mobility and urban development
2. Johanneberg Science park partners
3. Sustainability driven innovation for urban development
4. Area of advance energy
5. Integration and social innovation

After each dialogues a reflection sessions has been hold to identify the ''leverage points'' within the system. Leverage points are those spots in a complex system with a high potential to trigger an extensive change in the whole system (Meadows, 1997). These are the preferred points to intervene in a system since the potential for a shift is already present.

3.3 Envisaging the future scenario (Backcasting step 3)

By comparing today's situation and the defined criteria it became much easier to identify the gaps in between. As it is mentioned in the previous chapter, the aim of the third step is not to fill the gap with detail solutions but to explore the potential scenarios. This became possible by having a broader perspective about the future and considering the defined criteria and today's situation. Multi-level perspective (MLP) and multi-level Design (MLD) were two tools that helped the students to have a systematic approach in this step. MLD is formed by different steps and the difference with other methodologies is the presence of iterations throughout the process, see Figure 10. This tool is used to go deeper into each topic and investigate the hidden aspects.

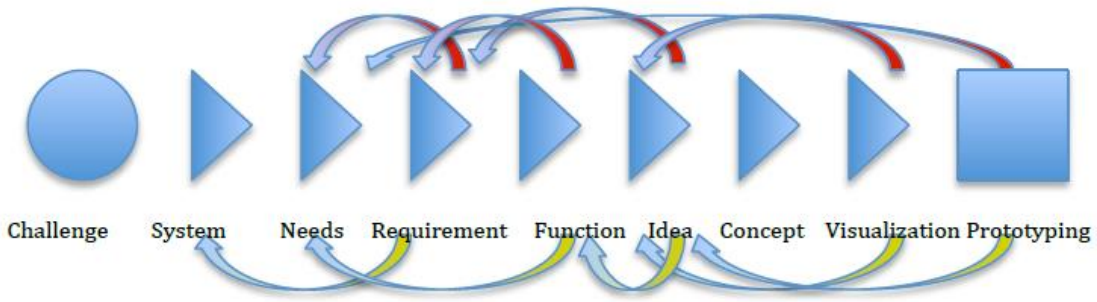


Figure 10 - Design thinking conceptual mode.

Three major fields were suggested by the challenge lab team as a starting point for this step:

- Urban mobility
- Urban development
- Bio innovation and Energy

The next step was to suggest different projects which could be related to the three mentioned fields. These projects were evolved from two different roots, firstly the identified gaps and secondly the background and interest of each student.

After having all the suggested projects, student were divided into three groups for the three fields. In each group it has been tried to categorize the projects into reasonable classes to have a better understanding of the respective field, and also to see if all the different aspects are covered. This process has been continued by discussion between the students and The Challenge lab and as a result, those Hot-topics which were interesting for the Challenge lab as a team were identified, see Figure 11.

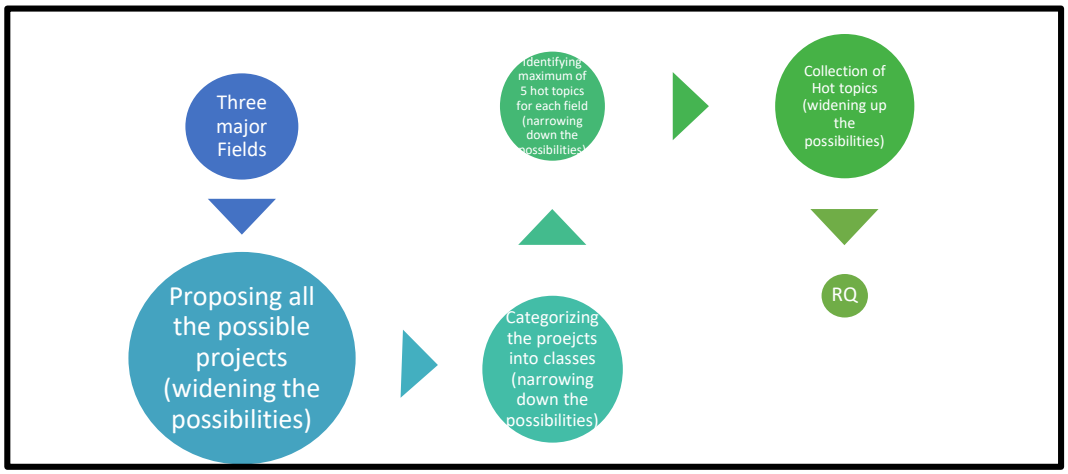


Figure 11 - This figure shows how the possibilities for a potential project has been widen up and narrowed down till finding the final research question. RQ stands for Research Question.

In each step different projects have been eliminated, emerged or evolved. This approach resulted in a deeper understanding of each particular project and to have a holistic perspective over the challenges. In order to achieve that, hot topics has been passed through a series of questions:

- Who are the stakeholders which are interested in this topic?
- What are dimensions of sustainable development?
- Is it transformative?
- Is it integrative? In what aspects and who are the stakeholders?
- Analyzing the socio-technical aspect
- Multi-level perspective
- Value chain

By answering these questions, all the aspects of a particular topic will be revealed. This will also help to realize if there is a potential in the stakeholders for a specific project or not.

3.4 Strategic plan

Based on the finding in the previous step, my background and my interest the research topic started to be formed.

4 Results

The overall outcomes of the phase 1 are presented in this chapter.

4.1 Criteria

Sustainability criteria can be seen as a framework or as a guiding tool towards the defined vision in the step 1 of Backcasting. This vision is taken from the Challenge Lab 2015:

> ''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 the meet theirs''

As it said before the four principles defined by Holmberg have been used as the basis for defining the criteria for the four dimensions of sustainability.

- **Ecology :** 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 & Robert (1996) *and Holmberg & Robèrt* (2000)*, Post-15 Goals, Criteria by C-Lab (2015).*

- **Well-being:** First we present the basics for survival and continue with components supporting self-fulfillment and self-realization. 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 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 be your 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 (1972)*, International wellbeing group* (2013)*, Cruz et al* (2009)*, Post-15 Goals, Criteria by C-Lab (2015)*

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- **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 ensures 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)*, Post-15 Goals, Criteria by C-Lab (2015).*

- **Societal Criteria:** The societal system is an instrument for individuals to live together within 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 and social equity;
        - equal human rights;
    - Its governing mechanisms (and societal institutions) are built on transparency, accountability, mutual trust, adaptability and recognition of diversity.

4.2 Leverage points

The outcome of dialogues for the author of this report, was the problems with the transportation system in Frihamnen by considering the traffic strategy and development plans for this district. Freight network in particular plays a significant role in the traffic in urban areas which has to be involved in the strategic plans from the very early phase. The city aims to reduce the car traffic which will increase the need for a better goods' transportation system. This puts pressure on logistic providers and might influence the quality of services. Delivering goods and collecting waste from a district are the basic needs for an urban district in a developed society. It emphasizes the key role of goods transportation.

4.3 Hot topics

As the result of step 3 of Backcasting, the leverage points or hot topics were identified. Three different topics have been evolved during step 3, 1) The transportation strategy, 2) The DenCity Project and 3) Value chain of material. This was the main step were students have been more focused on the topics that are most related to their background and to their interest. Based on my background and my interests, I decided to work on the DenCity project where I could see the potential to intervene.

4.4 Research question

During the exploration time about city logistics and Frihamnen, I realized the potential for such a project in the stakeholders to address the transportation issues. This was the place where I could intervene and try to make a change in their perspectives. As it is mentioned before, as students with a neutral perspective, we could provide a safe environment for the stakeholders. Fortunately stakeholders were very open to this and they were eager to have our point of view in their meetings.

DenCity is an ongoing project in the city of Gothenburg that aims to address the mobility issues in a district in the city. This study is done closely with one of the work-packages of this project. This work-package aims to bring together and integrate the other work-packages of the DenCity project and to work out a process for how to include urban freight system in urban planning. The multi-disciplinary setting of the DenCity project was a unique feature which could provide a rich platform for data collection.

Sustainability criteria which is the result of first step of Backcasting, has the role of a framework for a project. These criteria are planned to be defined and developed by the participant of a project. Co-created criteria will ease the path of implementing these criteria in decision-making processes. The initial research question evolved from this phase is:

- What are the criteria for a sustainable urban freight system?
    - What are the implications of these criteria?

This research question has been modified and broken down into sub-questions in phase 2 of this thesis.

''SUSTAINABILITY CRITERIA FOR URBAN FREIGHT SYSTEM

A tool to evaluate the relative sustainability of different scenarios

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Phase 2

The aim of this phase is to develop the criteria for a sustainable urban freight system based on literatures and empirical data from a case study. The research question formed on the previous phase will be broken down into sub-questions to help the author to achieve the purpose of this study. A rather extensive literature review (considering the limited amount of time) has been carried out followed by empirical data collection from the DenCity project (an ongoing project in the city of Gothenburg).

5 Introduction

An explanatory introduction followed by the outcome and research question of this study has been presented in this chapter to prepare the readers.

5.1 Background

Environmental impacts of the human activities, e.g. transportation system, food industry, etc., in our society are severe and challenging to solve (Holmberg & Robert, 2000). Nature has been continuously being destroyed by human activities where since 18th century the degradation of natural resources is higher than the whole period before 18th century (Hawken, et al., 1999). Although academia has been rather successful to understand the causes behind these impacts but the uncertainty is still huge. Minimal and fragmented changes in a system are not sufficient enough to deal with the unsustainable characteristics of the systems. These fragmented changes will usually lead to positive impacts on the target aspect but negative impacts on the others. These all will lead to more complex problems that need to be addressed.

Having a complex problem, emphasizes the need of a framework which is not only generally accepted but also co-created by the actors (Holmberg & Robert, 2000). This framework provides a platform to evaluate the solutions and to thoroughly discuss the problems. This brings together varied perspectives and suggests a shared perspective where all aspects are included.

The future of the human society cannot be clearly foreseen based on the past data. What will happen in the future is under the influence of variety of processes which might be unexpected (Holmberg & Robert, 2000). But this does not mean that people should stop to be worried about the future because it cannot be foreseen. Even if the goal is not specifically defined in detail, but more generally though completely by a framework of criteria, it will be possible to achieve the objectives and to define the direction towards the desired future (Robert, et al., 2002). Although a clear image of future cannot be defined but its principles can be. These principles can help to guide the society towards the desired future. The criteria originated form these principles will not limit the number of possible future scenarios since they do not suggest any solutions; on the contrary, they provide a platform to evaluate different alternatives for a potential future and to see how a certain solution will move the society closer to the desired future.

By the growing rates of population and urbanization a well-developed transportation network is needed. By 2050 more than 80% of the European population will live in the urban areas (MDS Transmodal Limited, 2012). This means more flow of material and people in/into the cities. This will lead to an increasing demand for transportation.

In today's world, literally everything that is being consumed has been transported from somewhere else. This could be a local, regional, continental or even intercontinental transportation (Rhodes, et al., 2012). Urban freight systems enable the accessibility to the products that are needed in a functioning city at the

time and place that is required. It is a fundamental component of a community and plays a vital role in fulfilling the citizens' needs. An efficient and functioning network of goods transportation is a crucial part of any urban unit which has to be considered in the very beginning of the development plans for each city.

It has been seen that transporting goods in a dense urban environment will lead to unwanted costs on the citizens and consequently on the urban unit itself (Rhodes, et al., 2012). It has been seen that the issues caused by an unsustainable freight system contributes to the majority of the negative impacts on the cities' path towards sustainability (Behrends, et al., 2008). On the other hands, urban freight system, a system to transport goods in an urban unit, is an inevitable system needed for any society. Urban freight system is of importance because of the services that it provides and its impacts on an urban unit (Anderson, et al., 2005):

- The basis for our existing life style;
- Key role in supply chain of material for any industry;
- Its contribution to the cost of supplies consumed in an urban unit;
- Direct impact on the efficiency of the economy for a region;
- The environmental impacts.

Despite the significant role of the urban freight system, it is not yet prioritized in strategic planning of the cities. This is because of the lack of knowledge about goods transportation and the variation in the freight transportation definition.

Incorporating the concept of sustainable development in today's engineering practices is a challenging process (Sahely, et al., 2005). Sustainable urban freight system and its criteria need to be clearly defined in order to address the ambiguities that exists in the current perceptions. A generally accepted definition can be used as a starting point to define the criteria for a sustainable urban freight system that can work as a framework towards sustainability. To incorporate the concept of sustainable development in urban freight system, a set of practicable and operational criteria are needed. These criteria can be used to evaluate and to judge the potential scenarios in the context of sustainability and to see whether or not a specific solution will move a society towards the desired future (Foxon, et al., 2002). Developing these criteria is the ultimate goal of this study. These criteria help to question the projects, to monitor the path towards the future and to see if the society is aligned with sustainability principles or not. A generally accepted framework formed by sustainability criteria will not only help to solve the problems, the unsustainable urban freight system in this case, but also to avoid potential problems in the future.

5.2 Purpose and Research questions

With the growing rate of population and the fast pace of urbanization and development, it is necessary to rethink the concepts, e.g. capitalism which gives more value to human-made capital rather than natural capital, quantity development rather than quality development. The Urban freight system as a crucial function in human society that provides the basic needs of human being, needs to be designed in a way to fulfil the requirements of the sustainable future. With the unsustainability impacts of the current urban freight system and the ever increasing population many of these requirements have been being violated, e.g. equity, environment. A sustainable urban freight system is an inevitable function of a sustainable urban area where not only environmental impacts are considered but also social and economic ones are met. Sustainability criteria need to be developed as a guideline to design a sustainable urban freight system. These criteria assist to move towards a desired future where the urban freight system is a

sustainable system. In order to define these criteria, a thorough understanding of the current urban freight system and the future system are needed.

The purpose of this study is to:

- Define the criteria for sustainable urban freight system and, by applying these criteria, to identify the shortcomings of today's urban freight system.

In order to achieve that, the following two research questions will be investigated:

1. What criteria define a sustainable urban freight system?
    a. Who are the actors and stakeholders?
    b. What are the stakeholders' needs and the demands?
2. What are the characteristics of today's urban freight system in relation to the sustainable future?
    a. What are the impacts of today's urban freight system on society?
    b. What are the causes of those impacts?
    c. What are the drivers and barriers for sustainability transition for urban freight system?

The aim is to raise the awareness between stakeholders about sustainability criteria and to propose these criteria as a framework for an urban freight system. It is intended to prepare an environment for the stakeholders based on trust and to emphasize the concept of co-creation and bottom-up approach to define a sustainable future where everyone is involved and feels the ownership. The sustainability criteria would particularly help to judge the relative sustainability of the proposed solution for a sustainable urban freight system.

5.3 Scope and Limitations

The main focus of this study is both on the positive and negative impacts of urban freight system on society according to literature and actors' perspectives. The upstream causes evolved from the impacts are limited to the system level. This means the causal chain has not been investigated in detail and the focus was on the influence of urban freight system on the society and not the other way around.

Regional, national and international goods transportation are excluded from this study. Freight system in urban units is the absolute target of this thesis. The proposed criteria are defined according to the role of city planners and designers of urban freight system rather than the final users or urban residents. This means users' behavior is assumed to be driven by the other components of the system.

The case study that is used in this study is not the primary target of this research and it is rather a tool to understand urban freight system and its impacts, hence a thorough analysis of the case study will not be provided.

5.4 Outline

In chapter 6 different concepts including the theory and models that are used in this study such as urban freight system, sustainable development and socio-technical systems are presented. The research approach of this study together with the data collection methods and the tools that have been used are presented in chapter 7. Chapter 8 includes the findings resulted from the data collections filtered by socio-technical analysis. Moreover the findings from the observations are also presented in this chapter. Impacts and causes (research questions 2.a and 2.b) are also presented in this chapter followed by the

result analysis in chapter 9. This includes the criteria as the ultimate result of this study. The results are discussed further from different aspects in chapter 10 followed by the conclusion in chapter 11.

6 Frame of reference

The theory behind this thesis is formed in this chapter. A theoretical background together with the models that have been used in this thesis are presented here. The first requirement to achieve the purpose of this report, sustainability criteria, was to understand the urban freight system and to identify the actors and the stakeholders involved. This chapter aims to fulfill this requirement.

6.1 Urban Freight Transport

Goods transportation contributes to 20-30% of vehicle kilometers (Dablanc, 2007). Although it contributes only to one fourth of the traffic flow in cities, it may cause up to half of the emissions resulted from transportation (Dablanc, 2007).

Urban freight systems are usually associated with negative impacts in our societies. It needs to be considered that these negative impacts are the consequences of an unsustainable system (Quak & Joannes, 2008). The question that readily arises from this statement is: why do we have an unsustainable urban freight system? Freight systems have always been neglected by the city authorities and it usually is considered as a market business in comparison with passenger transportation. Although the importance of urban freight system is known, it has rarely been included in the strategic planning of cities. Selecting the mode for transportation is a function of time requirements, network availability and total logistic cost (Rhodes, et al., 2012). Hence, urban freight system has always been driven according to the price of transportation, rather than the actual cost (actual costs includes the environmental, social, and economic impacts). As it can be seen in Table 1 these impacts have been violating the ecological, social, economic, and well-being principles.

Table 1- Impacts of unsustainble urban freight system

`	Social	Environmental	Economic
Impacts	1. Public health due to emission 2. Traffic accident 3. Noise pollution, vibration, visual intrusion 4. Reduce the attractiveness of urban areas 5. Less livable districts because of vast transport infrastructure 6. Damage to infrastructure	1. Pollutant emission 2.Non-renewable resources 3 High volume of waste products	1. Inefficiency 2. Less city accessibility due to congestion

The Increasing rate of urban development, hence higher income and cheaper goods, has increased the need for urban freight system and as a result more negative impacts. It has been seen that development, as a concept that is accepted, has a certain path towards mass production. And as a result the quality of life is strongly associated with higher consumption (Quak & Joannes, 2008). This means development and economic growth is coupled with increasing use of natural resources, hence increasing the negative impacts of current systems – urban freight system in this case. It has been seen that despite the great improvement in the industries such as vehicle production, engines efficiency and fuel consumption, the negative impacts of urban freight system is still increasing. This is the result of correlation between economic growth, resource consumption and the need for goods transportation.

Due to the increase in the negative impacts mentioned above, the urban freight system became more and more noticeable for policy makers in national and local authorities (Quak & Joannes, 2008). On the other hand, appearance of the concept of sustainability in the legislations during the 90's also increased the interest of policy makers for a sustainable urban goods movement. Since after, it has been seen that legislators and policy makers have tried to address the urban freight systems' issue by setting new regulations. But despite the effort to improve the urban freight system, the negative impacts are still increasing. Brown and Allen (1999) have claimed that ''introducing new policies to alleviate one environmental impact of urban freight movement can result in worsening the others''.

It is argued that identifying all the social costs is nearly impossible for policy makers and it makes it even more challenging to find a balance between the society's objectives and demand for goods transportation to have the least social costs (Quak & Joannes, 2008). As an example, reducing the nuisance will probably lead to an increase in costs and as a consequence decrease in service levels. This is aligned with the fact that the fragmented perspectives will lead to solutions that have positive impacts on one and negative impacts on the others.

Authorities usually have a reactive approach rather than a proactive approach when it comes to urban freight system. Because of that the regulations are initiated by the negative impacts of urban freight systems rather than the essential services that this system provides. As it is said before the legislations that are set to decrease the impact of goods movement has often led to increase in transport cost and the complexity of this system.

This is interesting that this reactiveness behavior of the legislator has always existed, where in the first known legislation for urban freight system in ancient Rome they just banned the movement in certain hours (Quak & Joannes, 2008):

> ''On the roads which are in the city of Rome or will be within the area where will be lived joined tightly, no one is allowed after next January 1st to drive or lead carriage during the day after sunrise and before the tenth hour of the day except if something will have to be supplied or transported for building temples of the immortal gods or for the implementation of a work for authorities, or as from the city or from those areas something of those things of which demolition will be out to tender by the authorities, will have to be removed on behalves of the authorities, and except for those cases in which it will be according to this law permitted to certain persons for certain reasons to drive or lead a carriage''

6.2 Urban freight system

A system to transport and distribute goods in a community is an inevitable component of any society (Quak & Joannes, 2008). In order to understand what a freight system is, the definition of urban freight transportation has to be cleared (Rhodes, et al., 2012). Different players in a society - business sector, transportation planners, freight providers, community planners, urban citizens, etc. – have different perceptions about urban freight system depending on the functionality of this system for themselves. As a consequence the urban freight system does not have a single definition.

The Organization for Economic Co-operation and Development (OECD) has defined urban freight system as ''the delivery of consumer goods in city and suburban areas, including the reverse flow of used goods in terms of clean waste'' (OECD, 2003). This definition is only focusing on the delivery of consumer goods within urban areas which is only a part of the urban freight system as a whole (Behrends, et al., 2008). Providing needed material (raw or semi-produced) for industries is the missing flow in this definition.

Although Dablanc has tried to have a more thorough definition of urban freight system, but this definition lacks the contribution of citizen to the flow of material. But it includes the cross flow of material (freight traffic which only passes an urban area) into this definition. Dablnac (2008, p. 248) defines urban freight system as ''the transport of goods carried out by or for professionals in an urban environment''.

Behrends (2008, p.10) has defined urban freight system and included different flows of traffic caused by freight transportation:

- ''provision of industry with raw materials and semi-manufactured articles;
- Provision of the wholesale trade with consumer goods;
- Provision of shops with consumer goods;
- Inbound and outbound consumer goods produced in the area;
- Home deliveries made by professional delivery operators; and
- Transit transport of goods.
- Shopping trips made by households
- Building (including services) and demolition traffic, and
- Waste (reverse logistics)''

6.2.1 Actors

After defining urban freight system and its functionality it is important to identify the stakeholders who affect urban freight system and those who are affected by this system (MDS Transmodal Limited, 2012). A large number of sectors in the spectrum of supply chain are involved in urban freight system, see Table 2.

Table 2 - Stakeholders identification and classification

Category of stakeholders	Stakeholders
Supply chain	Shippers
	Transport operator
	Receivers (large receivers)
	Consumers (Residents)
Infrastructure	Providers
	Operators
	Land-owners
Public authorities	European Union
	National government
	Local government and municipality

6.2.2 Demands

When it comes to urban district, local distribution of goods are of importance. In order to understand the demand of goods, the sources of demands need to be identified (MDS Transmodal Limited, 2012). These

demands form the local market for freight transport which strongly influence the flow of goods into the city and consequently the transportation operator behaviours.

Retail is the last point in supply chain where the finished product reaches to the final consumer (MDS Transmodal Limited, 2012). It determines the final consumers' access to the needed goods, from ordinary household goods to more specific products that are needed in an urban unit. Nowadays retail sector is formed by both off-town large stores and small local stores which makes the goods distribution a complex process.

Ecommerce also plays an important role in today's logistics. In 2015 almost 75% of households in Sweden have purchased once from online stores. This shows 16% increase in comparison to the previous year (Svensk Digital Handel, et al., 2015). This is only the business to consumer (B2C) e-commerce which only contributes to a small proportion of this market. The majority of it is contributed by business to business sector (B2B). Ecommerce is a growing service in Sweden where the total share of Ecommerce has increased more than 200% in the period of 2007-2015.

Courier and post services using small or medium trucks or large vans are one of the fastest growing transport services (MDS Transmodal Limited, 2012). This service plays e key role particularly when it comes to Ecommerce. As stated before, Ecommerce is an increasing business and this means more pressure on courier and post transport services. Each city has its own regulation regarding transportation and access to the inner city; this has caused this sector to operate in fragmented regulatory context. This is a major obstacle which will influence the overall quality of the provided services.

HoReCa represents the food industry. It stands for Hotels, Restaurants and Catering (MDS Transmodal Limited, 2012). HoReCa's distribution behaviour is characterized as a non-predictable one. Since the main service is about food, very strict regulations are in place. This will lead to a much fluctuated goods demand. Although there is a need for a large volume of products but orders are generally in very small volumes and as a result more frequent. Just in time deliveries is the delivery behaviour which is needed by this sector which in some cases has led to 400% increase in the cost in comparison to the deliveries to the retail sector.

Construction material needed for infrastructure and buildings is a very project-based demand (MDS Transmodal Limited, 2012). The needed materials in this sector are both in large and small volumes depending on the project. This will lead to a flow of varied size of lorries within a district which will move either full or emptied.

Waste: A very important sector in an urban district with continues need for logistic is the municipal waste collection (MDS Transmodal Limited, 2012). European Union has divided the total generated waste in an urban district into three categories:

- Sorted municipal waste: paper, plastic, metals, woods, clothes, batteries, etc.;
- Park and garden waste;
- Others: mixed waste, street cleaning residue, etc.

The actors and the demands in this system shows the complexity of this system. Having a unified system where all these demands are met in a high quality is challenge that needs to be addressed. This requires a thorough understanding of the system and its impacts from different perspectives in order to have a comprehensive result.

6.3 Sustainable urban freight system

In the 90's when the world realized that the crises that were happening, are not separated. Energy crisis is not separated from environmental crisis and they are all one (Brundtland, 1987). The world has been going through a dramatic growth and therefor fundamental changes. Humans had to live in a finite environment with finite resources in a way that they leave those resources to next generations. Production from the industry have been increased by 4000% in the period of 1950-1987. Considering the massive growth in economic activity and industrial development together with the increasing rate of population (more than doubled in the next 100 years), the profound impacts on the planet earth could be easily imagined. These impacts could be: soil degradation, water stresses, ecological stresses, deforestation, floods, pollutions, etc. Number of people suffered from the natural disasters per year in 70's were 200% more than the respective years in 60's. All the facts mentioned above led to the need for new way of development. Sustainable development thought to be the solutions to reduce the environmental impacts of human activities. Sustainable development will ensure to ''meet the needs of the present generation without compromising the ability of future generations to meet their own needs''.

Sustainable development is an abstract and generalized concept which covers all the systems that exists in society. This concept should be broken down into more actionable definitions in different fields. In order to integrate the concept of sustainable development in urban freight systems, a new definition of this system and its associated criteria need to be developed in a way that meets the requirements of sustainable development. The aim should be to envisage how a society is going to deliver the means of opportunities to fulfil environmental, social and economic requirements in an efficient and equitable way, while reducing the unnecessary impacts and the associated cost, over a specific space and time scale (Anderson, et al., 2005).

European Union (EU) vision for urban freight system in 2011, aims for a sustainable urban freight system. EU as a steering unit for European countries has developed this based on the definition of sustainable development (MDS Transmodal Limited, 2012). This vision includes:

- Minimizing the number of freight movement and the distance required to carry them out;
- Using low emission urban trucks to carry out deliveries
- Making maximum use of ITS to increase the efficiency of deliveries;
- Reducing noise pollution from freight movement, so that road infrastructure could be used more efficiently by making night deliveries and avoiding morning and afternoon peak periods''

This vision suggest a system which is economically and environmentally efficient in order to decrease the impacts. . Urban freight system should be planned in a way to reduce the negative impacts and to increase sustainability without damaging urban units (Russo & Comi, 2012)

Behrends (2008) has defined sustainable urban freight as a system which fulfils the following objectives:

- ''To ensure the accessibility offered by the transport system to all categories of freight transport;
- To reduce air pollution, greenhouse gas emissions waste and noise to levels without negative impacts on the health of the citizens or nature;

- To improve the resource and energy efficiency and cost effectiveness of the transportation of goods, taking into account the external cost;
- To contribute to the enhancement of the attractiveness and quality of the urban environment, by avoiding the accidents, minimizing the use of land and without compromising the mobility of citizens''

This definition should be evaluated with the sustainability criteria defined in phase 1, to see how aligned is this definition with the desired sustainable future, see Table 3.

*Table 3 - Comparison between the sustainability criteria and sustainable urban freight system. *to find the complete list of criteria see chapter 4.1*

	Desired sustainable future	Sustainable urban freight system
Ecology*	Do not increase the concentration of substances from the lithosphere in the ecosphere; Do not increase concentration of human made substances; Do not systematically deteriorate the resource base	To reduce air pollution, greenhouse gas emissions waste and noise to levels without negative impacts on nature. To improve the resource and energy Efficiency Minimizing the use of land.
Economic*	The function of the economic system is driven by the other criteria It enables further use of resources and avoids dissipative use of materials; It ensures 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.	To ensure the accessibility offered by the transport system to all. To improve the resource and energy efficiency and cost effectiveness of the transportation of goods, taking into account the external cost;
Social*	Equitable accessibility to education and health care; gender and social equity; equal human rights; Its governing mechanisms (and societal institutions) are built on transparency, accountability, mutual trust, adaptability and recognition of diversity.	To ensure the accessibility offered by the transport system to all Without negative impacts on the health of the citizens or nature; To contribute to the enhancement of the attractiveness and quality of the urban environment, by avoiding the accidents, minimizing the use of land and without compromising the mobility of citizens''
Well-being*	Right to basic human needs Having access to the same opportunities Social and economic inequalities are not justified	To ensure the accessibility offered by the transport system to all. To contribute to the enhancement of the attractiveness and quality of the urban environment, by avoiding the accidents, minimizing the use of land and without compromising the mobility of citizens. Without negative impacts on the health of the citizens.

6.4 Socio-technical system

A system is formed by different components which are interdependently co-operating towards the functionality of the system. Understanding these components and their functionality will help to understand the system as whole (Geels & Elgar, 2005). Socio-technical system is a tool which helps to determine the characteristics of a system in a diverged aspects. Because of the complexity of a socio-technical system, it is preferred to elaborate on one angle at a time instead of defining the entire system at a time. This can be done by analyzing a system by configurative elements (Geels, 2012). The Socio-technical system shape a system by different elements, i.e. technology, policy, consumer practices, infrastructure, scientific knowledge, culture, and market, see Figure 12.

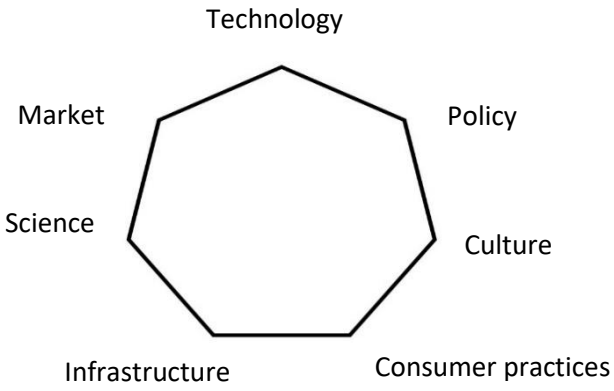

Figure 12 - Socio-technical system conceptual model

These seven elements are strongly interconnected and each of them has its own functionality. These configurative elements help to understand a system thoroughly. These elements are being reproduced, maintained and changed by the actors in the system (Geels, 2012). A major shift in this system is a socio-technical transition which is a co-evolutionary process where multi-stakeholders are involved. Socio-technical transition can be understood better in the context of multi-level perspective (MLP) methodology, see chapter XXX. These transitions are non-linear and are the result of development and processes in three different analytical level: niche level, socio-technical regimes level, and landscape level. MLP will help to understand the processes and the activities behind a socio-technical transition. Socio-technical analysis will specifically help in this study to analyze urban freight system, its different elements, and the linkages in between. This will help to identify the barriers and impacts of the existing urban freight system from different perspectives.

This has been used as the basis to structure the interviews in order to identity the drivers and barriers in different aspects. It needs to be mentioned that the drivers and barriers are investigated considering the innovative solutions in the niches level which are aiming to make a radical change in the socio-technical regimes that at the end tend to make a socio-technical transition towards a desired system.

6.5 Sustainability criteria

It can only guessed what future generations want todays' generation to do and what they desire and what are their objectives. Change over time is certain what those changes would be is uncertain. These changes

may influence the shape of a society hence the shape of socio-technical systems, e.g. the urban freight system. In the case of definite changes but unknown impacts an adjustable and evolving strategy is needed where all the actors are participating. Planning should be a sequential and adaptive process towards the desired future. (Loucks, et al., 1999).

Sustainable development has a very broad and wage definition which might lead to miss-interpretation when it comes to implementation of this concept in real world. In order to have a better approach to sustainable development and make it graspable by different levels of a system - to incorporate sustainability in decision making - a set of operational and practical criteria are needed (Hellström, et al., 2000).

Foxon (2002) has defined sustainability criteria as "the set of factors that may be used to assess which of a range of options offer greatest contribution to achieving sustainability objectives." Belkema (2002) defines sustainability criteria by emphasizing the future generations' needs: "translation of future generation demands into set of functional and operational criteria". These criteria help to evaluate the alternative solutions for the desired future and to see whether or not a certain solution will move the society a step forward or away from sustainability. This provide a platform to incorporate sustainability in decision-making processes. (Foxon, et al., 2002).

It is of importance to understand the difference between principles, criteria and indicators of sustainability (Foxon, et al., 2002). Principles are normative goals and definitive targets for sustainability which remain constant over time, while criteria are a set of factors to evaluate the relative sustainability of a set of alternatives. Indicators are a measurement tool to set up standards to evaluate an option in the context of certain sustainability criteria. Criteria and indicators may change over time due the improvement in knowledge. Indicators are based on historic data which is aligned with the forecasting methodology. This is against the approach of this study where the desired future is set as the fundament for decision-making rather than the historical events. Hence sustainability criteria are of importance. These criteria, as stated before, help to judge the relative sustainability of an alternative solution, while indicators only indicate whether or not a certain standard is violated. This application of sustainability criteria will assist to decide which range of alternative solutions will have the greatest contribution to the desired sustainable future. Sahely and his/her colleagues (2005) have used these criteria to develop a framework as a roadmap to future sustainability assessments in urban infrastructure systems. This has been done to incorporate sustainability in urban infrastructure systems and to tackle the associated challenges. Foxon (2002) and his/her colleagues have also used sustainability criteria for a similar purpose. They have used sustainability criteria in UK water industry as a tool to evaluate the relative sustainability of different projects. They have used these criteria as a framework to facilitate the inclusion of sustainable development concept in decision-making processes. Holmberg (2000) has also proposed sustainability principles (not criteria) as a strategic planning framework which assist the process of integrating the concept of sustainable development in decision making. Hellström (2000) and his colleagues has used sustainability criteria as a system analysis framework for urban water management. The main objective of all these previous studies was to incorporate sustainability in decision-making by providing a set of functional and operational criteria where all the requirements of a sustainable future are met.

These criteria will be developed based on the sustainability principles and the data collected during this study. Holmberg (1996) formulated the sustainability principles as the followings:

- ''Substances extracted from the Lithosphere must not systematically accumulate in the ecosphere;
- Society-produced substances must not systematically accumulate in the exosphere;
- The physical conditions for production and diversity within the ecosphere must not systematically deteriorated;
- The use of resources must be efficient and just with respect to meeting human needs.''

These four principles must not be violated during the path toward the future. This provides a platform to envisage the societal, economic and environmental demands where all of these four conditions are met. Sustainable development requirements, see Figure 13, defined by United Nations in (2016), is another source of data to develop the sustainability criteria for urban freight systems, see Appendix II.

Figure 13 - United Nations' 17 goal for sustainability. Source: (United Nations, 2016)

It needs to be considered that sustainability criteria takes into account the impacts on long term run. These are the impacts that may appear decades or centuries after the causes. But if the quality of life of future generation is a concern it makes no sense to ignore the impacts on today's generation not only in local scale but also in regional, national and international scale. It emphasizes the need for a realistic approach keeping in mind the desired future (Viktoria Transport policy institute, 2015).

6.6 Summary of frame of references

How the future will be is unknown but its principles and criteria can be defined. Concept of sustainable development helps to define these criteria. These criteria will help to incorporate sustainability into decision-making and engineering practices. Freight systems in urban units play a vital role in urban development, fulfilling the basic human needs, and the basis for the existing life style. Having fragmented and exclusive perspectives have caused significant failures in the existing urban freight system.

In order to understand the urban freight systems and its functionality, the demands of this system and the actors involved needed to be identified. This will together with socio-technical analysis help to have a thorough understanding of the vital role of urban freight system in an urban unit and to structure the data collecting strategy. The concept of sustainable development and its four principles defined by Holmberg (1998) on the other hand, provides the guideline to improve the urban freight system and to develop the

framework to reduce the negative impacts and to enhance the positive and sustainable impacts. The criteria for sustainable urban freight system will then be evolved from these two concepts: Urban freight system and sustainable development.

7 Methodology

The research approach together with the data collection methods and the general process of this research are presented in this chapter.

7.1 Research strategy

In order to develop the sustainability criteria for urban freight system, the shortcomings and impacts of urban freight system have to be identified. After identifying these impacts (downstream impacts of urban freight system) the upstream causes in the system should be identified. Criteria for sustainable urban freight system would then be evolved from these upstream causes. These three sequential steps will end to the criteria needed for a sustainable urban freight system, see Figure 14. This is important to add that both positive and negative impacts are being considered.

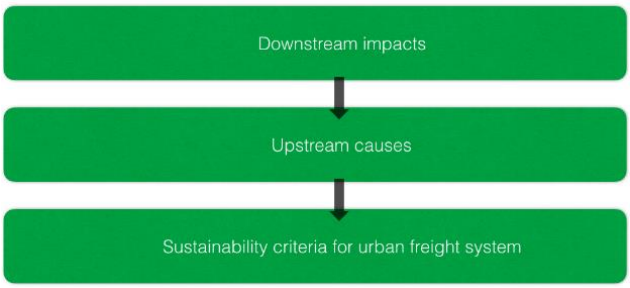

Figure 14. Three sequential steps to develop the criteria

Freight system is a crucial service in an urban area which the boundaries in between are not clear (urban freight city and urban area). On the other hand, urban freight system needs to be investigated in the context of urban area to understand their influence on each other. These emphasizes the need for a case study for the purpose of this research. Yin (2002) has suggested to use case study when there is no clear boundaries between the phenomena (urban freight system in this case) and the context (urban area in this case). Moreover a case study is beneficial when contextual conditions are going to be covered in a research (freight system and urban unit in this case). A case study can provide a detailed image of empirical phenomena which will enhance the process of systemic combining to develop and refine theories and to deliver the needed framework which is not only applicable to the particular case study but also to the other projects (Dubois & Gadde, 2002). Case study will provide a picture of a case, DenCity project in this case, which many different perspectives in different levels are being included (Vaus, 2001).

The DenCity project was selected as the case study for this research. It needs to be said that the purpose of this study is not to gain a deep understanding of DenCity as a case study but to facilitate the understating of urban freight system and its impacts. The case is of secondary interest while understanding impact of urban freight system is the main target. Instrumental case study is the appropriate approach for this research (Stake, 1995). This provides comprehensive insight and helps to refine and develop theories which is aligned with the model of systematic combining. The case is presented in section 9.2.

The research approach is based on systematic combining and abductive research, because this approach will particularly help to address the weaknesses which have been seen in case studies (Yin, 2002). This is done by investing in the theoretical background which will work as an intellectual guidance throughout the project to avoid a solid descriptive and passive case study. This will help in the process of identifying the impacts of urban freight system on todays' society. Case studies in particular help to analyze and to understand complex phenomena within a system. The research approach is described in section 9.3.

7.2 The Case study

Unique characteristics of DenCity project has made this project a suitable choice for the purpose of this study. These characteristics were: presence of three sides of triple helix (private, public, and academia), willingness to change in the stakeholders, Backcasting approach as the methodology, and multi-disciplinary setting of the groups. Another important factor to choose DenCity project as the case study was availability of data through direct contacts with the actors from the beginning of the study. The result of this case study is then generalized by analytical reasoning.

7.2.1 The DenCity Project

DenCity project is addressing the challenges, in different scale, towards urbanization and densification. Transportation system is the ultimate target of this project as a tool for an attractive and densified urban unit. DenCity as a project aims to integrate goods and passenger transport by consolidating the fragmented transportation system. The purpose is to achieve a sustainable goods and passenger mobility system in a dense urban environment. The proposed solutions will be developed and demonstrated through five different work packages where each has a certain goal and responsibility under an overarching vision:

- Work-package 1: Zero emission deliveries
- Work-package 2: Urban waterways
- Work-package 3: Enabling physical and digital infrastructure for dense living
- Work-package 4: Urban services and deliveries
- Work-package 5: System integration and evaluation

Work-package one task is to develop the possibility of using electric trucks in order to reduce the emissions (Closer, 2016). This work-package will investigate the practicality of these trucks in the DenCity project. Work-package two aims to propose a combined goods and waste transportation while utilizing the existing river by carrying out a demonstrator project on the river Göta älv. Work-package three is formed by three smaller sub work-packages, Mobility as a Service, Digital platform and mobility hub. This work-packages aims to enable an effective passenger transportation via variety modes of transportation, goods delivery and waste management. Work-package four will develop a delivery package for consolidated deliveries for private users and small companies. Work-package 5 has an integrative responsibility. This work-package aims to integrate the solutions and alternative that are resulted from the other work-packages in order to develop a unified system goods and passenger transportation. The ultimate goal is to integrate transportation sector (passenger and goods) in strategic planning of the city.

7.2.2 Actors

Companies, institutions and organizations from different sectors are involved in this project, see Table 4

Table 4 - The involved actors in the DenCity project and their respective sectors. Source: (Closer, 2016)

Title	Sector	Type of business/organization
City planning administration	Public	Strategic planner for urban development
Urban transport administration		Strategic planner for traffic
Älvstranden Utveckling		City Developer
Västra Götaland region		Municipality
Sweden post		Logistic provider
Göteborg Frihamn AB		City developer
Parkering Bolaget		Car parking planner
Water and waste management administration		Water and waste management
AB Volvo	Private	Vehicle producer
Baghitch		Logistic provider
Closer		Research and development
Coop Logistics		Logistic provider
Ericsson		Digital infrastructure
Schenker		Logistic consult
School of business – Gothenburg university	Academia	Research and development
Chalmers university of technology		Research and development

The multi-disciplinary setting of the DenCity project can be seen in the above table. This will help to have a thorough understanding of urban freight system and include all the perspectives in the process of data collection.

7.2.3 Frihamnen

Frihamnen is a developing district in the central part of Gothenburg which is the target district in the DenCity project. It is located at the point where the river Kvillebäcken reaches the river Göta älv (Stadbyggnadskontoret, 2015). It is part of bigger project called the River City. The vision of the River City is to build an inclusive, green and dynamic community close by the river Göta älv. Frihamnen plays a strategic role in the city. This role is to connect both side of the city, see Figure 15. The aim is not only to physically connect different districts but also mentally to address the segregation issue in the city of Gothenburg.

This district will be formed by a mixture of working places, 2500 workplace, and 3750 residential units and a well-developed transportation network. Having a dense and mix community is one the main goals of this project (City of Gothenburg, 2014).

Figure 15 - Left image: current status of Frihamnen. Right image: future plan for Frihamnen. Source: (Stadbyggnadskontoret, 2015)

The transportation network is planned to be built in a way that public transport, cyclists and pedestrians are prioritized. In general, the transportation system in Frihamnen should be designed in a way that fulfills all the requirements of the transportation strategy planned by traffic authority of Gothenburg.

A unique aspect of this project is the intention to integrate all aspect of mobility into city planning processes. This has provided a multi-disciplinary setup with involvement of different stakeholders sharing a same vision.

7.3 Research approach: Abduction and Systematic combining

This research is structured in an abductive form where the theories are collected from scientific papers, both in phase 1 and phase 2, followed by qualitative data collection via several interviews and observations within a case study and an analytical framework. These qualitative data have been analyzed and integrated into the scientific background to develop the criteria for sustainable urban freight system. Different tools have been used to have a comprehensive understanding, analysis of the system and to draw a well-developed conclusion.

7.3.1 Abductive approach and systematic combining

In this approach, data is being collected continuously to build or develop theories. This approach is formed by at least one back and forth direction between empirical study and literature. This study begins with theoretical knowledge followed by empirical observation, see Figure 16. The next step would be to include observations, from a case study in this case, in the theoretical background. In order to combine the theoretical and empirical study and to extend the theoretical information used prior to the empirical data, a process of systematic combining or theory matching is needed (Kovaces & Spens, 2005).The main purpose of this approach is to have a better understanding of the new phenomena and to develop or generate theories or frameworks.

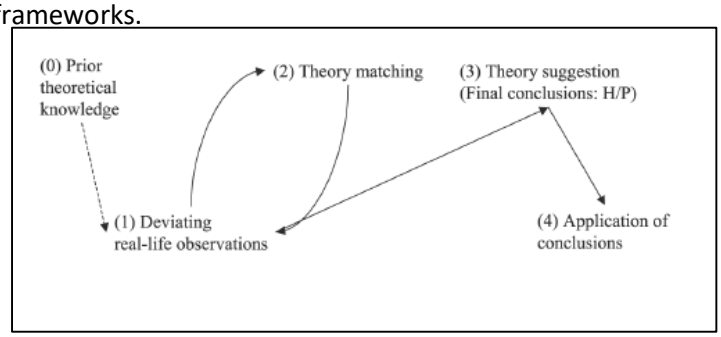

Figure 16 – Abductive approach conceptual model. Source: (Kovaces & Spens, 2005)

Dubois (Dubois & Gadde, 2002) has suggested ''systematic combining'' as a methodology where:

> ''Theoretical framework, empirical fieldwork, and case analysis evolve simultaneously, and it is particularly useful for development of new theories.''

The purpose of this study is to develop the criteria for sustainable urban freight system from a theoretical background followed by empirical data including a case study. Systematic combining could be the methodology which is aligned with the purpose of this study. The ability to include a case study in a research is a significant strength which can offer unique basis for developing theories by providing a thorough understanding of empirical phenomena (Dubois & Gadde, 2002). Going back and forth from a theoretical world to an empirical world will help to have an extensive understanding of both empirical and theoretical world.

The ultimate outcome of this methodology evolves throughout these back and forth processes. It is emerged from the theoretical background and then developed regarding the observations from the empirical world followed by analysis and interpretations utilizing the theoretical models.

This study has been carried out according to the model presented in Figure 17. Analytical framework, sustainable urban freight system in this case, has formed the basis for this study. A tight and evolving framework which is not too structured to blind the author and not too loose to cause data overload (Dubois & Gadde, 2002). This framework has provided a guideline for the author to direct this study. The extensive and strong theoretical background while is continuously being inspired by the empirical observation throughout the research. This is the author guideline to convey the study and to enter the empirical world. Continues movement between theory and empirical world is the main feature of this approach. This is also an important characteristic of an abductive methodology. This emphasizes the need for a case study and data from empirical world to have a better understanding of the theories.

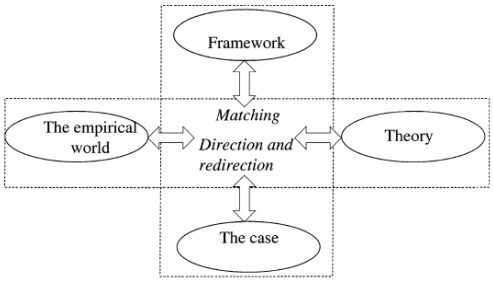

Figure 17 - Arrows in the figure represents the back and forth processes in this model which shows continues confrontation of empirical world and the theoretical world. Source: (Dubois & Gadde, 2002)

7.3.2 Research process

Data collected from the literature have provided the theoretical background for this thesis. Investigating the role of urban freight system and the concept of sustainable development has emphasized the need for sustainability criteria and it has initiated the basis for developing these criteria. Literature review has also helped to identify the actors and stakeholders that involved in urban freight system. Moreover this has provided the needed information about the needs and the demands of urban freight system.

Interviews, as the primary mode of data collection, have been designed and structured based in the theoretical background and tools that have been chosen. These interviews have been carried out within a case study followed by workshops and observations. DenCity has been chosen as the case study in this research not only for theory confirmation but also to develop the theories based on empirical world. Data has been collected by various modes to understand the empirical world according to the preconceptions.

This has enabled an environment to confirm, check and to adopt the developed criteria. It needs to be mentioned that the questioner have been continuously influenced by the theories and the case study itself. The aim of these interviews was to investigate the drivers and barriers in the existing system and to determine the shortcomings of today's urban freight system. The final criteria has been evolved from these two steps, the theoretical background and the empirical data.

7.4 Data collection methods

Literature review has formed the fundamental basis of this study. Previous research similar to purpose of this study has been used to develop a theoretical background to begin this study.

It is crucial to envisage the data needed to answer the research questions. This will guide the researcher to address the research questions. Data is going to be collected in a qualitative approach to have a deep understanding of the urban freight system and to analyze different perspectives. Semi-structured interview and observations are the selected tool to collect these qualitative data. This will provide results which are as ambiguous as possible and leave the interpretation for the researcher (Vaus, 2001).

7.4.1 Literature review: Exploring the concept of sustainable development and urban freight system

This study has started with an extensive literature review in order to develop the theoretical basis. Different definitions of urban freight system and sustainable development have been introduced and the concept of sustainable urban freight system is investigated. Sustainability criteria defined in the phase 1 are used as a reference to evaluate the current definitions of sustainable urban freight system and to see how aligned are the definitions with those criteria.

7.4.2 Interviews

Interview has been chosen as primary mode of collecting data for this study. A qualitative and explorative approach has been designed to provide an environment where the interviewees can share rich description about the processes and phenomena (Dicicco-Boom & Crabtree, 2006). This will leave the analysis to the researcher to explore different aspects of the target and to investigate deeper into different perspectives.

The purpose of using socio-technical analysis is to understand the system and identify the drivers and barriers in the process of socio-technical transition from the current state to the desired state. Interviews are used as a primary tool to understand the barriers in the current system in this study.

The elements of socio-technical system are used to identify the drivers and barriers of the current urban freight system for each work-package. It was necessary to prepare the interviewees for the interviews In order to prepare the interviewees for this socio-technical approach and to ease the data collecting process, two short presentations have been carried out in advance were the majority of the actors were present. In this presentations, the process of sustainability transition, including the multi-level perspective (Chapter 4.2.2) and socio-technical systems methodologies, has been introduced. MLP has been introduced to demonstrate how an innovative idea/technology can lead to the transition to a new socio-technical system. Characterizing the current urban freight system by configurative elements of socio-technical system has helped to have a thorough and classified understanding of urban freight system, its impacts, and the linkages within the system. The questioner is presented in Appendix III.

Semi-structured qualitative interviews have been done as an active mode of collecting data where a series of questions have been prepared in advance which would help the author to extract the desired results,

in this case a more explorative interviews rather than to test prior hypothesis (Dicicco-Boom & Crabtree, 2006). In this method the interviewee will share rich description of phenomena and leave the analysis to the researcher. A series of open-ended questions have been prepared to help the author to address the research questions. These interviews have been done in order to understand the current urban freight system, its impacts and the barriers. Eleven interviews from different sectors have been carried out in this study, see Appendix IV. The interviews were done face to face except three of them which have been carried out via telephone and Skype. The questioner have been sent in advance to have an efficient interview. All the interviews were recorded and transcribed after (with the permission of the interviewees). The result of these interviews together with the background studies are used as the basis for developing the criteria for a sustainable urban freight system.

7.4.3 Observations during meetings and workshops

Observations as an unstructured qualitative method has been done as a passive mode of collecting data (Dicicco-Boom & Crabtree, 2006). The observations from the meetings and workshops where different actors were participated, are also a source of active data. Active data is a result of a rather passive researcher (data from observations in this case) while passive data is a result of an active research approach where the researcher has intended to find those data (Dubois & Gadde, 2002). Active data is associated with discovery which results to the data that will not be available with an active approach, e.g. interview. This passive approach helps to understand the reality of the participants' perspectives since they are not intentionally exposed to a data collecting method. This provided data that could not be appeared with an active data collecting method. This has helped to identify the unforeseen aspects of the existing urban freight system.

7.5 Validity

It has been planned to only interview the key persons in the DenCity project. The first round of interviews was carried out with the work-packages' leaders to have an insight of each work-package, their objectives and their perception of today's urban freight system. In addition to the work-packages' leaders, an extra interview has been carried out with a project manager of the logistic division of the traffic authority Gothenburg. The second round of interviews have been carried out with the project managers from the business sectors, see Appendix IV. This has helped to investigate the system and its impacts from different perspectives.

The result evolved in this study had to be validated. This has to be done for two main purposes: firstly to see to what extent the actors can relate themselves to the result and secondly to see whether or not an important topic is missing. Because of the limitation of time, the validation process has been carried out only for the identified impacts. A list of identified impacts from the interviews and literature has been distributed among the actors during a workshop. The attendants were asked to go through the list and to see if there is anything missing or if they want to change something. This has helped to have a more comprehensive list of impacts. The result of this workshop has influenced the final result and has added to the value of the evolved criteria.

It has to be mentioned that the criteria are developed and continuously checked according to the four socio-ecological principles defined by Holmberg and Robert (1996) so it would be redundant to validate the criteria based on those principles again.

8 Empirical findings

Findings from the interview are presented in Appendix V. This is the initial step to analyze and to extract the data needed to answer the research questions.

8.1 Socio-technical system analysis

Drivers and barriers in the existing urban freight system will particularly help to have a better understanding of the system by considering the different perspectives. This will also help to understand the shortcoming of today's system. By structuring these result using socio-technical analysis, each aspect of the system can be independently analyzed. This enables the possibility to identify the gap between the current system and the desired system. These data are resulted directly from the interviews.

8.1.1 Infrastructure

It can be said that there is not an absolute perception of infrastructure. For some it is a driver and for some it is a barrier depending on individuals' perspectives, backgrounds, and objectives. Nevertheless the hurdles were those who everyone agreed upon. The rigidity of both infrastructure (available land) and transportation network[2] were among those challenges that need to be overcome. This is because of the fact that the future generation demands cannot be clearly known, hence flexible and adoptable infrastructure and transportation network is an inevitable requirement for a sustainable future.

Another challenge that has been identified is the fact that the transportation system is strongly adopted to the road network where other modes, waterway transportation in this case where the infrastructure (the river Göta älv) is available, have been being neglected.

An important challenge that has been identified is to avoid segregated districts with fragmented solutions. Existence of a homogenous transportation network is crucial mainly for transport providers but also for the city itself. It will not be economically efficient to only develop a service or a network which only works in one district without considering the demands out of its geographical boarders. Transportation network can be analogized as a jigsaw puzzle which the network in one district is only a part of this whole puzzle and it needs to be connected to the whole network to shape the whole puzzle. Having fragmented solutions, as it is mentioned before, will probably lead to new problems in the system. This needs an extensive collaboration between all the actors throughout a supply chain and city authorities.

8.1.2 Policy

Regulations exist in different levels: local, national and international. Policy changing is a significantly slow and complicated process. This is because of the involvements of many different actors in the mentioned three levels with different perspectives and demands. This is also the case for regulations regarding urban freight systems. Although the current policies are not an absolute pushing element to achieve a sustainable future, but slow changes are happening. The current regulations are not tough enough and will not initiate radical changes in the system, for example the emission limits are not as high as they should be. One of the existing challenges that were identified was that the regulations cannot be in favor of only one industry or technology, so for new and innovative systems it is always difficult to compete with the established systems. And this is because of the strong relation between market and policy. Another challenge is the fact that the focus of current regulations have always been on passenger

[2] Transportation network includes roads, routes, nodes, parking lots, loading and unloading zones, refueling stations, and charging stations.

transportation while goods transportation has not been deeply considered. Moreover the problems of urban freight system is considered as market problem and as a result supporting regulations do not exist, e.g. the lack of incentives. On the other hand, not knowing how the future would exactly look like will make the process of policy making to support new technologies an even more challenging process, mentioned by one of the interviewees which represents the traffic authority. It emphasizes the need for sustainability criteria to envisage the future without suggesting or limiting any certain scenarios.

8.1.3 Public/scientific knowledge

Public knowledge regarding urban freight systems does not really exist. From the whole chain of freight system people only see the disturbing, big and noisy trucks moving around the cities. But at the same time shopping is a favorite activity where everything from perishable product (e.g. fresh milk) to bulky goods (e.g. furniture) need to be continuously available. On the other hand E-commerce is a growing market which increases the need for a more frequent goods transportation. So the lack of public knowledge about the importance and function of urban freight system is a challenge for developing and extending new systems.

Scientific knowledge in some cases is very well-developed but in some cases not. The major challenge identified is ‘’how to evaluate a specific solution or system?’’. The environmental, social and economic benefits of a certain solution cannot be accurately estimated.

Many new technologies (e.g. electric vehicles) are still in transition period which makes the economy of scale a hindering process. This is a major obstacle when it comes to decision-making. In general it can be said a framework to evaluate the relative sustainability of certain system is lacking.

8.1.4 Market

Market is a crucial element in socio-technical system due to its influence on all the other elements. In most cases it is the driver of a system. This is one of the unsustainable characteristics of any system, urban freight system in this case. Finding a beneficial business model to make the innovative systems beneficial for market owners is a major challenge. The current market is adopted to the existing freight system with the road transportation as the dominant mode. This makes the today’s solutions a cheaper option for the society in comparison with innovative alternatives. On the other hand, the economic benefits of new systems cannot be clearly determined. This make it difficult to motivate and to convince big players to change. Here again the need for a framework to ease the decision-making process can be seen. Sustainability criteria will help to motivate the actors and provide a platform for decision-making.

8.1.5 Culture and user behavior

Since user behavior and culture are strongly interconnected and interrelated, it is decided to combine the analysis into one part. A functioning socio-technical systems have a tendency to be stable and to refuse external changes although minor changes to improve the functionality within the current trajectory is happening. Users, people in this case, have also a tendency to be stable and to refuse sudden changes. Of course it depends on each individual where some might be pro-environment and some might be just neutral. Although the current trends indicate that the society is going towards more sustainable alternatives and people are being more aware but the market shows the opposite. As a result of one of the interviews from the industry sector which provides green transportation, it has been identified that people do not pay extra for a sustainable solution in the current system although they (people) may orally support sustainable solutions. So user will always go for the cheapest alternative, this behavior will force

the market to also choose the cheapest alternative to have a higher revenue. As a result the green market will not be developed and will not be the dominant one in the system (considering the existing system).

8.2 Observations during workshops and group meetings

As a passive mode of collecting data by only participating in workshops and meetings as an observant a new perspective of the project and actors have been gained. Although the methodologies have been introduced and the importance of going beyond the lock-ins have been emphasized, the tendency to follow the trends was visible. This is not a surprising finding since the process of imagining the future regardless of the current trends is a rather challenging process, read more in Appendix VI. But willingness to change and accepting the methodologies, by the majority, is a great accomplishment to initiate a change. It needs to be also considered that this study has been conducted in the very early phase of the DenCity project so the actors were also new to the project. But on the other hand it shows the importance of defining a clear framework as an effective and strong foundation for the project towards its vision.

It is a great opportunity that the actors from all the three sides of triple helix (business, academia and public) were present in this project. This provided a strong platform where different perspectives were included. And this might be an initial step, where everyone feel welcome and included, to integrate urban freight system in urban planning in an early phase of city planning.

One of the identified issues in this project was the doubt about the extent of flexibility of the detailed plan. There is a detailed planed confirmed by the municipality of Gothenburg where some characteristics of the desired Frihamnen are already defined. Keeping this in mind, the actors seemed not sure about the flexibility of the detailed plan. This is a very significant issue when it comes to integrate urban freight system into the city planning since starting with a detailed plan will obviously limit the alternatives for urban freight system. This is in contradiction of the process of integrating the urban freight system in city planning in an early phase.

8.3 Downstream impacts and upstream causes

By combining the collected data from the interviews and the literature, the impacts of todays' urban freight system have been identified.

In order to develop sustainability criteria, firstly the impacts of the current urban freight system on today's world are identified. Secondly the upstream causes of these impacts have been determined. These impacts are extracted from the interviews and the theoretical background of this study.

Upstream causes are those mechanisms in the existing urban freight system that need to be considered in the design of urban freight system. These causes need to be either eliminated from the system or improved in way to increase the positive impacts and reduce the negative impacts. This will help to provide a system which does not violate the requirements of sustainable development. These mechanism are used to develop the sustainability criteria for urban freight system, see Table 5.

Table 5 - Downstream impacts and upstream causes of urban freight system on sustainability

Downstream impacts	Upstream causes
Noise Vibration Visual intrusion Attractiveness of cities Livability Accidents Time loss safety security	High interaction between ICE vehicles and sensitive area
Public health Damage to infrastructure Global warming Stress on environment and the ecosystem Water pollution Habitat loss	Emissions
Vast transportation infrastructure Congestion Less accessibility to city districts (mobility barrier) cheap unsustainable solutions obstacle to innovation Car dependency Low space efficiency Non-flexible transportation network Land use planning	Rigid system built to fit the existing transportation system (road transportation)
Air quality Working environment for the drivers Depletion of non-renewable energy	Fossil fuel dependency
High volume of waste High resource consumption Stress on environment Time loss Economic development Quality of life Large storage unit	Inefficient system
willingness to pay customer acceptance Acceptance	Not participatory and non-inclusive decision making, low quality of service, expensive services, low level of awareness
Ability to pay	expensive services,
Access to basic human needs Freedom of choice Equity impacts	Adequate, available, affordable, accessible, and high quality alternatives
Non-homogenous system	Fragmented solutions

Noise, vibration and visual intrusion (e.g. light intrusion) are caused directly by the frequent presence of heavy vehicles with internal combustion engines (ICE) in sensitive areas, e.g. residential areas. High and close interaction of vehicles, not only ICE vehicles, with pedestrians will also significantly influence the number of injuries due to traffic accidents, hence less feeling of safety and less secure urban units[3]. These all will lead to a less attractive, safe, secure, and livable city for the inhabitants.

[3] A system can be secure but it might not provide the feeling of safety, on the other hand people might feel safe while the system is not professionally secure.

Healthiness of the earth ecosystem -including human beings or any other being is being influenced by the hazardous emissions from human activities, urban freight system in this case. Loss of different natural habitats not only due to emissions but also due to over extracting the resources is a major challenge. Emissions do not only disturb the life but they are also affecting the material by causing erosion via chemical and physical reaction.

Vast transportation infrastructure, including massive roads, tunnels, highways, bridges, terminals, etc., has influenced the livability of cities. The existing transportation network is adopted to the current transportation system. This has been both the result and the cause of the current trends and lock-ins. An inflexible and rigid network has a high resilient to changes which makes it very difficult to adopt to the new demands and also to challenge the unsustainable processes in the system. This rigid network of transportation which do not accepts radical changes has led to high congested areas, less accessible districts and a car dependence society. This influences also the freedom in land use planning where the majority of available land belongs to transportation rather than green, functional and livable zones. The current system with off-hours deliveries require large storage units in stores. This will also influence the land use efficiency. The presence of the rigid infrastructure with its lock-ins will always work as a barrier against radical and sustainable changes by providing cheap and unsustainable solutions.

Fossil fuel is the dominant source of energy for transportation mainly because of its cheap price. Vehicle industries are strongly adopted to the fossil fuel. This has caused an uncomfortable situation for drivers and noisy and polluted environment for people. Adoption of ICE vehicles to fossil fuel resources makes new alternatives, e.g. electric cars, an expensive alternative for urban freight system which will lead to an expensive service provided by this system. The ever-increasing use of fossil fuel has led to depletion in non-renewable energy resources which violates the first principle of sustainable development. Air quality is significantly worsened since the introduction of fossil fuels to the industry and as a result severe problems in human and ecosystem health.

Not-optimized network due to a rigid system results to an inefficient urban freight system. Unnecessary trips by the vehicles because of the lack of optimized routes decreases the efficiency of the system and as a result it will negatively influence the resource consumption, e.g. fuel and material, and waste production in urban freight systems. Inefficient system will also lead to time loss in the system both for service providers and for the citizens. This will directly influence the reliability of services for all the actors. As it is stated before, urban freight system has a key role in economic development. Having an inefficient system will then definitely disturb the process of economic development and might lead to economic decline instead. Another issue is the need for large storage units due to the characteristics of today's system, e.g. off-hour deliveries. This will increase the final costs of products and will reduce the land-use efficiency where a proportion of land has to be allocated to storage units.

9 Analysis

The result of this study is the combination of the result of phase 1 and the data collected in phase 2. Sustainable development is a broad concept and the definition might be vague when it comes to specific projects. In order to avoid this ambiguity, a set of operational and comprehensive criteria could be of great help. In a sustainable urban freight systems where sustainability is deeply incorporated, none of these criteria should be violated. The purpose of these criteria is to evaluate the relative sustainability of

potential scenarios and to ease the process of decision-making. An important challenge that was identified during interviews was the lack of tools to evaluate a certain scenario or solution in the context of sustainability. The main purpose of sustainability criteria is to address that issue: To provide a framework that helps to ask relevant question about a project and to judge relative sustainability of a certain solution or scenario.

9.1 Sustainability criteria

The upstream causes have to be either eliminated or improved in a way that they reduce the negative impacts or increase the positive impacts of the system. By negating the identified causes the following criteria would be evolved:

1. Minimum interaction between vehicles and residents while providing adequate services.
2. High quality of services that are equitably available, accessible, and affordable by all at all levels regardless of the gender, background, ethnicity, and economic status.
3. Urban freight system should be durable, flexible and adoptable to changes at a reasonable cost.
4. Decision making should be Participatory and inclusive at all level while considering the urban freight system as whole.
5. Emissions should be lowered to the level that do not violate the closed loops in the nature.
6. Material and resource usage should be efficient and effective and in the limit of earth tolerance capacity.
7. Provide homogenous and inter connected districts

9.2 Clarification of criteria

When it comes to take action towards the sustainable future, one should be realistic about the today's situation. New systems need to be cost efficient in a way that the granted revenue are high enough to cover the costs of maintenance and operation.

Freedom of choices can be provided by affordable and high quality services. As a result users have the freedom to choose a service according to their preferences. Basic human needs[4] including food, water, and health are the crucial requirements of human well-being which should be considered in urban freight system by providing available, accessible, affordable and adequate services. This can provide a system which serves the users in an equitable way where everyone regardless of the gender, age, background, impairments, ethnicity and economic class are being served with high quality services. This needs to be mentioned that well-being will be fulfilled by improving the quality of desired services and not only by increasing the flow of material and use of natural resources.

Willingness to pay is strongly connected to social aspects and affordable services, but it also takes into account people's awareness about environmental impacts of human activities. It arises the question: Do people want to pay for a product or are they paying because they do not have any other alternatives? It emphasizes the need for inclusion, participation and flow of information in a sustainable future. It can be said that a system should take into consideration both affordability and willingness to pay.

[4] Health, security, future security, food, water, sanitation, recreation, shelter, and energy.

Durability covers the lifetime of the products, services or basically materials which suggest a longer lifetime to decrease the environmental impacts and to increase the cost benefits, keeping in mind a high quality of service during the lift time. Flexibility suggests the ability to make future changes at a reasonable costs. This is aligned with the fact that how the future would look like is uncertain, so a system should be designed in such a way to provide an open platform for all the sustainable alternatives without limiting the needs of future generation.

Economic system should not be rigidly resilient. This does not suggest a feeble economic system, nevertheless, it suggests a stable and strong economic system which has the ability to adopt to the shocks and to use the disturbances to move to a better state instead of having resistance and springing back to its former state. This suggest an economic system which takes the advantages of shocks to move to a higher state instead of resisting or collapsing.

The urban freight system has usually been neglected by city planners and has not been included in city planning, hence the decision-making process for this system has been done independently by business sector and city planners. This has resulted to fragmented solutions and consequently unsustainable urban units. Business owners readily choose a service according to its economic revenue. This results to a series of unsustainable freight services. In order to address this issue and ease the path for radical changes, urban freight systems should be incorporated in cities' strategic planning from the very beginning. A participatory decision making will increase the level of acceptance of the services and a better revenue model for the business sector. Increase in level of acceptance is also influenced by people's knowledge about urban freight service and associated negative and positive impacts. This will increase the level of awareness and feeling the responsibility of societal activities. Awareness is a simple but game-changing concept. If individuals are aware of the consequences and unsustainable and sustainable impacts of human activities, a major change in the behavior will be initiated. This will lead to a society where the actors will behave consciously by choosing the sustainable alternatives, not only for the benefits of the next generation but also for themselves. Integrated urban freight system with city planning together with participatory and inclusive decision-making will reduce the cost of urban freight system for society. This results to cheaper services that are more available, accessible and affordable by everyone. This will influence the ''willingness to pay'' by providing enough services with reasonable price that people can choose from while being aware of the consequences.

Flow of material and energy into the system and flow of residual from the system should be minimized in a way that they do not violate the closed loops of nature. Earth is a self-sustained unit and it can tolerate the natural circles, e.g. natural water cycle. Human activities have been influencing these natural cycles by over-extracting and over-consumption and material and consequently massive waste production. This directly is influenced by the efficiency of the system.

In order to convey the society towards a future where inequality is eliminated and growth is replaced by development, above criteria have to be taken into consideration. These criteria are originated from on single concept, sustainable development and its three pillars, which explains the interconnectedness of these criteria. This means urban freight system should be designed in a way that meets all the requirements of all the criteria simultaneously.

10 Discussion

Inclusion, providing equitable opportunities, flexibility, ability to adopt and resource efficiency are among the most important requirements that have been covered. Due to the urbanization, cities are turning into a multi-cultural units where people from different backgrounds, ethnicities and religions are coming together to live in an urban unit. It emphasizes the need for inclusion where all the citizens regardless of their backgrounds are being equally included in the process of decision-making in different levels; and opportunities, services and products are not only available but also accessible. Economic growth have to be decoupled from natural resources. This not only means the energy and resource efficiency of the products should be significantly improved but also excessive use of material due to the existing mindsets, i.e. capitalism, should be decreased. The true value of natural capitals including natural resources, social and cultural systems, and living systems need to be understood.

Economy is the major driving force in the system with a strong steering mechanism for urban freight system. This influences the legislation and the policy sector. In a sustainable future economy should be driven by the other criteria and not the other way around.

One important issue mentioned by the interviewees is the slow process of change. It is aligned with the fact that socio-technical transition might take up to decades. This path can be eased by understanding the existing system and the desired system. Being aware of the challenges and the needs will provide an environment aligned with the desired trajectory. A rigid system is another major obstacle toward the desired future which refuses radical changes. In order to provide a platform where any sustainable alternative can be a part of, a flexible platform is of importance. This will significantly reduce the cost of changes and improve the efficient use of land, material, and resources. Having a flexible platform will eliminate the probability of lock-in formation, hence a system which is ready to accept sustainable changes will be available.

Incorporating the concept of sustainable development in societal activities has been a major challenge. This could also be seen in interviews where a clear outcome, positive impacts, of the defined objectives was missing. In some cases whether or not a scenario or a solution will help to have a more sustainable society was not of concern. This shows the miss-interpretation of sustainable development and lack of dialogue and collaboration between different actors to share the perspectives and to reach to a certain level of understanding. Considering these issues will significantly improve the process of decision-making.

Although all the pillars of sustainability were not in focus of every individuals but as a group all the pillars have been considered. But it is of importance to have a common understanding of sustainable development as a concept and believe in the fact that sustainability can be achieved only by meeting the requirements of all the pillars simultaneously. This also emphasize the need of dialogues and a shared mental framework.

It is important to mention that these criteria are non-prescriptive and they provide a safe environment for unlimited alternative scenarios which have the abilities to move the world closer to a sustainable state. Although they might seem simplistic but they are quite comprehensive and cover many different aspects. It has been tried to develop these criteria in a way that they are valid in various levels and scales in urban freight system. These criteria will assist to go beyond the current trends and to evaluate different

scenarios only based on the future demands, and to see whether or not they (scenarios) will bring society closer to a desired future. Actors can use these criteria to question their project and to judge the relative sustainability of each solutions or each projects. This can be analogized as light houses in the shore which will help a lost ship to find, adjust and modify its paths regardless the directions of the other lost ships.

Sustainable development is an abstract and vague concept. These sustainability criteria help to make that concept operational and functional. But since these criteria are also based on the future demand, they might seem abstract. This does not reduce the operational feature of the criteria, but this will help to have an open platform for different alternatives which are sustainable. One can say it is still a very abstract concept which the real challenges of today's world are not included. This is a very true argument but this does not reduce the accountability of sustainability criteria; this mainly affects the pace toward the future. When it comes to take actions one should of course think realistic while keeping in mind the sustainability criteria as a guidance. The challenges in today's world, limit only the pace towards the desired future while the criteria show the future demands and the potential path toward future. A major challenge identified in the case study was to go beyond the trends. An important requirements is to isolate the mind-set from the current trends and the current systems in different levels (landscape, regimes, and niches). This will help to go beyond the lock-ins and to imagine the desired future without considering the current world. A failure in this step will lead to a feeble foundation for the project, i.e. a foundation based mainly on the current socio-technical system. Einstein said: it is almost impossible to solve the problems with the same mind-set that has created the problem. It emphasizes the importance of going beyond and imagining the future regardless the current trends. But it has to be said that to be on that level (to ignore the current systems) is a major challenges since all the actors, from the users to providers, are the results and producers of the current system. Even today's science is locked-in in the current systems to some extent. So imagining a desired future regardless of the existing systems is a major challenge and needs to be done in a more extensive way. Having a loose foundation will led to an unclear framework and as a consequence a lot of ambiguities for different actors throughout the whole project.

These criteria are based on future demands and the concept of sustainable development. It has been tried to cover all the four principles of sustainability by the combination of all the defined criteria. These criteria help to ask relevant questions within project to see whether or not this project move the society towards the desired future.

Municipalities have usually had a reactive approach when it comes to urban freight system. Cities have waited for a problem to occur and then tried to solve it by limiting measures. A proactive approach is necessary from municipalities not only to integrate urban freight system in their decision-making processes but to also incorporate sustainability into this system.

30 years after Brundtland report still big failures can be seen in today's development. The concept of sustainable development has failed to make a radical change in people's behavior (Martizen-Alier, et al., 2010). Still capitalism is a dominant mindset that supports excessive consumerism and fossil fuel addiction. Sustainable de-growth is a concept that can address the issues mentioned above. This concept suggests a society based on quality rather than quantity where competition is replaced by cooperation. It needs to be mentioned that de-growth is not a negative form of growth and it means ''stepping forward while going backward''. Economic development – as an accepted concept - is strongly connected to use

of resources which is inherited from the concept of capitalism while sustainable de-growth goes beyond this trends and argue that the growth (as a concept that is accepted now) is part of the problem not a path towards development. It argues that sustainable development has turned to sustainable growth which has caused the severe impacts in today's society.

Although a process of validation has been carried out for this study but the final results, sustainability criteria, have not been validated by the actors. This is an important issue that needs to be addressed later on. Validating the criteria will help to have a more comprehensive and applicable criteria and to improve the feeling of ownership in the actors' perspective. This will particularly help to have more involvement from the actors hence a set of co-created criteria where different perspectives are included. This has been undertaken to some extent by interviewing actors from all the three sides of the triple helix but the validation process will significantly improve the quality of results. This was of course out of the scope of this thesis by considering the timing issues.

11 Conclusion

The major challenge identified in the case study was to evaluate relative sustainability of different scenarios. Sustainability criteria will help the evaluation process and as a consequence the concept of sustainable development will be incorporated in decision-making and engineering practices. These criteria are operational, non-prescriptive and comprehensive by considering the future generation needs and unsustainability impacts of today's activities. One of course needs to be realistic when it comes to take action to implement sustainability in the real world. These criteria provide a flexible platform where any sustainable alternative can be a part of. They will help to adjust the path toward the future by asking relevant questions about the projects, to see whether or not a certain project is contributing to sustainable development.

Urban freight as a system has a vital role in any society and it needs to be integrated in city planning. This system is an inevitable component of the society and needs to be aligned with the society's trajectory towards the sustainable future. Keeping in mind that incorporating sustainability in decision-making demands radical changes in the system. This means a need for transition in socio-technical systems which takes up to decades. This transition needs a proactive approach particularly from the municipalities.

The world is in a dilemma of development. The purpose of development has always been to increase the quantity rather than to improve the quality. This is an issue that needs to be addressed. The concept of sustainable development promotes a society where quality is in focus. The difference between sustainable growth and sustainable development should be clearly defined and understood by individuals. This suggests a new concept of de-growth where competition is replaced by cooperation. Today's societal trends need to be challenged, questioned, and changed if necessary.

The result of this thesis could be the initial step to plan for urban freight system not only for the DenCity project but also for any other projects with the same vision. It needs to be considered that these criteria are limited to the current knowledge. This means changes could be seen over time in the criteria while the principles of sustainability are constant throughout the time.

The criteria identified in this study need to be validated and processed in further studies. This can be done via several dialogues where representatives from different sectors are involved. It needs to be considered that the four sustainability principles have to be also clarified for the stakeholders in order to have a better

understanding of the purpose of these criteria. Validating the criteria will help to improve the level of stakeholders' engagement and the reliability of these criteria, hence increase in the level of ownership over the criteria (among stakeholders). This will ease the process of implementing the criteria into the engineering practices and decision-making processes.

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Appendix I

Johan Larsson, October 2015

ON THE UN POST-15 SUSTAINABLE DEVELOPMENT GOALS

In New York during the end of September this year more than 150 world leaders adopted the sustainable development goals (SDGs). The 17 goals replace the millennium goals, are global in their
character, cover all aspects of sustainability and are central for the UN post-2015 development agenda. They are expected to be used by all UN member states outlining their development agendas
for the next 15 years to come.

The SDGs were first discussed during the Rio +20 Summit in 2012 and following this discussion an
open working group (OWG) with member state representatives was established to prepare a proposal.

The OWG conducted the yet biggest global public consultation combined with inputs from UN-led consultations persons and a number of related sessions to deliver the final report in 2014.

Now that the post-15 development agenda is agreed upon the SDGs will be applied from 2016. The
goals are to be delivered as a package the implementation is to be ensured by a Global Partnership;
bringing together and engaging governments, the private sector, civil society, the United Nations and
other actors mobilizing all available resources.

Goal 1. End poverty in all its forms everywhere
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3. Ensure healthy lives and promote well-being for all at all ages
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5. Achieve gender equality and empower all women and girls
Goal 6. Ensure availability and sustainable management of water and sanitation for all
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and
decent work for all
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10. Reduce inequality within and among countries
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12. Ensure sustainable consumption and production patterns
Goal 13. Take urgent action to combat climate change and its impacts
Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests,
combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for
all and build effective, accountable and inclusive institutions at all levels
Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

For a list of indicators see https://sustainabledevelopment.un.org/topics

Appendix II

Sustainable Development Goals

Goal 1. End poverty in all its forms everywhere

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Goal 3. Ensure healthy lives and promote well-being for all at all ages

Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Goal 5. Achieve gender equality and empower all women and girls

Goal 6. Ensure availability and sustainable management of water and sanitation for all

Goal 7 Ensure access to affordable, reliable, sustainable and modern energy for all

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Goal 10. Reduce inequality within and among countries

Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable

Goal 12. Ensure sustainable consumption and production patterns

Goal 13. Take urgent action to combat climate change and its impacts[*]

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

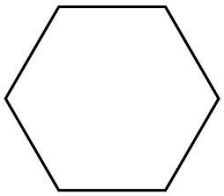
[*] Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

Appendix III

Interviewee:

- Introduce yourself and the company/organization that you are representing

- Freight activity:
  - What kind of freight activity is your company/organization involved with?
  - What are the challenges that you are faced to (in regard to your freight activity)?
- Innovation (in regard to the DenCity project):
  - What is your vision?
  - What are your objectives? And which problem are you aiming to solve?
  - What innovation(s) will you test in the DenCity project?
  - What are the challenges towards this innovation and what are the benefits?
- Drivers and barriers (In regard to the existing urban freight system and your innovation):
  - What are the barriers and what are the drivers towards your goal?
    - Infrastructure
    - Market
    - Policy
    - Culture
    - Technology
    - Users
    - etc



Appendix IV

Interviewee	Role	Type of business
A	Project leader	Work-package 1
B	Project leader	Work-package 2
C	Project leader	Work-package 3
D	Project leader	Work-package 4
Transportation authority	Project manager	Logistic consult
PostNord	Product manager	Logistic provider
Coop Logistics	Project manager	Logistic provider
Svenskdigital handel	Project manager	E-commerce provider
Baghtich	Project manager	Logistic Provider
Volvo cars	Project manager	Passenger transportation provider
Schenker	Project manager	Logistic Consult

Appendix V

	Work packages									
	AP1	AP2	AP3	AP4	COOP	PostNord	Schenker	Svensk digital handel	Baghitch	Volvo
Innovation	How should delivery with electric look like? Although it is expensive, but you will save some money and the end if the network is well-designed.	1. Electric boats, 2.Waterway transport for goods and waste 3. transporting goods to households with waterways	1. Organizational innovation: how can you get these actors to collaborate and to find benefits in a business ecosystem. 2. New delivery service (you don't need a car) 3. Delivery service will be packaged as a service. 4. having the control of last mile delivery	A new setup to for goods and waste where residents do not need a car	1. Hybrid vehicles to deliver goods	Providing new alternatives in addition to the established ones in today's urban freight system. Cooperation between different actors (post, DHL< SCHENKER, etc)	1. Electric trucks in commercial routes with real costumers. 2. Geofencing	Make e-commerce easier	To show Baghitch can work in future.	-
Challenges	1. range of electric truck 2. how to design the network, route, charging stations, etc. (a flat city and a hilly city need a different approach) 3. driver couching	1. Many different actors. 2. it has to be planned in advance 3. No one wants to have barge in front of their apartments. 4. Logistics has to come early into the project. 5. How to evaluate to see if this is a good solution or not 6. Many different type of goods and waste 7. so many vehicle alternatives 8. to choose the proper combination is a challenge	1. Access to mass service immediately 2. To decide the capacity of the system 3. time tables, number of vehicles, etc 4.adaptibility in the infrastructure 5. high level of service (distance to nodes, preferences) 6. to challenge the norms (car in this case) 7. provide the service in the range of ppl willingness to pay and possibility to pay	1. Variety of goods, waste, and customer 2. a seamless network where all the players are there	1. low range 2. how fast can it be charged 3. where are the charging spots	Consumers are not aware of any other solutions that are being offered. A business model to have an open platform for all the actors.	1. infrastructure (charging stations) 2. homogenous network not only a segregated system for Frihamnen	1. Last mile delivery 2. Delivery at the weekend 3. Exact delivery time	1. Regulations (taxation) 2. Competing with established actors.	-

	Work packages									
	AP1	AP2	AP3	AP4	COOP logistics	Trafikkontoret	PostNord	Schenker	Svensk digital handel	Baghitch
Freight activity	Supplier of the vehicle/ transport solution provider	Shipping on water way		Last mile delivery (delivery services)	Intermodal activities in Coop train	Infrastructure provider,	Parcel, letters. Complete solution in terms of freight	Logistic consult	Drive e-commerce	Provide a platform for transportation
Objectives	Efficient hub to hub shuttle, electric vehicles with sufficient range	1. To demonstrate if it is feasible to transport goods on waterways. 2. combing goods and waste 3. to evaluate from technical, economic and environmental perspective	Challenges: 1.costumer acceptance 2. willingness to pay 3. Revenue model. Payment model 4. business model 5. how different actors can see a business potential in it Objectives: how to design a MAAS package that can get customer acceptance and actually solve user problems to live without a car 2. build the area for everyone	Challenges: 1. Offering very high level of service while having an efficient logistic. 2. different type of demands 3. the current world that we live in 4. Innovations are automatically more expensive 4. customer acceptance Objectives: 1. a new delivery service for costumers (2 or 3 solutions) Higher level of service with less stressful solutions for dense city and dense city's environment via a digital platform	Challenges: 1. road transport is much cheaper 2. foreign drivers with lower wage 3. loaded in both direction 4. Deliver at night times.	1.To minimize the interaction between vehicles and pedestrians 2. To create a pleasant, lively, and safe city environment Problems: Congestion Air quality Noise Interaction between heavy vehicles and pedestrian	Challenges: To add value to the business. Cost efficient production. Last mile is most expensive delivery. Objectives: More convenient way of delivering for consumer. Consolidated delivery to reduce the number of scheduled routes.	Emission and noise	1. To grow e-commerce business in Sweden. 2. Change the mind-set of freight companies. 3. Challenges: 1. International sites are taking over 2. Take such a long time to change processes.	1. Increase capacity of vehicles on root 2. utilize empty space in vehicles 3. Eliminate the geographical limitations. 4. Cost efficient and environmental friendly. 5. Challenges: 1. Mind-set of users. 2. It is a niche and still trying to develop.
Vision	Zero emission and zero noise in Frihamnen	To demonstrate two different kind of solutions: large scale with barge, and small scale with small boats	Alternative solution for city without a car. To challenge "car is a norm'' To live in DenCity without owning a car and to get access to your needs of transportation.	High level of service with less stress on the environment via digital and physical platform	1. Noise and low emission	Quite dense built district, livable, available, low frequent motorized traffic. One does not need a car to meet the basic needs in Frihamnen	None. Because there are no limitations	A transport which create less emission and less noise	New ways to deliver goods (e-commerce)	

			Radical reduced resource consumption. 90% of transports should be made by other modes of transportation rather than car.							
Framework	A framework for the whole project is needed not for each work-packages.	That's where you come in!	Sönke	1. costumer driven 2. focus groups Same framework as the DenCity project. Zero emission for example		-				

Socio-technical system elements	AP1	AP2	AP3	Ap4	COOP	Trafikkontoret	PostNord	Schenker	Svensk digital handel	Baghitch	Volvo
Infrastructure	1. many cities are willing to invest a lot in infrastructure 2. existence of clean energy system	1. driver, vacant space in the river 2. barrier, proper infrastructure for loading the goods 3. the whole structure is adopted to the road transport	Barrier: to have a flexible infrastructure 2. To include in the city planning 3. Rigid transportation network (trams) Driver: digital infrastructure is fine.	Driver! Even if we want to have radical change but the infrastructural issues are solvable.	To locate charging station is big challenge	Not a major challenge	Technology as a digital infrastructure is a driver.	1. Charging stations 2. technology costs a lot	Driver	1. Is available and not utilized yet.	
Policy	1. it is not tough enough 2. Slow to change 3. Cannot be in favor of one industry 4. lot of interest to invest in environmental friendly systems 5. EU commission is pushing 6. a more flexible policy is needed 7. No incentives for green vehicles 8. more focus on passenger level rather than logistics	Is partly supportive.	1.Environmental zones are needed 2. Incentives are needed.	Lack of policy from Gbg for emission, noise, to support new services	It's not in favor of green systems	1. to develop new policies in regards to newly built area is an extensive process 2. Since we don't know what do we want to achieve in the end, setting policies is	Now it's a barrier, but it has the potential to be a strong driver.	Not supportive.	Takes time to adjust the regulations	Regulations are not adjusted to sharing economy.	

						rather challenging.					
Knowledge	1. public knowledge is low about trucks and logistics	Driver	1. environmental benefits are not clear	Hinder Where goods are and how you can access that		To determine the flows, volumes, demands is a big challenge					
Culture	Positive trend towards electricity	People might not like a quay close to their expensive apartment	understanding	50/50	Does not support environmental friendly systems when it comes to act.	Not a barrier in newly built district	Driver/barrier People have already some expectations from the delivery services.		It's supportive.		
Market	Willing to invest	1. It is adopted to the road transport 2. Economically is not super beneficial.	1. How to deal with competing markets, uber for example.	Definitely a hinder 1. todays' solutions are cheaper and will be	1. Low market share 2. the cheaper is always the best for ppl	We don't know how the market would be	A tough challenge. Business model	Business model is a challenge	Collaboration between freight companies is a strong barrier.	Competing with established actors.	
Users	Bad work environment for the drivers (Comparing to electric vehicles)		1. they go for cheapest	50-50		Not a barrier in newly built district	Want a homogenous system	The cheaper the better	Not a barrier	Supportive but still this service should be more visible	

Appendix VI

Observations from the workshops:

Backcasting as a methodology chosen for the DenCity project is formed by 4 substantial steps which sequentially lead to the desired result. In order to have an effective use of Backcasting, each of these steps and their requirements need to be understood.

Since the steps of Backcasting were not thoroughly introduced and explained in the beginning, the actors did not have a clear understanding of this approach. Because of that, the tendency to work on the solutions from the beginning was sometimes the dominant process. This made it difficult to see if it is a forecasting approach or a Backcasting one. This issue emphasized the need for the work-package 5 which has a steering role by developing the framework and the guidance to firstly ease the collaboration between the other work-packages and secondly co-create (since the intention is to include all the voices in the framework and make all the actors to feel the ownership of this framework, the word co-create is used instead of create) the framework for the project.