MASTER'S THESIS · STRATEGIC PRODUCT DESIGN · TECHNICAL UNIVERSITY DELFT

SUSTAINABLE BUSINESS MODEL INNOVATION FOR PASSENGER TRANSPORT OVER WATER: A STRATEGIC DESIGN TOOL

Designing a sustainable business model innovation strategy for a hybrid and/or electric waterbus fleet

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February 2025 - July 2025

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Dear reader,

With this thesis I conclude my student time in Delft. Over the past six years in Delft, I learned to form opinions, to connect ideas, to recognize my own strengths and weaknesses and, I learned to learn. I found my interest in strategy and sustainability, and the value of interaction, creativity and diversity. I deepened my knowledge in areas that I would not have expected to end up in as an 18-year-old industrial design engineering student who had just arrived in a new city, with very limited experience. During my internship at STBY in Amsterdam, a design research agency, I developed workshop hosting skills, and learned the value of collaborative, social design. I realized there that everybody can be creative if given the opportunity. The research approach and methodology that I learned from collaboration with Dr. Marina Bos-de Vos for an academic research paper gave me the structure and confidence to do that on my own for this graduation project. I would like to thank her for sharing her knowledge and giving me that opportunity.

By studying at the Delft University of Technology, where it is quite normal to show up every day and study from 9-5, I slowly but surely got rid of my procrastination tendencies and learned how to structure and plan. The many client projects that we did as students showed the importance of project and stakeholder management, and communication. This thesis is a cultivation of all of it. I got very lucky with my supervisors, Dr. Steven Flipse and Dr. Shahrokh Nikou from the Faculty of Industrial Design Engineering, and Thijs Verwoerd, my company mentor at Damen Shipyards. They were supportive and open, and available for weekly meetings and feedback whenever necessary. I would like to thank them for guiding me through the project by giving me constructive feedback on my work, but also mentally supporting me to believe in myself and my design and research abilities.

Lastly, I would like to thank my friends and family for their support with various user tests, design iterations, proofreads, discussions and patience in hearing me talk about the same thing for five months. They showed me that it is always better to share and communicate rather than get in my own head too much. A special thanks goes out to my brother, who helped me through the rough part in the middle, where the design panic shortly had a grip on me. I think many designers will know the feeling. Another thanks goes out to all the people at Damen. They made me feel welcome from the start and were always open to help, and to teach me about the maritime industry and financial solutions.

In conclusion, I am proud to publish this thesis as a final product of my student life.

I hope you enjoy it.

Lili Sanders

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The ferry industry encounters growing initiatives in creating environmentally friendly and efficient travel solutions. As urban areas are expanding, efficiently employing waterways is getting more attractive for government bodies wanting to tackle issues such as overcrowded city-living space, traffic congestion and connectivity to rural areas for forensics. In firms as well, it is being recognized that environmental and social impact should be considered to create durable and responsible business models. Connecting business models to industry innovation and sustainability creates a high level of complexity and strategic potential for future-proof business development. Therefore, the aim of this thesis was to investigate and drive the connection between water transit systems and sustainable business model innovation and leverage it for highly innovative sustainable initiatives.

To structure the project from problem to solution, the Double Diamond design method was used. The first two phases, Discover and Define, covered an empirical case study at Damen Shipyards. The second two phases, Develop and Deliver, included the subsequent design phase. The case study was in the context of the Waterbus fleet that at the time of this thesis, was operational in the Rotterdam-Drechtsteden area for public transportation. The Waterbus was built and owned by Damen Shipyards and operated by Aqualiner. Within the water transit system, the operation faced business model challenges. Therefore, the existing water transit business model was investigated and a tool for driving sustainable innovation of it was developed: the Pyramid Toolkit. The generalized toolkit contains a pyramid-shaped model, innovation cards, and a co-creation method for any organization wanting to create an innovation strategy for deploying or developing a water transit system. The Pyramid Toolkit was applied at Damen Shipyards, which yielded the Waterbus Strategy, containing recommendations to overcome the current challenges.

The thesis makes the following theoretical contributions. Firstly, it explains the complexity of the water transit system client structure and how it influences (financial) responsibility within the stakeholder network. Secondly, the profit formula of water transit systems was investigated. Income that is dependent on route design, ship passenger capacity, fare structure and subsidies must together cover total costs, which include maintenance and operating costs, capital investments in the ships, and potential penalties from the governmental body. Thirdly, water transit systems are inherently sustainable. However, regulations and subsidies are essential to reduce cost barriers. Lastly, the shipyard can take a leading role in the maritime sustainability transition, as it has the advantage of technological knowledge and capabilities for building and financing hybrid and electric vessels.

Practically, this thesis contributes to the ferry industry with a tool for systemic, holistic overview of water transit business models. It provides structure and ability to analyze current practice and strategy. The Pyramid Toolkit highlights sustainability as a fundamental part of water transit systems – how it is already present, how it can be introduced, what difficulties arise, and how it can be improved or leveraged for stakeholders. Furthermore, the Pyramid Toolkit, as a hierarchical, methodological model, can potentially be crossed over to other industries with some adaptations. Lastly, the Double Diamond process, design strategies, gigamapping as a systemic design approach, visualizations, participatory design methodology and design roadmapping as presented in this thesis are contributions to strategic product design theory and practice.

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LIST OF ABBREVIATIONS

BM	Business Model
BMI	Business Model Innovation
DFS	Damen Financial Services
FOD	Ferry-Oriented Development
POW	Personenvervoer Over Water (passenger transport over water)
SBM	Sustainable Business Model
SBMI	Sustainable Business Model Innovation
TOD	Transit-Oriented Development
WTS	Water Transit System

CHAPTER I

INTRODUCTION

Chapter Contents

1.1 PROJECT CONTEXT AND FOCUS
1.1.1 Problem introduction
1.1.2 Project objective

1.2 PROJECT APPROACH
1.2.1 Personal learning objectives
1.2.2 Project structure

1

As urban areas are expanding, efficiently employing waterways is getting more attractive for government bodies wanting to tackle issues such as overcrowded city-living space, traffic congestion and connectivity to rural areas for forensics. Furthermore, it offers potential to connect touristic attractions and social facilities (Provincie Zuid-Holland, 2018). Internationally, there is growing interest in and development of (sustainable) water transit systems. For example, the shipbuilder Damen Shipyards produced the first fully electric ferry fleet that has successfully been operating a demanding water transit system in Copenhagen as 'harbour busses' since 2018 (Enchandia, 2023). London, Stavanger (Norway), Gothenburg (Sweden), Lisbon, Geneve, and Antwerp are other examples of locations with ferry systems, but also in the Middle East, both inland and coastal waterways are either of interest or already in service for maritime passenger transport (The Official Portal of the UAE Government, 2024).

The maritime sector has a poor reputation regarding sustainability because of its large generation of greenhouse gases and fuel consumption, but in various respects it is performing quite well. It offers socio-economic, employment, and food supply potential. Water transportation – next to rail – is additionally found to be the most economically and environmentally efficient way to travel or transport goods (Mitra et al., 2019). In the development of the maritime industry in general and specifically in moving passenger transportation to waterways, sustainability plays a critical role. Not only in the design of the vessels, but also in system design. Questions concerning product longevity of one-off vessels designed for a specific transportation service, production and operational emissions, charging implications on route design and social impact of the services arise. In Geneve, vessels are supplied with solar panels, and initiatives such as Artemis Technologies are working on "The world's first commercially viable, zero emission propulsion solution for high-speed maritime transport" (Artemis Technologies, 2025). Here the focus on combining zero emission with commercial viability is highlighted, forming a link to the research domain of this study. The discussion on how solutions can be implemented to be both sustainable and commercially viable is continuous and complex. Topics such as sufficiency, efficiency, and the circular economy are gaining traction and are investigated by companies to find the most economically attractive way forward without further damaging the planet (Bocken et al., 2022). Political influence is vital in stimulating the circular economy, and recent global developments have led to a reversal of climate regulations. However, many companies and investors recognize the benefits of sustainable solutions, and influential asset managers like PME still acknowledge climate risk as investment risk—regardless of policy (Smal & Beunderman, 2025).

To shape and communicate their strategy for commercial viability, companies generally use a business model as an exploratory, analytical, and reflective tool (Shafer et al., 2005). Traditionally, the components and their architecture as defined in the business model describe the strategic activities and interactions needed to create economic value, often in terms of company growth. However, it is now being recognized that environmental and social value should be equally considered to create a durable and responsible business model – with more potential than those only focusing on economic value (Joyce & Paquin, 2016). Consequently, business models become more complex and connecting them to a certain context or industry is a challenge as well as an opportunity. Current literature has not addressed how a business model and its potential sustainable innovation applies to passenger transportation over water (i.e. water transit systems). This thesis focuses on that gap.

I.I PROJECT CONTEXT AND FOCUS

This thesis is conducted in the context of Dutch shipbuilder Damen Shipyards. Damen is a frontrunner in the maritime industry with its standardization model and strategic focus on customer centric design, operational excellence, digitalization, and sustainability. Damen operates across 55 companies and 35 shipyards worldwide, with an annual turnover of over €3 billion in 2023 (Damen Shipyards, 2025). For manufacturing, services such as chartering and repair, financing and more, Damen Group is divided into various divisions. The divisions each have their own responsibilities, but they are interrelated and work together for Damen "to become the most sustainable maritime solution provider in the world".

In The Netherlands, a Waterbus fleet containing both hybrid (electric and fossil-fuel powered propulsion) and fully electric vessels, is under management of division Damen Financial Services (DFS) in joint venture with Aqualiner. Waterbusses can be described as a type of ferry, which has therefore been designed and built by the ferry branch of Damen Workboats. The fleet is currently partly operational for public transportation routes between Rotterdam and the Drechtsteden in the Province of Zuid-Holland, the Personenvervoer over Water (POW) concession. The main stakeholders are DFS, Damen Workboats, Waterbus end-users (including passengers, skippers, and deckhands), the Province of Zuid-Holland, Aqualiner and public transportation providers. DFS needs a viable use-case and business model innovation for their waterbus fleet to keep the vessels in service. Damen is aiming to become the most sustainable maritime solution provider in the world; therefore, the business model innovation should also be sustainable.

I.I.I PROBLEM INTRODUCTION

The water transit system in the Rotterdam-Drechtsteden concession faces financial, technical, logistical and reputational challenges for both the Damen Group and Damen Financial Services who partly own, finance and operate the fleet.

I.I.2 PROJECT OBJECTIVE

The aim of the first part of this thesis, the empirical study at Damen Group in Gorinchem, is to investigate and map the existing business model of a water transit system to form a basis to design a sustainable business model innovation for the optimal deployment and development of a hybrid and/or electric waterbus fleet across diverse maritime regions. This will be investigated through the following research question:

How can a hybrid or electric waterbus fleet be optimally deployed through a sustainable business model innovation?

The second part of the thesis focuses on the process and development of a strategic design solution to drive sustainable business model innovation for water transit systems. This solution is twofold. The first part is a toolkit that is applicable to any organization wanting to deploy and develop water transit systems: the Pyramid Toolkit. The Pyramid Toolkit contains a pyramid-shaped model, innovation cards, and a co-creation methodology. Figure 1 shows the Pyramid. On its lower level, the Pyramid contains water transit elements, innovation triggers, and challenges for water transit systems, which are explained on innovation cards. The method to apply the Pyramid Toolkit, as explained

in a user manual, is through a co-creation session using Appreciative Inquiry ideation. The Pyramid Toolkit can be found in Chapter 7. The second part of the solution is the application of the Pyramid Toolkit at Damen Shipyards through a co-creation session, which cultivated a recommended strategy for Damen to optimally deploy the Waterbus fleet. Both design outcomes have been validated: the Pyramid Toolkit externally at Aqualiner, the Waterbus Operator; and the Waterbus Strategy internally at Damen Financial Services. The thesis concludes with scientific and practical contributions and a personal reflection on the project. Figure 2 shows the report structure in three parts: Part 1: Research, Part 2: Model, and Part 3: Design.

PERSONAL LEARNING OBJECTIVES

Deductive qualitative research

In a previous academic study I conducted a qualitative inductive multiple case-study on joint value creation in small-scale experimental projects. For that article, I learned how to do a thematic analysis inductively, by coding and reviewing as I went and then grouping codes in emergent themes. In this project, my aim was to get acquainted with another research approach: efficiently using a theoretical framework to guide a deductive analysis of the emprical data within the short time-span of the thesis.

Sustainable business model design

I have found that in the field of sustainability, for example in areas such as the energy transition, sufficiency and the circular economy, there are many opportunities and ideas, but still much uncaptured potential. It raises this type of question: How can a sustainable solution be structured in such a way that it is viable and profitable for the business that deploys it? Both business and sustainability are topics I am very interested in, making sustainable business model innovation a fitting focus. I believe that to ensure implementation and applicability of sustainable initiatives and innovation for various industries, their economic viability is critical. Knowing the specifics and strategies to approach this is not only relevant now, but it is rapidly becoming indispensable for future-proof business development.

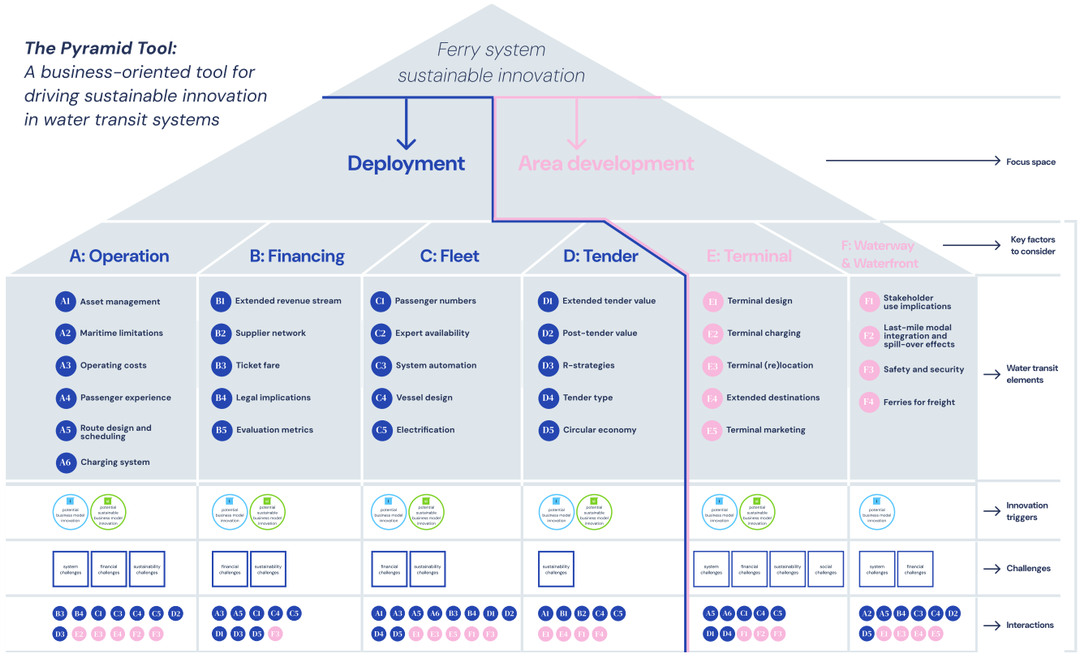

Figure 1: The Pyramid Tool

I.2 PROJECT APPROACH

PERSONAL LEARNING OBJECTIVES

Visualization

I believe data visualization is essential to effectively communicate acquired knowledge. Although graphic design is not my natural strength, I think there was a lot of potential for growing my visualization skills during this project. The design outcome is a highly complex business model innovation including a strategic roadmap for implementation. To convey the theories and ideas in a structured way, and ensure their accessibility for multidisciplinary stakeholders, requires high-quality visualization. Also, beyond this project, this is a valuable skill to have.

Connection to industry

There are endless applications and contexts in the field of industrial design, ranging from social to digital, and interactive to integrated product design. I chose to do my graduation project at Damen Shipyards, because I wanted to gain more industry experience before graduation. The tangibility and real-life application of strategic design for industrial products makes for a complex environment with lots of potential. In the maritime sector, and many similar industries, there is room for sustainability improvement. I think a strategic design engineer can bridge the gap between heavy industry and social and sustainable developments that are necessary to create long-term viable solutions (both in terms of financial viability and the prevention of resource depletion).

To answer the research question, the case was approached through a literature review of water transit systems and sustainable business model innovation, and a consequential empirical case study of four themes in the context of the project:

1. Water transit system design
2. Business model components
3. Sustainability
4. Innovation

I.2.2 PROJECT STRUCTURE

To structure the project from challenge to outcome, the Double Diamond design method is used. The first two phases, Discover and Define, are part of the empirical case study at Damen Shipyards. The second two phases, Develop and Deliver, are executed during the subsequent design phase. Figure 3 shows an overview of the activities and phases of the project according to the Double Diamond.

REPORT STRUCTURE

CHAPTER I: INTRODUCTION

PART I: RESEARCH
- CHAPTER 2: LITERATURE REVIEW
- CHAPTER 3: THEORETICAL FRAMEWORK
- CHAPTER 4: EMPIRICAL CONTEXT
- CHAPTER 5: METHODOLOGY
- CHAPTER 6: RESULTS

PART 2: MODEL
- CHAPTER 7: THE PYRAMID TOOLKIT
- CHAPTER 8: WATERBUS STRATEGY
- CHAPTER 9: VALIDATION

PART 3: DESIGN
- CHAPTER 10: DESIGN STRATEGY
- CHAPTER 11: DESIGN PROCESS
- CHAPTER 12: CO-CREATION SESSIONS

CHAPTER 13: CONCLUSION

Figure 2: Report structure in three parts

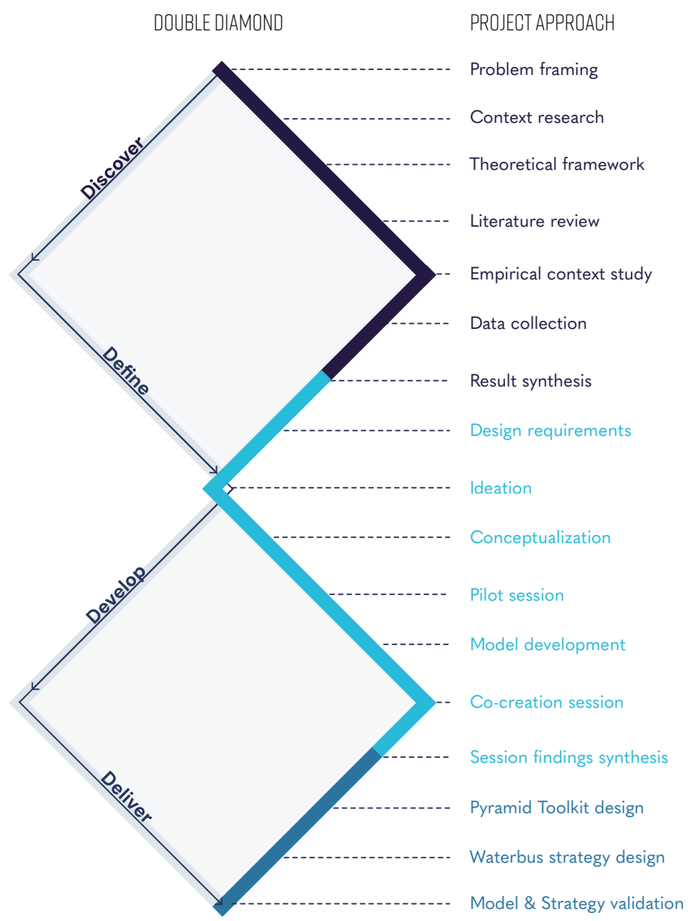

Figure 3: Double diamond project structure

PART 1
RESEARCH

CHAPTER 2

LITERATURE REVIEW

This chapter explores literature related to both the project context and its scientific domain. The project context is defined as water transit systems, and the scientific domain is sustainable business model innovation. These topics are explored to develop a theoretical framework, which is used as the basis for designing a sustainable business model innovation for the hybrid Waterbus fleet at Damen Financial Services.

Chapter Contents

2.1 WATER TRANSIT SYSTEMS
- 2.1.1 Systemic overview of water transit
- 2.1.2 Urban examples

2.2 SUSTAINABLE BUSINESS MODEL INNOVATION
- 2.2.1 Business model
- 2.2.2 Business model innovation
- 2.2.3 Sustainable business model
- 2.2.4 Sustainable business model innovation
- 2.2.5 Conclusion

2

2.1 WATER TRANSIT SYSTEMS

Firstly, this chapter explores the contex of this thesis: ferry transportation in and around urban areas, i.e. Water Transit Systems (WTS). Secondly, the scientific domain Sustainable Business Model Innovation (SBMI) is investigated.

In this section the literature on water transit systems (WTS) is reviewed to form an understanding of its elements and systemic implications, as well as its sustainability objectives, opportunities and challenges. There are several titles in the literature that describe the context of this study including urban waterborne public transport systems, water transit systems or networks, maritime public transportation, maritime transportation, ferry systems, water-based public transport, and public transportation over water. For this study, the title 'water transit systems' was chosen to describe the operation of transporting passengers from A to B over water with a vessel designed for carrying people. This definition was chosen to extend the scope of the current application of waterbuses as public transportation to any possible use case of passenger transportation over water.

Regarding its current application, the literature describes various benefits of (increased) maritime public transportation services, including but not limited to its sustainability potential through reduced emissions from the use of fossil fuel – especially for hybrid and electric vessels – and its ability to relieve road traffic congestion (Pamucar et al., 2022; Ekinci et al., 2018).

2.1.1 SYSTEMIC OVERVIEW OF WATER TRANSIT

Water transit is – much like a business model – a combination and interaction of various components in a network. Its systemic complexity is described in this section and offers both opportunities and challenges. First, system components such as contextual information of fleet and vessel design, landside connectivity, network connectivity and the end-user perspective are discussed. Second, route design, and lastly principles for planning urban ferry systems are investigated.

WATER TRANSIT SYSTEM

A water transit system describes the entire operation of transporting passengers from A to B over water with a vessel designed for carrying people, and the systemic implications of its organization.

System Components

Considerations such as hull type, engine type, maximum speed, capacity and on-board facilities are part of the vessel design of the operating fleet. Other contextual information is maritime limitations – speed limit, maximum tidal range, natural hazards –, and working hours as named by Tanko et al. (2018) to describe a water transit fleet. Furthermore, system and performance factors are route types, distances, terminals (fixed or floating), frequency of service, network integration and fare. Another key consideration is patronage; the number of passengers using the service in comparison with other various modes of public transportation, such as metro or bus. Cheemakurthy et al. (2018) add further influential factors for the deployment of water transit networks. These, in combination with the previously mentioned systems components, are grouped and outlined in Table 1.

Route

Routes are a vital part of the design of a water transit system. According to Cheemakurthy et al. (2018), there are three route types that ferry services can employ in urban public transportation appliances. The first type is referred to as linear ferry systems: the route follows the river within urban limits and connects multiple destinations along the waterfront. Depending on the city and context, the route either stays on one side of the river or follows a zig-zagging pattern across it. This linear system is favored for maximized efficiency of water transit services, and vessel speed is highly competitive. The second route type follows a cross-river pattern, with shorter travel times and often double-ended vessels to reduce terminal time. The speed of the vessels in this case is less relevant since, in many cases, this service will outpace the overland alternative. The interior of the vessels on this route type also generally are designed for this purpose, with open spaces for bicycles and high passenger capacity. The last type connects suburbs and the inner-city area through lengthy trans-river routes. The ferries operating on these routes often carry low passenger volumes and operate mostly during peak hours. These route types are found to be more difficult to create an economically viable service for.

Ferry- and Transit-oriented Development (FOD/TOD)

According to Cheemakurthy et al. (2017) "Transit Orientated Development (TOD) is a land use planning strategy that promotes a model of high density residential and commercial development centered on transit stops along a route to encourage public transport use and decrease urban sprawl. An equivalent system is Ferry Oriented Development (FOD), which encourages the development of waterfront areas located around ferry terminals on a linear ferry route line." Though there is limited research on best practices, the extent of FOD and supportive land use around terminals is regarded as a key consideration of the success of a water transit system (Cheemakurthy et al., 2018; Tanko et al., 2018). Weisbrod & Lawson (2003) found that most water transit passengers more often decide on usage for leisure purposes than for practical transportation needs and are therefore less occupied with efficiency and are more likely to spend time at the surrounding area of the terminals. It would therefore be beneficial to create an attractive destination space and experience.

A water transit system can be strategically embedded in an area's development plan to achieve FOD, effectively a sub-term of TOD used to describe the concept specifically for ferry systems. Even though the system did not initially have a policy for TOD, an analysis of the CityCats in Brisbane, Australia by Sipe & Burke (2011) shows successful FOD in the

Table 1: Water transit system influential factors adapted from Tanko et al. (2018) and Cheemakurthy et al. (2018).

Factors	***Description***
Vessel design	Based on operating route, traffic volume and climate featuring stability, low resistance, accessibility. Other factors include hull material, hull form, internal passenger capacity, other loading capabilities, engine type, maximum speed, on board facilities, capacity
Maritime limitations	Speed limit, maximum tidal range, natural hazards
Fare	Passenger charge
Patronage	Number of passengers using the service in comparison with other modes of public transportation
Route types	Linear ferry system, cross-river pattern, city-extended trans-river routes
Scheduling	Working hours, frequency of services, passenger transfers, timetable
Transit network integration (multimodal transit systems)	Interchange within existing public transportation network, intermodal integration
Terminal design	Time to load and unload passengers, passenger convenience (seating, shelter, accessibility, information), temporary or permanent terminal, fixed or floating docks, local weather conditions
Accessibility, comfort and public perception	Board facilities, seating, access points, positive utility of travel, emphasized perceived safety
Operating costs	Crew size, propulsion technologies, conversion flexibility, economic sustainability, equipment, fuel consumption
Ferry- and transit-oriented development (FOD/TOD)	Urban design in accordance with water transit lines to optimally seize potential of land-use around terminals in terms of commercial and residential development.

city. Tsai et al. (2017) confirm this view with their study of the WTS in Brisbane that finds increased property value around ferry terminals. Based on insights drawn from Sipe & Burke (2011), Tsai et al. (2017) and Tanko & Burke (2015) the following potential strategies for achieving FOD can be adapted:

1. Heavy (television) marketing to ensure that the ferries become part of the city's image
2. Waterfront developer contributions and private investments of and around terminals
3. Competitive frequency, trip duration and reduced transfers of ferry compared to bus transport
4. Integration in the public transport system through uniform fares and fare collection networks
5. Involving land use planners in processes of technical inquiry and engagement with stakeholders and decision-makers
6. Re-imaging the city or area to logically fit a water transit system and make it part of its branding (e.g. Brisbane: River City)
7. Connecting major business centers and public attractions to increase property value and attract further development.

End-User Perspective

In the Waterbus case, the client is a Municipality or governmental organization. However, there is always the end-user's perspective that needs to be taken into account to provide a service that creates relevant and sustainable value. According to Tanko et al. (2019), passenger satisfaction is influenced by frequency of service, cleanliness, punctuality, space, and ride comfort to enable working on board. Comfort was found to have the highest impact on satisfaction. Another finding is that passengers indicate a preference for electric vessels, due to lower noise and higher comfort on board, as well as its environmentally friendly transportation image, which is important to eco conscious passengers. Activities that passengers perform on board were found to be reading emails (36%), talking to other passengers (33%), checking social media (32%), and enjoying the view (11%).

Principles for planning urban ferry systems

Based on case studies of ferry systems in various urban areas with maritime connections, Weisbrod & Lawson (2003) introduced six principles to consider when designing an urban water transit network. The introduced principles for public transportation and their corresponding key planning considerations are listed in Table 2.

Table 2: Water transit system principles for design and key recommendations adapted from Weisbrod & Lawson (2003)

Principle	***Key recommendation***
(Modal) integration into transportation planning	Integrating the surface transportation modes with waterborne ones, in terms of (digital) accessibility, waiting spaces and planning.
Seamless integration with land-side connections	Taking into account passenger experience with regards to last mile movement, terminal design, transfer seamlessness and comfortability. Spillover economic activity from terminals into nearby commercial destinations should additionally be considered.
Maximal economic development potential of the system's landings and terminals	Enhancing economic development through the ferry system by increasing residential, touristic and real estate value. The terminals could be used as promotional sites for touristic attractions specifically invented for the WTS and as attractions themselves.
Maximal environmental benefits and minimal adverse environmental effects	Using zero-emission vessels and design for reduced 'wake' (waves induced by watercraft) to decrease environmental impact of the WTS.
Maximal safety and security	Diligently perform 'what if planning', address vulnerabilities, communicate system abilities and acquire approval of security and emergency measures by the relevant authorities.
Creating ferry systems for freight	Examine untapped opportunities to relieve urban congestion by supporting fast delivery of high-value and time sensitive goods with the existing water transit system, for example, from and to business districts.

2.1.2 URBAN WATER TRANSIT EXAMPLES

There are many examples of ships for public transportation in urban areas. Gelesz et al (2017) mention the "Venetian vaporettas, Parisian bateau mouche, rondvaartboten in Amsterdam, or „Hotaluna" i „Himiko" in Tokyo". Aside from their functional purpose, they serve a cultural purpose as well. These stem from touristic markets, but innovations in ferries and water bus systems as part of public transportation are present in the literature as well. An overview of worldwide urban maritime public transportation systems is depicted in Table 3.

In Istanbul alternatives for the Municipality to increase sustainability of the WTS were reported as either improving ferry operations, converting existing ferries to hybrid or electric ones, or purchase of a new electric fleet from a company that will deal with parts, service and the newest technology. The latter was considered the most advantageous for the public transportation system as studied by Pamucar et al. (2022).

Another case in the region of Vastra Gotaland, an area in Western Sweden, was studied by Bellone et al. (2019). Styrsöbolaget, a shipping company that operates passenger traffic over the rivers of Gothenburg, was considering a transition to battery powered ferries, for sustainability objectives. However, challenges related to fully electric vessels made hybrid solutions more attractive. For example, charging batteries is both logistically challenging—since ferries only dock briefly between stations—and infrastructurally demanding, as it requires significant investments in multiple charging quays across the operating area. Furthermore, challenges arise with regards to the technology of battery-operated vessels, and operational implications (i.e. maneuverability, timetable changes, additional ferries due to power differences).

Table 3: Worldwide urban water transit system adapted from Cheemakurthy et al. (2018)

Scale	*City*
Large	Amsterdam, Auckland, Brisbane, Hong Kong, Istanbul, Izmir, London, New York, San Francisco, Seattle, Stavanger, Sydney, Venice
Medium	Copenhagen, Gothenburg, Hamburg, Rio de Janeiro, Stockholm, Vancouver
Small	Boston, Oslo, Rotterdam, Wellington

2.2 SUSTAINABLE BUSINESS MODEL INNOVATION

SUSTAINABLE BUSINESS MODEL INNOVATION

Sustainable business model innovation is defined as a transformation of the conventional business model, which takes into account environmental and societal impact, while aiming for long-term organizational and stakeholder prosperity.

To define sustainable business model innovation, several sub-definitions need to be explored. According to Geissdoerfer et al. (2018), underlying concepts of sustainable business model innovation (SBMI) include business models (BMs), sustainable business models (SBMs), and business model innovation (BMI).

2.2.1 BUSINESS MODELS (BM)

In literature and in practice, there are various definitions of Business Models (BMs) across multiple industry perspectives. Shafer et al. (2005) define business models as "a representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network.". The business model is considered a reflection of the firm's strategy. Its components - through a descriptive system of elements and activities that interact to create value - show how the firm conducts business for certain marketable information, product and/or services with the aim of achieving competitive advantage (Wirtz et al., 2016; Zott and Amit, 2010). To illustrate, the elements, and activities, that are interacting and shared through stakeholder collaborations, may include immaterial and material resources, capabilities, customer role and interface design, the value proposition and revenue and cost model. If a business model is created to represent a company strategy – after the fact – and is in itself not a strategy, what purpose does it serve? According to Shafer et al. (2005), business models can be used to analyze, understand, communicate, and validate a company's strategic choices. As a reflection of reality, the business model illustrates the logic, mutual supportiveness, and internal consistency of the strategic choices introduced to assess business performance under a certain strategy. Baden-Fuller & Morgan (2010) list various other purposes of business models, such as means to describe and classify businesses, or to act as recipes for creative managers to copy.

Many tools exist for firms to shape their initial business model. The most prominent one is the Business Model Canvas. Other business model tools include, for example, Osterwalder's 9-point decomposition of a business model, or IBM's Component Business Model.

Business Model Canvas

A well-known simplified visualization of the concept and approach to business model design is the Business Model Canvas. The canvas offers a means to communicate and describe the basic building blocks of a business model over four areas of business: customers, offer, infrastructure and financial viability. The building blocks, forming a strategy to implement through organizational structures, processes and systems, are; customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure. All of which are combined and linked in a comprehensive, visual canvas, where the left side represents efficiency, and the right side represents value (Osterwalder & Pigneur, 2010).

The Four-Box Business Model Framework

Johnson (2010) created a business model framework that categorizes and covers the structure of the different elements of every business model. It is a framework that provides both a tool to analyze the existing core business, and a model to base the shape and design of a new business model on. Figure 4 shows the interaction between the four key elements – customer value proposition, profit formula, key resources and processes – of the framework, and Table 4 further explains each element.

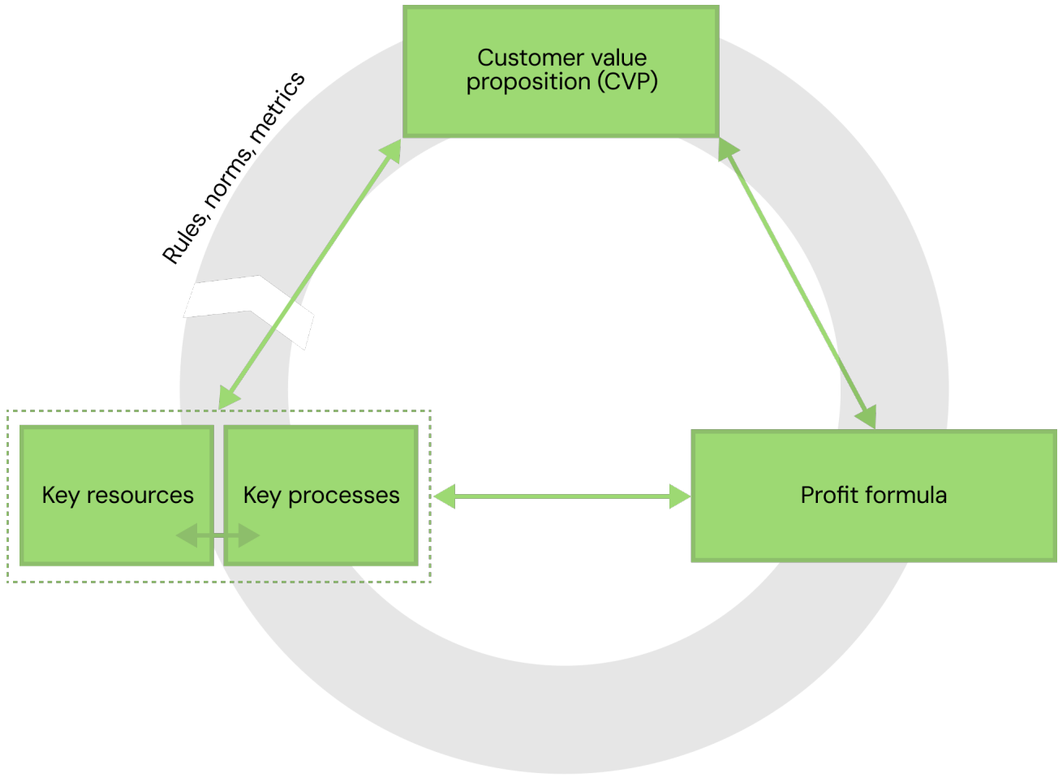

Figure 4: The Four-Box Business Model Framework of Johnson (2010)

Table 4: The elements of the Four-Box Business Model Framework of Johnson (2010), including definitions from Kühn & Louw (2017).

Key element	***Key element definition***	***Sub-element***	***Sub-element definition***
Customer value proposition (CVP)	How value is created for a given customer at a set price.	Job-to-be-done (JTBD)	The functional, emotional or social need that the customer is trying to get served more conveniently, efficiently or affordably.
		Offering	A focused solution that will address the JTBD, both in terms of how and what and at an affordable price.
Profit formula	How the firm will capture value for itself and its shareholders from its customers in the form of profit, and how fast the firm must turn over its assets to achieve adequate returns.	Revenue	Quantity sold, time taken to perform service or number of transactions times offering price (plus adjacent sales, e.g. chargers for mobile phones)
		Cost structure	Structure of fixed and variable costs inherent in resources – includes direct costs (directly tied to production), overhead costs (ongoing business expenses) and economies of scale (lower costs at higher production levels).
		Target unit margin	Operating profit per unit sale required to cover overhead costs to achieve desired profit level at target volume.
		Resource velocity	How quickly resources need to be used to support target volume; i.e. the ability of the resources and processes to establish the planned turnover. Determines overall capacity of the firm to achieve the CVP. The greater the resource velocity, the greater volume of its offering the business can produce.
Key resources	How the firm conveys or delivers its value within itself and to its customers. Critical assets, skills, activities, routines, ways of working that enable the enterprise to fulfill the CVP and profit formula in a repeatable, scalable fashion.	The unique people, technology, products, facilities, equipment, funding and brand needed to deliver the CVP to the customer.	E.g. people, technology, products, equipment, information, channels, partnerships, alliances, funding, brand. Can be outsourced.
Key processes		The means by which the company delivers the CVP in a sustainable, scalable, repeatable, and manageable way.	E.g. design process, product development, sourcing, manufacturing, marketing, hiring and training, IT. Might also include business rules and success metrics (margin requirements for investment, credit terms, lead times, supplier terms), and behavioral norms (approach to customers and channels, opportunity size needed for investment).

2.2.2 BUSINESS MODELS INNOVATION (BMI)

The third underlying concept, Business Model Innovation (BMI), is defined by Lindgardt et al. (2009) as the reinvention of two or more elements of a business model to deliver value in a different manner, to provide companies the opportunity to differentiate from competition. To do this, the existing business model is analyzed, and its faults are identified to uncover opportunities for innovation. This might seem straight forward, but the literature is divided on multiple aspects of BMI. For example, whether it is process oriented or outcome-oriented, and where the emphasis of the transformation most effectively lies. However, it is generally found that BMI can be approached either through changes in the business model architecture – i.e. the links between the different components of the business model – or through changes in the components themselves – i.e. a changed value proposition (Foss & Saebi, 2017). Similarly, according to Taran et al. (2015), BMI can be approached through 1) radical innovation of any one of the various building blocks of BMs – by significantly altering their previous nature – i.e. by offering something different or forming new partner alliances, 2) newness to a related entity, i.e. to the company, the market, the industry, etc. or 3) an increase in complexity of the BM by innovating multiple of the BM components. The first approach of Taran et al. (2015) of radical innovation of one of the building blocks can also be more broadly explained as either organizing activities differently or changing the level of participation of the business model actors across those activities (Sorescu et al., 2011).

Though there are many opportunities, there are also some pitfalls of BMI. These include for example an overfull company portfolio, failure to scale up, continuing with projects that have no future, isolating efforts from the mainstream business, fixation on ideation, internal focus at the expense of customer needs, or historical bias towards past ideas (Lindgardt et al., 2009). Furthermore, Johnson (2010) claims that the main reason why business model innovations fail is the unambiguity of their motivation. To be clearer, firms are uncreative because they are afraid to transform their business model without structure and sensemaking in relation to the existing business model, which in turn causes an aversion to taking risks into the unknown that could lead to higher value creation and capture. Business models are considered complex systems due to the non-simplicity of activities, links and governance of which they are contrived. To structure the different types of BMI, Foss & Saebi (2017) created a typology, based on scope and novelty. They introduce four types, which can be found in Table 5.

To bring about business model innovation, it is useful to study some tools in literature that give an overview of its complexity and how it can be approached or identified in various situations. According to Agarwal et al. (2022), BMI tools can be classified into three categories: innovation process stage-based tools, strategic objective-based tools, and organizational size-based tools. Some relevant tools are listed in Table 6.

More simplified business model design and innovation tools like the Minimum Viable Product (MVP), Value Network, Lean Canvas, Interview, Empathy Map, Customer Exploration Map, PESTLE Analysis, SWOT, and Thinking Hats, are offered by online tool providers like the Business Model Toolbox (2020) or Business MakeOver (2018) for interactive use.

Table 5: Business model innovation typology adapted from Foss & Saebi (2017).

Novelty	***Scope***	
	Modular	***Architectural***
New to firm	Evolutionary BMI (naturally emerging changes in individual business model components)	Adaptive BMI (changes in the overall business model, often as a reaction to competitive BMs in the industry)
New to industry	Focused BMI (mechanisms are kept intact while one specific area of the BM is actively changed to create new market value)	Complex BMI (active transformation of the BM in its entirety to create new market value)

Table 6: Business model innovation tools adapted from Agarwal et al. (2022).

Tool	***Source***
Business model canvas	Osterwalder & Piquer (2002, 2010)
Activity system design framework	Zott & Amit (2010)
The White Space	Johnson (2010)
Lean venturing	Breuer (2013)
Business model roadmapping	De Reuver et al. (2013)
VISOR	El Sawy and Pareira (2013)
The 4I-framework of BMI	Frankenberger et al. (2013)
The innovation pivot framework for startups	Gutiérrez et al. (2016)
Performance assessment and experimentation tool for BMI	Batocchio et al. (2017)
From strategic goals to business model innovation paths	Heikkilä et al. (2018)

2.2.3 SUSTAINABLE BUSINESS MODELS (SBM)

The third underlying concept, Sustainable Business Models (SBMs), can be defined as an alignment of all interests between stakeholder groups, where society and the environment are considered key stakeholders as well (Bocken et al., 2014). The sustainable business model concept arose as a complement to the conventional business model for companies that aim to meet sustainability goals, while still performing for productivity and profitability. The goal is to integrate sustainability considerations into the business model components and to create value for the Triple Bottom Line: Economy, society, and the environment (Nosratabadi et al., 2019). In the literature SBMs are also referred to as business models for sustainability (Schaltegger et al., 2016).

Table 7: Sustainable business model archetypes adapted from Bocken et al. (2014).

	Archetype	*Explanation*
1	Maximize material productivity and energy efficiency	
2	Create value from 'waste'	
3	Substitute with renewables and natural processes	
4	Deliver functionality, rather than ownership	
5	Adopt a stewardship role	
6	Encourage sufficiency	
7	Re-purpose the business for society/environment	
8	Develop scale-up solutions	

Table 8: Business model archetypes for longer product lifetimes adapted from Bakker et al. (2014).

1	The Classis Long-Life Model	Long product lifetimes achieved through quality, branding, service and repairability.
2	The Hybrid Model	The functionality and durability of one product depends on a complementary other product with a limited lifetime.
3	The Gap Exploiter	The residual value of a specific existing product is exploited, and its lifetime is extended through repair, refurbishment and/or repurposing as a service.
4	The Access Model	Multiple consumers get (temporary) access to or share the same product.
5	The Performance Model	The value proposition is based on functionality instead of a particular product. A provider offers a product and its maintenance, for the consumer to enjoy its functionality.

Sustainable Business Model Archetypes

Based on learnings from the literature and practices of sustainability innovation, Bocken et al. (2014), categorized SBMs in eight archetypes which can be used as exemplars for Sustainable Business Model Innovation (SBMI), as shown in Table 7.

Business Model Archetypes for longer Lifetimes

In their book 'Products That Last: Product Design for Circular Business Models', Bakker et al. (2014) introduce five business model archetypes that are distinct and sustainable in that they benefit from a longer product lifetime (Table 8). These business model archetypes go hand in hand with circularity through 'business modelling', or the continuous planning of the value proposition. In that way, the business model is designed to be able to keep evolving under changing circumstances.

2.2.4 SUSTAINABLE BUSINESS MODEL INNOVATION (SBMI)

Businesses increasingly experience pressure to become more sustainable. A means to this end is sustainable business model innovation. Though still quite a young research field, the literature examines various approaches to Sustainable Business Model Innovation (SBMI), of which Nosratabadi et al. (2019) found four main ones based on multiple cases in the literature of sustainable business models in various domains. These approaches are summarized in Table 9.

To qualify as SBMI, the BMI process of business model exploration (adjustment, improvement, redesign, revision, creation, development, adoption and transformation) must aim at "1) sustainable development or positive, respectively reduced, negative impacts for the environment, society, and the long-term prosperity of the organization and its stakeholders, or 2) adopting solutions or characteristics that foster sustainability in its value proposition, creation, and capture elements or its value-network." (Geissdoerfer et al., 2018).

Unfortunately, it has been recognized that often efforts to innovate SBMs are futile, an occurrence that Geissdoerfer et al. (2018) call the 'design-implementation gap', which is caused by challenges such as Triple Bottom Line – challenging balance and co-creation of profits, social benefits and environmental benefits -, a firm mindset regarding e.g. performance metrics and business guidelines, reluctance to allocate resources to new BMs, complexity of integrating new technologies with BMs, extra effort for external stakeholder relations, and scarcity of available SBMI tools.

Value uncaptured

According to Yang et al. (2017), SBMI can be achieved through identifying and transforming value uncaptured - value surplus, value absence, value missed, and value destroyed - of the current BM into value that has higher sustainability potential. An approach that is in line with the assignment of repurposing a fleet of water buses that is currently underperforming in terms of value creation, where an opportunity would be lost if the transformed value is not sustainability focused.

Triple Layered Business Model Canvas

To explore potential creative innovations of the business model with regard to the Triple Bottom Line – including sustainability from a life cycle perspective -, the TLBMC is a practical tool, introduced by Joyce & Paquin (2016), that can be easily implemented to visualize, communicate and develop organizational sustainability. The TLBMC is used by horizontally and vertically aligning three

Table 9: Sustainable business model design approaches adapted from Nosratabadi et al. (2019)

	Sustainable business model design appraoch
1	Designing a sustainable value proposition
2	Designing a sustainable value creation
3	Designing sustainable value delivering
4	Generating sustainable partnership networks for creating and delivering such sustainable value which can meet the social, environmental, and economic benefits at the same time.

layers of an organization's environmental, social and economic impacts. It can both be used to analyze a current business model, as for innovating towards a new sustainable one. It is designed as a visual representation, a creation and a validation tool. Figure 5 shows the TLBMC by Joyce & Paquin (2016).

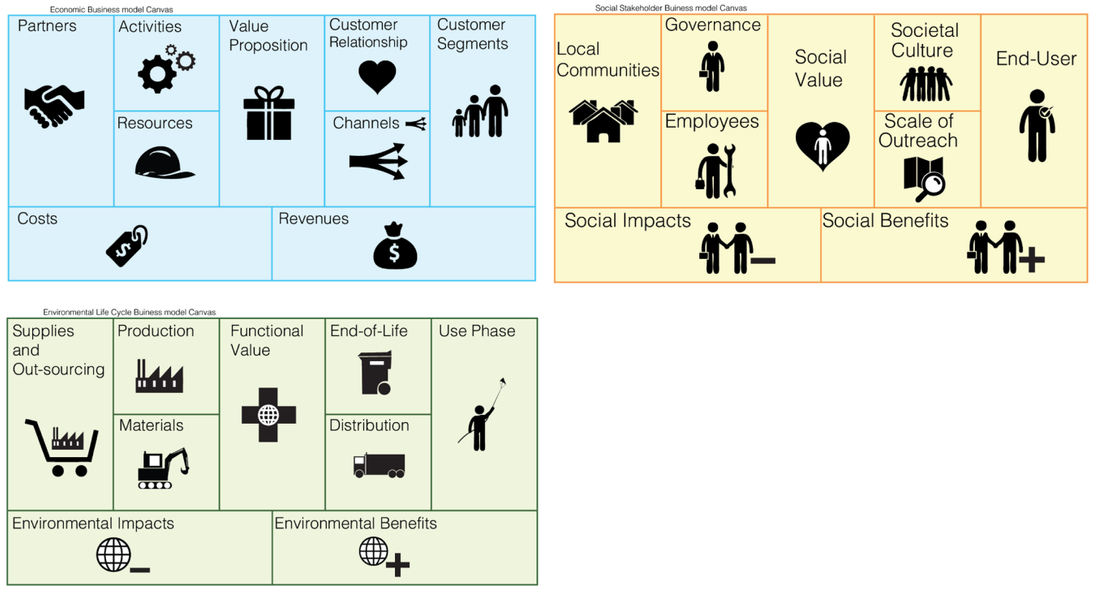

Figure 5: Triple Layered Business Model Canvas tool, adapted from Joyce & Paquin (2016).

2.2.5 CONCLUSION

The reviewed underlying concepts BM, SBM, BMI, and SBMI and their respective discussed tools and approaches are presented in an overview in Figure 6.

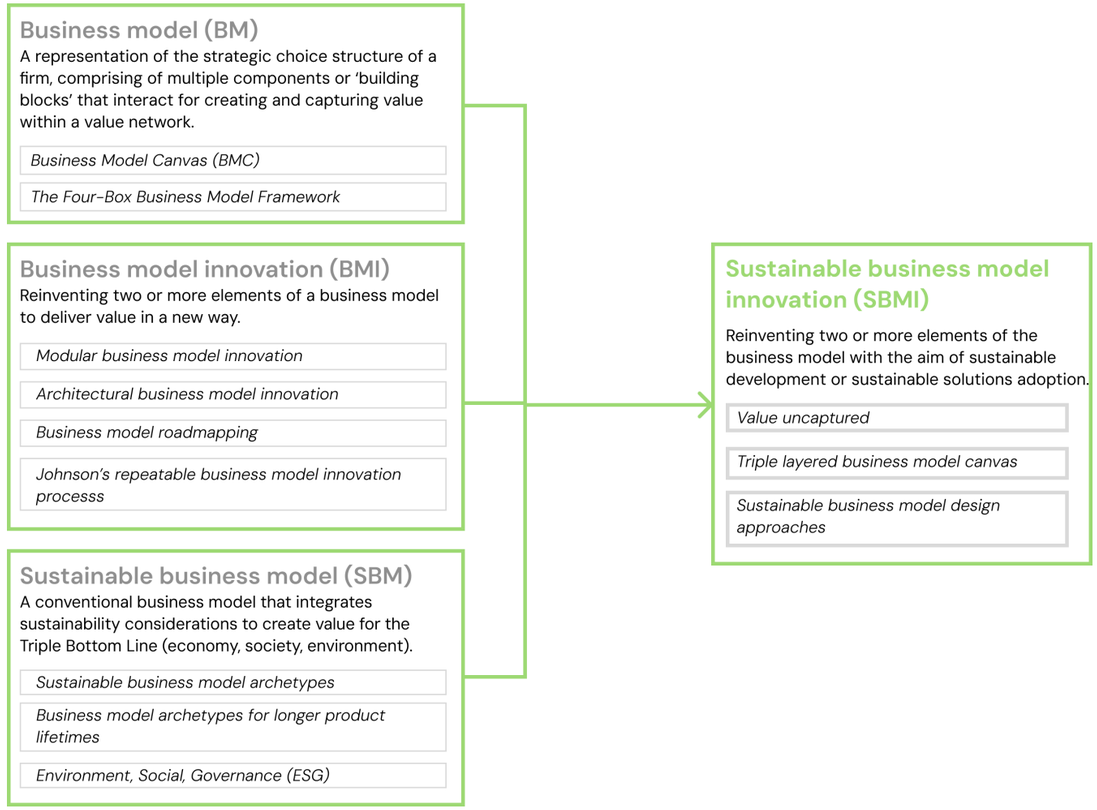

Figure 6: Underlying concepts of sustainable business model innovation.

CHAPTER 3

THEORETICAL FRAMEWORK

This chapter introduces a theoretical framework which contains the context and domain that were investigated in the literature review. The theoretical framework is the scientific foundation of this thesis on which the empirical case study and design are based.

Chapter Contents

3.1 FRAMEWORK INTRODUCTION

3.2 EXPLANATION AND ITERATIONS

3

3.1 FRAMEWORK INTRODUCTION

The theories from the scientific domain of Sustainable Business Model Innovation (SBMI) and from the context of Water Transit Systems (WTS) that were introduced and discussed in Chapter 2 are visually shown in the theoretical framework in Figure 7. Three extra contextual elements were added to the framework: tender partners, fleet financing, and operating profile. During informal conversations at Damen, these elements were found to be relevant to the specific WTS case of Damen Financial Services. The first box in the framework, Water Transit System, presents these elements as well as theories Urban Ferry System Principles (Weisbrod & Lawson, 2003), FOD (Sipe & Burke, 2011; Tsai et al., 2017; and Tanko & Burke, 2015), and Ferry System Components (Tanko et al., 2018; Cheemakurthy et al., 2018).

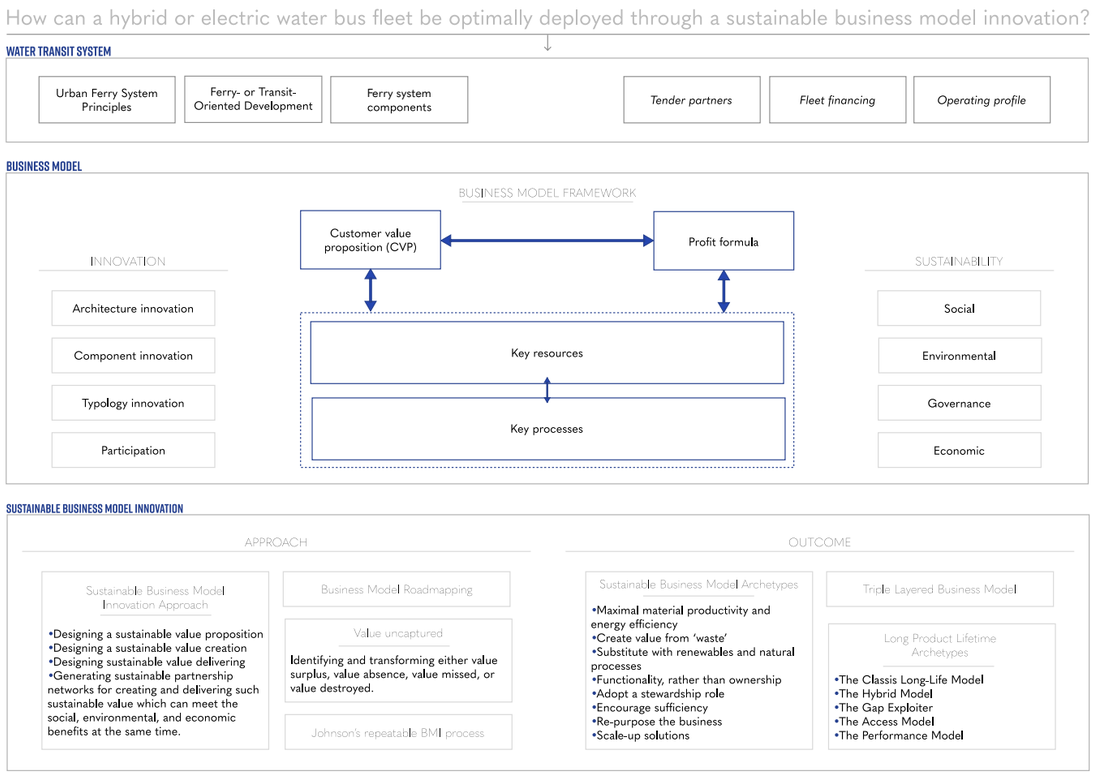

Figure 7: Theoretical framework for sustainable business model innovation for water transit systems.

The second box, Business Model, presents the business model components of the Four-Box Business Model Framework (Johnson, 2010), potential sustainability components within a business model (social, environmental, governance, and economic) and business model innovation types (architecture innovation, components innovation, typology innovation, and participation innovation). Johnson's Four-Box Business Model Framework was chosen to define business model components for the scope of this thesis because of its completeness, its representation of systemic interactions with minimal complexity and because it can function as both an analytical tool (of the current BM) and as a tool for transformative growth.

The lower box, SBMI, presents an overview of approach-based theories for SBMI: the SBMI design approach of Nosratabadi et al. (2019), Business Model Roadmapping (De Reuver et al., 2013), Value uncaptured (Yang et al., 2017) and Johnson's repeatable BMI process (Johnson, 2010). It also contains an overview of outcome-based theories for SBMI: Sustainable Business Model Archetypes (Bocken et al., 2014), the Triple Layered Business Model (Joyce & Paquin, 2016), and the Long Product Lifetime Archetypes (Bakker et al., 2014). Iterations of the theoretical framework can be found in Appendix A.

THEORETICAL FRAMEWORK

What is it?

A theoretical framework is a scientific tool to (visually) shape the structure of the study. It contains the different concepts that are relevant to the study topic and shows interactions and structure between these concepts as found in the literature and as interpreted by the researcher. The framework forms a theoretical justification and foundation for the research within the scientific domain and study context and gives direction and guidance in developing the research design, study methodology and analysis (Varpio et al., 2020).

What is it used for?

The theoretical framework serves two purposes. Firstly, it forms the basis for the research protocol used in the deductive qualitative empirical study. The theories presented in the framework are used to define the structure and content of the interview guide. As such, the findings from the empirical study will follow the basic structure of the theoretical framework. Secondly, and as a consequence of the first purpose, the theoretical framework serves as a conceptual model for the strategic design phase and its outcome. The design outcome is based on insights from the empricial study, which in turn was guided by the theoretical framework. Therefore, the design outcome is grounded in theory and enriched by empricial insights.

CHAPTER 4

EMPIRICAL CONTEXT

This chapter introduces details of the problem case that is at the core of this thesis project: the passenger transport over water (POW) concession in the Rotterdam-Drechtsteden urban area. It forms the basis for the qualitative empirical case study at Damen Shipyards in Gorinchem.

Chapter Contents

4.1 STAKEHOLDER MODEL

4.2 WATER TRANSIT SYSTEM DESIGN

4

4.1 STAKEHOLDER MODEL

An empirical study was conducted at Damen Shipyards in Gorinchem, which forms the context for testing the theoretical framework for sustainable business model innovation in water transit systems. Specifically, the case and problem space are the project and public transportation service resulting from the tender 'Personenvervoer over Water' (people transport over water - POW) Rotterdam-Drechtsteden in The Netherlands. Aqualiner in a joint venture with Damen Financial Services started operating in the Province Zuid-Holland from Januari 1st 2022, after the previous t ender came to an end on December 31st, 2021. In the nineties, a pilot project for POW was succesfully completed in the Rotterdam-Drechtsteden area, which led to a broad network of water transit systems in the Netherlands, and a continuation of ferry services in the area. The routes are aimed at socially relevant connections (e.g. work-living) and touristic destinations such as the 19 historical Windmills in Kinderdijk (UNESCO World Heritage Site) or the Biesbosch (nature reserve).

STAKEHOLDER MODEL

A stakeholder model provides a visual overview of the various players involved in the project. They often have diverging interests, are multidisciplinary, and can exercise varying levels of influence on the project's direction.

Multiple interdisciplinary parties hold stakes in both designing the tender for POW, bidding for it and in executing the project, The value that they create and capture from the project varies as well. The client, Provincie Zuid-Holland (PZH) aims to create with POW Rotterdam-Drechtsteden the following values - as derived from its policy framework (Provincie Zuid-Holland, 2018):

1. Best accessible province
2. Healthy and attractive living environment
3. Energy renewal & promoting innovations

To create these values and reach the goals of 'smarter, cleaner, and stronger POW' three themes were drafted for the tender. These are:

1. Better alignment between passenger needs and supply
2. Encouraging sustainable and innovative forms of passenger transport over water
3. Improving the quality of passenger transport over water

The core team members of the project – after the concession was won – are Damen Shipyards and Aqualiner. Aqualiner is the service operator and Damen Shipyards can be divided into two involved divisions. The division Damen Workboats which designs and builds the vessels and the division Damen Financial Services (DFS) that is integrated in the project through a financial solution and joint venture with Aqualiner. Aside from being a core team member, DFS also functions as project sponsor. This function can also be partly performed by banks, but in the case of the Waterbus, this is indirect because they provide financial means via the Damen Group to which DFS belongs. The Province additionally sponsors the Waterbus project with subsidies, while also being a client organization. Also directly involved are the end-users. They include the Municipality - that represents its inhabitants and is owners of the terminals - and the Waterbus crew and its passengers.

Other, more indirect stakeholders, are external sub-contractors: consultancies involved in either research for creating the tender, or for bidding to it. There are also the community: independent (civil) activist stakeholders with knowledge and (political) opinions on specific issues. Lastly, the model includes external independent concerned groups which includes landside and waterborne public transportation parties, commercial transportation providers, the region, certification agencies, harbors and urban development projects. These stakeholders usually do not directly have influence on or an obvious a stake in the project, unless intentionally included by core team members.

Figure 8 shows a generalized stakeholder model for water transit systems. A specified stakeholder model of the project 'Personenvervoer Over Water' can be found in Appendix B. The stakeholders were identified using the stakeholder model tool by Bourne & Walker (2005) and based on document analysis and informal conversational interviews.

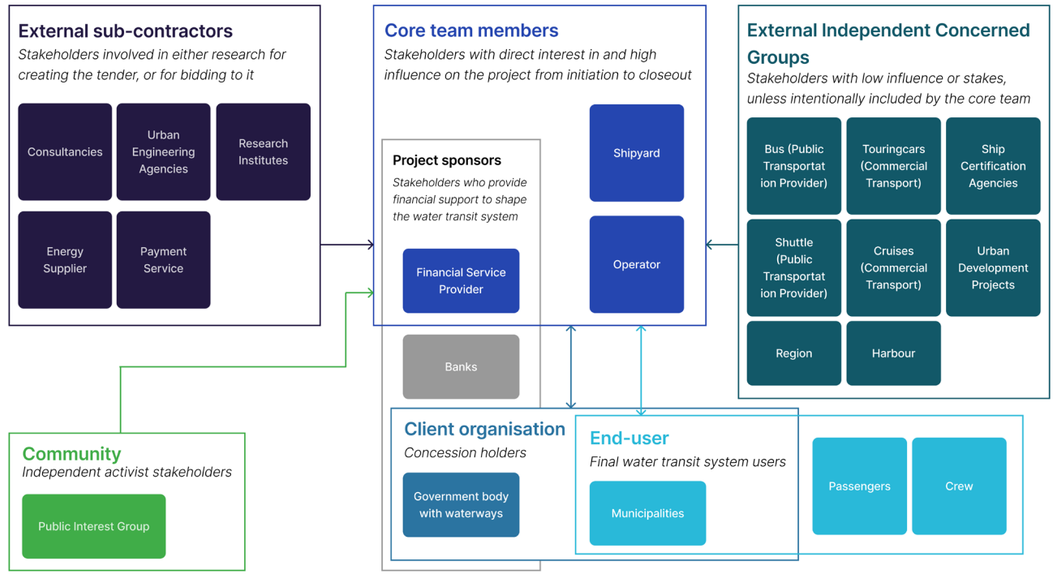

Figure 8: Generalized stakeholder model of a water transit system project (stakeholder modelling tool from Bourne & Walker, 2005).

4.2 WATERBUS OPERATION DESIGN

The water transit system in the Drechtsteden area consists of four lines. Line 20, line 21, and line 23 can be considered long transriver routes and are either sailed with a diesel or a hybrid waterbus WBU 2907, a diesel WBU2407 or with vessels that were bought out from the previous operator of the POW tender. According to the official schedule the longest line, line 20, takes 58 minutes across 8 stops – leaving a maximum loading- and unloading time of 8 minutes per stop. The operating frequency is 30 minutes, which is reduced to 60 minutes on Sundays in wintertime, and various operating times depending on weekdays or weekend days. As the best performing line in the system, line 20 transports more than 450K passengers annually. Line 21, a shorter tourist-focused route scheduled for 40 minutes beginning to end across 3 stops, has an operating frequency of 45 minutes, reduced to 1 hour and 40 minutes in wintertime. Annually it accounts for around 100K passengers. Line 23, 26 minutes across four stops, carries below 50K passengers annually. Line 22, which follows the only relatively short-distance cross-river route is sailed by three full-electric Damen WBU2306 ferries. The route should take 22 minutes across four stops and carries just below 450K passengers annually, which is impressive in comparison to trans-river line 23. The water transit route is shown in Figure 9.

Revenue from ticket sales is generated through online sales, OV-pay (the Dutch public transportation payment system, coordinated via Translink), onboard sales or combination tickets. The terminals that the waterbus stops at are owned and managed by the municipalities in which they are located.

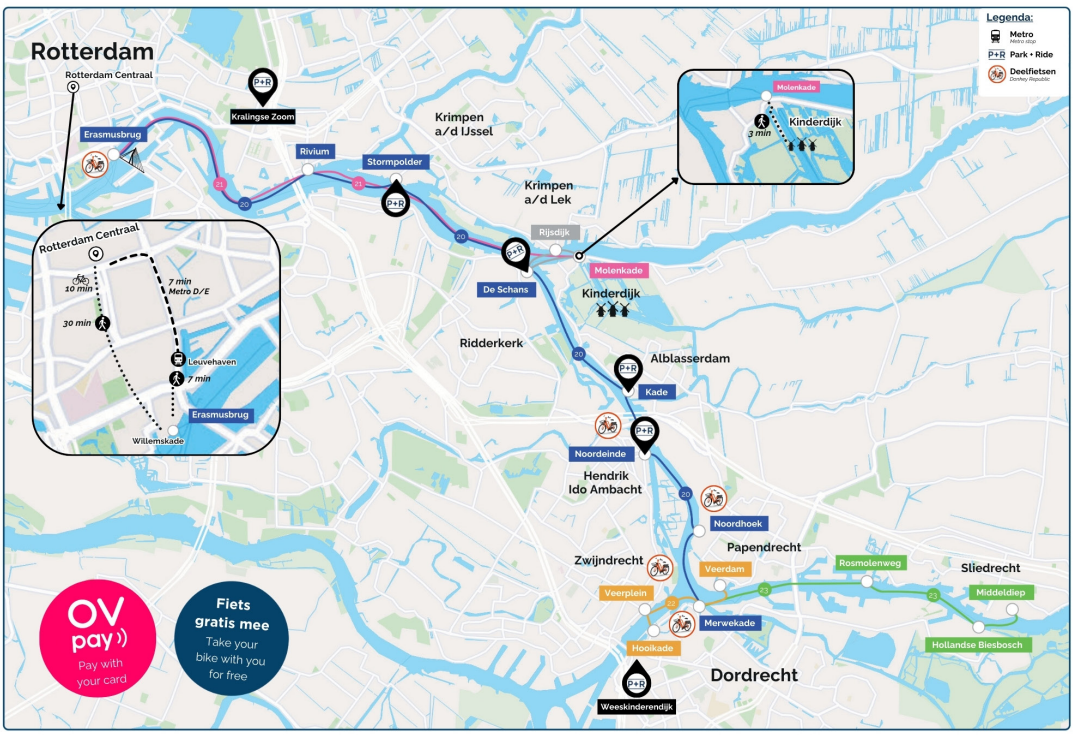

Figure 9: Water transit system routes POW Rotterdam-Papendrecht (Waterbus, n.d.).

CHAPTER 5

METHODOLOGY

This chapter outlines the methods framework and study procedures including the research design, validity procedures, data collection, and the data analysis approach for data gathered during in-depth interviews that were conducted over a period of 4 weeks.

Chapter Contents

5.1 METHODS FRAMEWORK & STUDY PROCEDURES
- 5.1.1 Research design
- 5.1.2 Validity in research design

5.2 DATA COLLECTION
- 5.2.1 Document data collection
- 5.2.2 Interview participant collection

5.3 DATA ANALYSIS
- 5.3.1 Thematic analysis
- 5.3.2 Document analysis
- 5.3.3 Interview analysis
- 5.3.4 Pattern matching

5

5.1 METHODS FRAMEWORK & STUDY PROCEDURES

5.1.1 RESEARCH DESIGN

A deductive qualitative research design was chosen for a single case study of the business model, sustainability and innovation for water transit systems. A qualitative research design was chosen due to the researcher's postpositivist worldview and the study's context. Furthermore, the limited previous research of SBMI in the context of water transit systems supports the choice for qualitative research. Through an in-depth case study conducted over an extended period at the host company, objective empirical observations of participants' reality enable the researcher to structure specific ideas and generalize findings to test a predetermined theory and ultimately design a more widely applicable solution (Creswell, 2014).

To conceptualize the theoretical framework a literature review was conducted which consequently informed the qualitative interview protocol to test it. Table 10 shows an overview of the steps and procedures taken as part of the study process including data analysis and results disseminations.

Before formulating the research questions, sub-questions were formulated according to the theoretical framework. These can be found in the protocol in Appendix C1. To test the theoretical framework a semi-structured interview guide was developed with question formulation according to Patton (2002). Patton (2002) recommendations were followed by keeping the questions neutral and creating presupposition by implying case background knowledge. Additionally, the interviews were structured in such a way that allowed probing, where a topic of interest or relevance could be elaborated on with extra prompting. The interviews were concluded with the question whether the participant had anything to add or to ask from the researcher. These questions can be found in Appendix C2. The informal conversational interviews that were also used in the data collection after requesting consent from the interviewee in retrospect, were based on the research parts and sub-questions from the interview protocol. Lastly, three expert interviews were conducted with participants that had specific knowledge on one part of the interview protocol but none or very little on other parts. These interviews were typically shorter and more focused.

Each participant was asked to sign an informed consent form according to the guidelines of the TU Delft Human Research Ethics Committee. This form can be found in Appendix C3. The form includes informed consent to recordings of the interview, which were transcribed and stored for the duration of the thesis research. During and before the interviewing phase of the study, relevant documents were gathered to support interview findings and to form a full understanding of the case. All participant and document data were stored and handled under code names in a secured online environment.

Table 10: Overview of research activities and materials that were used as part of the study

Double Diamond Phase	*Thesis timeframe*	*Activity*	*Aim of activity*	*Materials used*	*Outcomes of activity*
Discover	Week 0	Project brief	Setting up project description and learning goal	University template	Preliminary introduction, problem statement, literature domain, project context, learning goals
	Week 1	Set up document and participant collection files, code names and literature collection file	Structured, secure and valid data collection	Microsoft OneDrive	Document data file, Participant data file, Literature overview file
	Week 2	HREC Application	Research approval	Data Management Plan, Informed Consent forms, HRX Checklist, host company contract and addendum	Approved HREC application
	Week 1 – 3	Literature review	Understanding SBMI and water transit systems	Google Scholar	Research sub-questions, Theoretical framework
	Week 1 – 3	Informal conversational interviews	Gathering background information on case to inform interview guide, understanding host company	Notes	Basic case understanding
Define	Week 3	Interview protocol	Outlining sub-questions to be answered during semi-structured interviews	Literature review, case information	Interview protocol, Semi-structured interview guide
	Week 4 – 7	Semi-structured interviews	Testing theoretical framework	Google LLC (recording, transcribing), Microsoft Teams (calling, recording, transcribing), Microsoft Word (transcribing)	Interview transcripts
	Week 5 – 6	Coding tree	Set up coding tree based on interview protocol and theoretical framework		Preliminary coding tree and themes
	Week 6	Document analysis	Gathering case information and testing coding tree for interview analysis		Revised coding tree
	Week 6	Stakeholder model	Form an understanding of players in a water transit system to base innovation design choices on in later phases		Stakeholder map
	Week 7 – 8	Transcripts and coding tree	Gathering interview transcripts from audio recordings and preliminary coding tree development	Microsoft Word transcriber	Transcripts, preliminary coding tree
	Week 7	Report writing	Reflexivity of study progress		Midterm report
	Week 8	Midterm evaluation	Evaluation of study progress		Midterm presentation and discussion

Double Diamond Phase	*Thesis timeframe*	*Activity*	*Aim of activity*	*Materials used*	*Outcomes of activity*
Develop	Week 9	Coding	Gathering relevant insights from the interview data	Atlas.ti	Quotations, clusters, coding tree
	Week 10	Pattern matching	Structuring the insights into layered results	Atlas.ti, Fimga	Three layers of sub-thematic integration via code co-occurences
	Week 11	Design strategy	Direction and means of validation for the design outcome in line with the research results		Design requirements, design directions and success metrics
	Week 11 - 12	Ideation	Creating maps to structure research findings	Figma, Atlas.ti	Conceptual model
	Week 13	Workshop objectives	Methodology and objectives for co-creation workshops	Literature review, co-creation playbook	Pilot session materials and objectives
	Week 14	Pilot session	Testing conceptual model and co-creation session methodology and peer feedback	Figma slides, paper handouts, post-its, pens, markers, Google LLC (recording), notes	Filled out handouts, peer feedback
	Week 15	Preparation co-creation session	Improving workshop materials and conceptual model	Notes, Figma	The Pyramid Toolkit, co-creation session methodology and preparatory material
Deliver	Week 16	Co-creation session	Idea ownership, innovation strategy co-creation, testing the final model	Figma slides, the Pyramid Toolkit, paper handouts, pens, markers, Google LLC (recording), Microsoft Word transcriber, notes, survey	Innovation strategy components (most relevant water transit elements and innovation ideas), filled out handouts, survey results
	Week 16 - 17	Innovation strategy	Recommendation of an innovation strategy for the Waterbus WTS		Written strategy
	Week 17	Green light meeting	Evaluation of study progress		Supervisor feedback and discussion
	Week 17	Validation preparation	Findings a participants for external (outside Damen) validation of the Pyramid Toolkit and internal validation of the innovation strategy	Damen network	2 Participants
	Week 17	User manual for the Pyramid Toolkit	Creating a user manual for the Pyramid Toolkit to be used independently	Figma, Adobe Illustrator	User manual
	Week 18	Innovation strategy visualization	Visualization and writing of innovation strategy for Damen	Figma	Strategy visualization and textual recommendation
	Week 18 - 19	Validation	Validating the Pyramid Toolkit and the innovation strategy	Google LLC (recording), notes, survey	Feedback and survey results
	Week 20	Final thesis report		InDesign	Master's Thesis

5.2 DATA COLLECTION

5.1.2 VALIDITY IN RESEARCH DESIGN

To ensure quality and trustworthiness of the study, validity was taken into consideration. This encompasses the processes and approaches that were used to assess the rigor of the qualitative study at hand. The primary validation approach is through the warranting of qualitative standards credibility, transferability, dependability, and confirmability (Ravitch & Carl, 2015).

Credibility is achieved through strategies of methodological triangulation – both collecting and analyzing document and interview data –, data triangulation – interviewing participants from multidisciplinary backgrounds and perspectives – and peer debriefing through weekly and bi-weekly discussions with university thesis mentors and the company mentor and periodic official process evaluations. Transferability, an important aspect of this study as its results are case-specific and the conceptual model attempts to apply findings to broader contexts, is achieved through 'thick descriptions' - detailed descriptions of the data as well as the context (see sections Emprical Context and Data Collection). Basing the research questions and design on the theoretical framework and the researcher's situation – thesis research at host company - as well as between-methods sequencing of document analysis and interviews followed by a co-creative workshop ensures dependability. Lastly, confirmability is taken into account by recognizing researcher bias through reflexivity processes in the form of continuous author commentary on personal choices and considerations as the study progresses and activity tracking throughout. Some example commentary can be found in Appendix D.

5.2.1 DOCUMENT DATA COLLECTION

Appendix E shows an overview of primary document data collected in the case study. Because of the confidential nature of some of the documents, their descriptions are limitedly presented. The documents support a full understanding of the products, partners and system components in the case study. Furthermore, the documents serve the purpose of testing and iterating on the preliminary coding tree that was initially deductively developed based on the theoretical framework and research protocol. The documents were either publicly available or sent internally to the researcher by participants or employees at the host company.

5.2.2 INTERVIEW PARTICIPANT COLLECTION

To test the theoretical framework through semi-structured in-depth interviews, a group of 10 participants were interviewed. To recruit participants a combined sampling strategy was used. Based on Patton's (2014) 40 sampling strategies, the participants were selected through key informants, opportunity sampling, illumination & elaboration additions and snowballing. Table 11 shows an overview of interview participants in the case study including how they were sampled. Participants labelled as 'key informants' were initially introduced to the researcher by the company mentor. The key informants were initially selected due to their experience and involvement with the studied case. Snowballed participants were recommended by key informants to elaborate on the studied theory. For specific parts of the study, such as 'sustainability', illumination & elaboration additions were approached, either through recommendations or requests. Opportunity sampling was done on an informal field trip during the case study (Shaheen & Pradhan, 2019).

Table 11: Overview of interview participant data, 10 in-depth interviews, 1 informal conversational interview, 1 co-creation session, 2 validation interviews (14 participants in total).

Organization	***Participant code***	***Function***	***Interview typology***	***Interview duration (minutes)***	***Sampling strategy***
Shipyard	F1	Sales Manager Commercial Asset Management	Semi-structured in-depth interview & validation Waterbus strategy	~ 59 & ~60	Key informant
Shipyard	F2	Managing director Financial Services	Co-creation session	~ 90	Key informant
Shipyard	F3	Teamlead ESG and digital	Co-creation session	~ 90	Key informant
Shipyard	F4	Manager Financial Solutions	Validation Waterbus strategy	~60	*Company mentor*
Shipyard	W1	Program manager	Semi-structured in-depth interview & co-creation session	~ 49 & ~ 90	Key informant
Shipyard	W2	Director products	Semi-structured in-depth interview & co-creation session	~ 62 & ~ 90	Key informant
Shipyard	W3	Product portfolio manager	Informal conversational interview	~ 75	Key informant
Shipyard	S1	Sales manager	Semi-structured in-depth interview	~ 55	Key informant
Shipyard	S2	Sales manager	Semi-structured in-depth interview	~ 36	Snowballing
Shipyard	S3	Sales manager	Semi-structured in-depth interview	~ 52	Key informant
Shipyard	R1	Research Engineer	Expert interview on sustainability in maritime sector	~ 39	Illumination & elaboration addition
Operator	A1	Ad Interim CEO	Pyramid Toolkit validation	~ 18	Snowballing
Operator	A2	Operations manager	Informal conversational interview	~ 30	Opportunity sampling
Academic Institution	E1	Dr.Ir. Maritime Engineering	Expert interview on SBM for maritime sector	~ 61	Illumination & elaboration addition

5.3 DATA ANALYSIS

The data was analyzed with a deductive top-down thematic approach on the semantic level. The analysis is considered top-down because the themes were formulated to identify water transit system components, business model components, and sustainability and innovation opportunities and challenges as described in the interview protocol, with the specific research aim of understanding the case and setting up a foundation for the design phase of a conceptual model for SBMI of water transit systems. Therefore, it is most fitting to approach analysis deductively and top-down (Braun & Clarke, 2006). To set up the coding tree and to analyze the data, the software Atlas.ti was used. Though Atlas offers Artificial Intelligence insights into the data, this was not used due to data security concerns.

5.3.1 THEMATIC ANALYSIS

The themes were identified before analyzing the interview data, based on surface meanings found in the literature and documents. According to Braun & Clarke (2006) the analysis is therefore on the semantic level. A preliminary coding tree and theme structure was driven by the theory, in that it was derived from the research (sub-)questions in the interview protocol and guide. The preliminary coding tree can be found in Appendix F1. Coding was approached on an explicit level because the initial aim of analyzing the data was to objectively define and match components from the Four-Box Business Model framework and components of a water transit system. The broader meaning and significance of the data will be pursued in the discussion of insights to form a basis for a sustainable innovation model in the design phase.

5.3.2 DOCUMENT ANALYSIS

Only part of the documents in the data corpus – all collected data – were included in the document analysis and were thus part of the dataset. The documents included are D-A4 and D-A4 supplement, D-A9, D-A10, D-A11, D-A14, D-A16, D-S2, D-S3, D-S4, D-F1 and D-F2. The initial coding tree was tested by coding the documents in the dataset. The coding tree was refined with knowledge from the theoretical framework when quotations could not be coded with the preliminary coding tree. The result forms the coding tree that was used to perform the thematic interview analysis pilot. The revised coding tree can be found in Appendix F2. The document analysis furthermore allowed immersion into the case and strengthened the empirical context and case description.

5.3.3 THEMATIC ANALYSIS

The interviews were thematically analyzed after the documents, with a refined theme and coding tree. To test the coding approach, the first interview was analyzed as a pilot case to add last codes and structure them as Themes, Sub-Themes, and Codes. The themes were deductively derived from the theoretical framework and the research protocol: Water transit system, business model, innovation, sustainability, and sustainable business model innovation. The sub-themes are the components, principles, theories and frameworks as identified in the literature review. For example, a sub-theme of Business model was Profit formula, of which the codes consequently were revenue model, cost structure, resource velocity and target unit margin, according to the Four-Box Business Model Framework. A visual overview of the final coding tree that was used for the interview analysis can be found in Appendix F3. The program Atlas.ti which was used

for the analysis, does not allow theme identification so the 'sub-themes' are labeled as code groups in the program.

5.3.4 PATTERN MATCHING

To find opportunities and design spaces for model development based on the literature review and empirical study, and to ensure repeatability and rigor of the scientific study, pattern matching is included as a qualitative analysis strategy. According to Sinkovics (2018) pattern matching allows comparison between theory patterns and observed empirical patterns, which in the context of this study involves comparing the connections between the context (WTS) and the research domain (SBMI). Figure 10 shows a visualization of the general logic of pattern matching. For this study a deductive top-down partial pattern matching approach was taken, because the theoretical framework was devised a priori to the empirical study.

In line with Noel's (2019) stepwise approach to combining pattern matching and deductive thematic analysis, the theories identified in the theoretical framework were initially investigated through their corresponding themes, after which theoretical triangulation is applied to the analysis to disseminate where the theories from the theoretical framework complement (or do not complement) each other to inform a basis for the design process. Appendix G shows the layered pattern matching with code co-occurences structure.

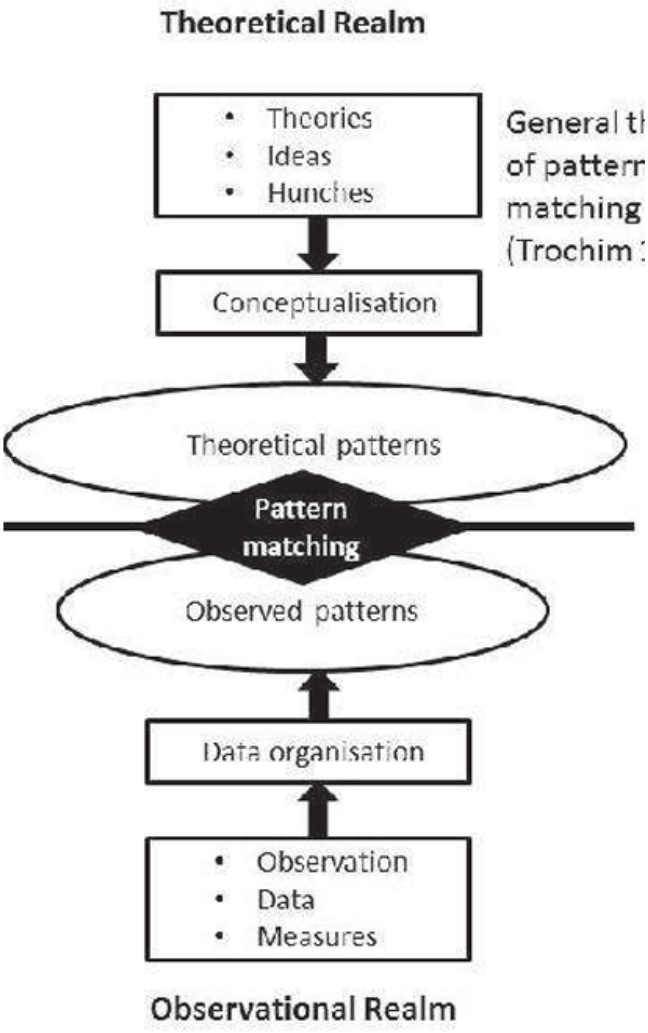

Figure 10: Visualization of the general logic of pattern matching (Sinkovics, 2018).

CHAPTER 6

STUDY RESULTS

This chapter reports the findings from the empirical study in three sections: first layer sub-thematic integration, second layer sub-thematic integration, and overarching findings. The chapter concludes with a referral to the integration of the empirical study results in the design phase.

Chapter Contents

6.1 WATER TRANSIT SYSTEMS VS. BUSINESS MODEL FRAMEWORK
- 6.1.1 Ferry-oriented development vs. business model components
- 6.1.2 System components vs. business model components
- 6.1.3 System principles vs. business model components
- 6.1.4 Tender lifetime, operating profile, and fleet financing vs. business model components

6.2 WATER TRANSIT SYSTEMS VS. SUSTAINABILITY, INNOVATION, & SUSTAINABLE BUSINESS MODEL INNOVATION
- 6.2.1 Ferry-oriented development
- 6.2.2 System components
- 6.2.3 System principles
- 6.2.4 Tender lifetime, operating profile, and fleet financing

6.3 OVERARCHING FINDINGS
- 6.3.1 Ferry-oriented development
- 6.3.2 System components
- 6.3.3 System principles
- 6.3.4 Tender lifetime, operating profile, and fleet financing

6.4 RESULTS DESIGN INTEGRATION

6

To answer the research question, the findings are discerned into three layers of sub-thematic integration. Pattern matching is approached via two layers of analysis. The first layer investigates code co-occurrences between Water Transit System (WTS) sub-themes and Business Model (BM) sub-themes (Section 6.1). The second layer reports on results from combining WTS sub-themes and Sustainability, Innovation and Sustainable Business Model Innovation (SBMI) interview insights (Section 6.2). Finally, overarching insights, which Noel (2019) refers to as the 'integrated section', and combine insights from both the first and second layers of analysis, are investigated (Section 6.3). To strengthen and illustrate findings in context, each section contains quotations from empirical interviews. The Results form a basis for design for Sustainable Business Model Innovation for Water Transit Systems, and is therefore built up to form a layered, comprehensive integration between all of its elements. Figure 11 shows the theoretical framework on which the layered result dissemination was based. The specific layers are shown in their respective Results sections.

A note should be made on how the value proposition (a business model component) was investigated in analysis. In a business model analysis, the value proposition is usually from the perspective of the customer, i.e. 'customer value proposition' (CVP). However, in a water transit system, the customer can be defined from multiple points of view. It can be the passenger that is using the travel service, it can be the crew or the Operator that is a Shipyard customer, it can be the Shipyard, that is a customer of the Province, it can just as well be the Municipality, whose citizens that they represent use the service. Therefore, all these parties were considered in the analysis of the value proposition, both in what they offer (Offering) and what they need done (JTBD) in the system. Another note for the results is that in the case of POW Rotterdam-Drechtsteden, the Municipality, the Client (i.e. the Province) and the Operator are separate entities. However, in other cases these might be merged. In Dubai, for example, the Client represents the governmental institute that publishes the tender but is simultaneously the Operator. In Copenhagen, the Municipality is also the Client, but the tender was published through a third party, a commercial transit agency.

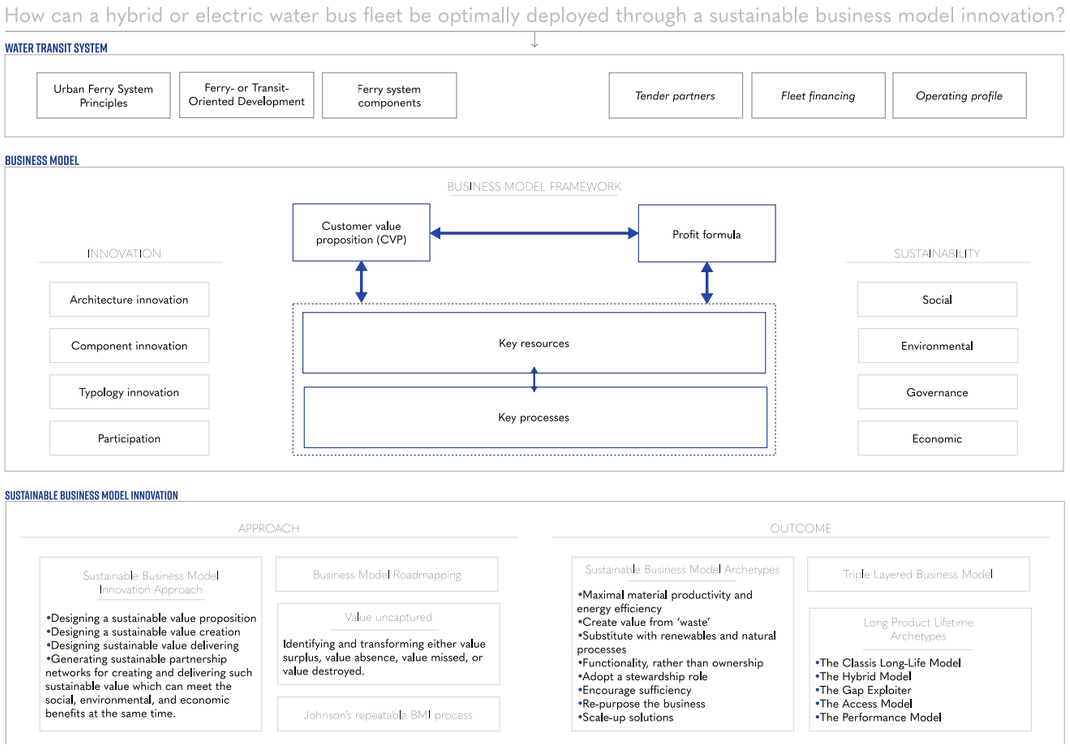

Figure 11: Theoretical framework basis without pattern matching visualizations

6.1 WATER TRANSIT SYSTEMS VS. BUSINESS MODEL FRAMEWORK

This section discusses the results of the first layer pattern matching between sub-themes of WTS and the components of the Four-Box Business Model Framework. The sub-themes are as defined in the theoretical framework and research protocol. Figure 12 shows the visual representation of this connection in the theoretical framework.

6.1.1 FERRY-ORIENTED DEVELOPMENT VS. BUSINESS MODEL COMPONENTS

Profit formula

Through analysis of co-occurrence of Ferry-Oriented Development (FOD) sub-themes and business model sub-themes, various matches and dependencies were identified. FOD is found to be largely dependent on municipality initiative and budget to increase economic value of the terminals, because the Municipality retains ownership and responsibility of them when a WTS is put in place. Increasing terminal economic value can be done by making them more attractive and partnering with commercial initiatives. Terminal costs, including maintenance and construction, are additionally for the Municipality's account. This often results in little action being taken to create attractive stops. Altering terminal locations, to facilitate increased area property value or for adding convenient charging stations is challenging because of municipality ownership and habitual passenger travel behavior. To shape the revenue model with regards to FOD, collaborations with touristic attractions could produce combo-tickets to increase sales, but its profitability depends on circumstantial factors such as weather conditions or holidays. It is also found that when WTS is set up for the sole purpose of providing touristic destinations with targeted ferry services, it depends on the touristic destination's demand and development and therefore its success is found to be rather volatile.

Value proposition

Terminal design influences the job that the crew needs done; for example, whether mooring can be done from the captain's cabin or if a deckhand needs to be present, which in turn impacts the Shipyard's design process and consequential vessel offering. For passengers, strategically placing ferry terminals in remote country-side areas can provide value of connectivity and a comfortable alternative to public transportation such as bus, tram, train and metro.

Key processes and resources

Partnerships and alliances are important to the collaborative processes between project and advisory groups and stakeholders to shape terminals and high potential locations. Scalability goes hand in hand with the found potential of WTS to increase house prices around areas all over the world. Whether the Shipyard invests in an integrated offer – which could include additional commercial services at the terminal – is related to company behavioral norms. Furthermore, successfully operating innovative vessels were found to depend

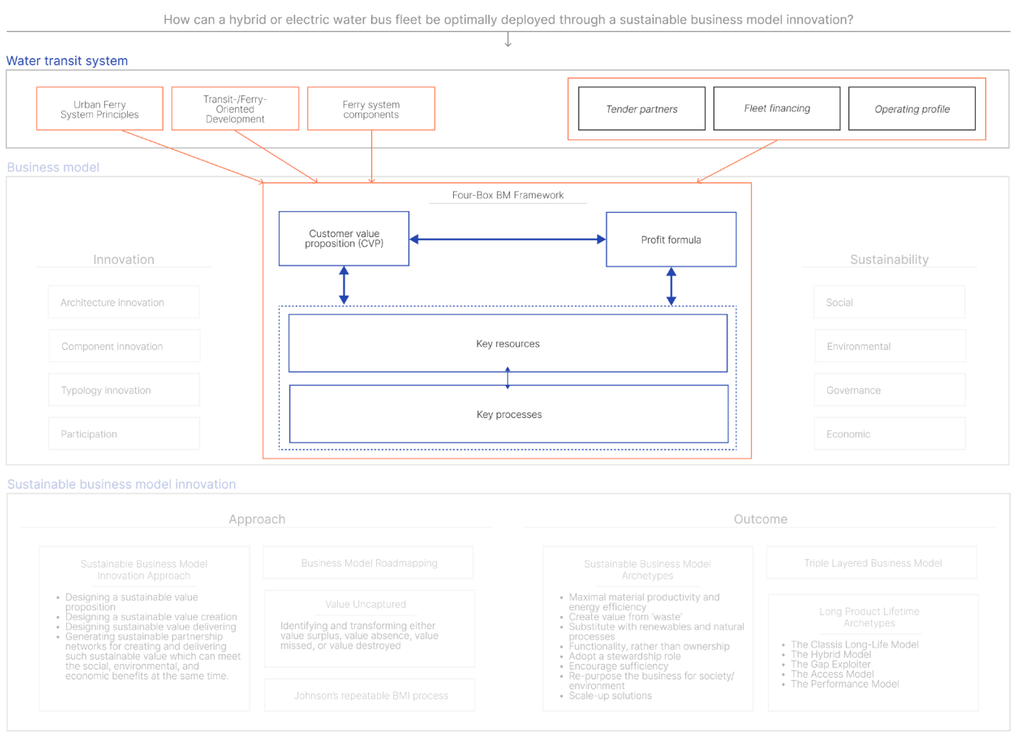

Figure 12: First layer pattern matching visualization

on whether the Operator invests more in the product or the terminal to fit the new operating profile, thus related to business rules and success metrics, and the design process.

Terminal marketing could be helpful to promote the touristic destinations along the WTS route and whether people choose the ferry system over alternative public transportation is additionally largely dependent on marketing efforts and information availability.

6.1.2 SYSTEM COMPONENTS VS. BUSINESS MODEL COMPONENTS

Profit formula

Through analysis of co-occurrence of system components and business model components in the interviews, various matches and dependencies were identified. Firstly, the vessel design, its operational capabilities and operating costs are closely linked to the shape of the profit formula of a WTS. Robust vessel design will keep maintenance costs low, and therefore necessary downtime of the vessels low as well. When there is a high proportional downtime, it means the vessel cannot make revenue and is transformed into a cost item until it is running again.

Ticket fare and route design are connected within the profit formula as well. For many government-funded WTSs, ticket fare is fixed to protect the consumer. Interviewees, however, mentioned that for the WTS to be profitable, it should depend on the passenger time spent aboard and the capacity of the ship. Cross-river or linear ferry routes will transfer more people in less time and consequently generate more revenue, and they are easier to operate than long distance. In the specific case of the Waterbus for POW in Zuid-Holland, it was found that when the vessel is operating, its 'Operating Expenditures' (OPEX), which include charging batteries - the choice and price of the battery depend on the required range – and services are too high to be compensated by sales revenue and funding from the Province. Furthermore, because the Waterbus was designed for increased bike capacity, it has limited people capacity, which needs to be compensated with higher service frequencies and top speed sailing - which in turn requires peek sharing (hybrid) and thus more energy and higher costs.

Another OPEX related to passenger satisfaction is that during colder months, more energy is required to heat the boats for comfort, which is done with a diesel heating system. It was furthermore found that scheduling - stop time, frequency, duration of the route – affects the profit formula. The risk of vessel damage and increased mooring time, among other factors, depends on how many times a day the vessel needs to dock and what the mooring circumstances are (i.e. floating jetties, fenders). If the schedule is tight, there is more time pressure, more docking in a day, thus more risk. The Operator, together with DFS in the case of the Waterbus, carries costs for damage and penalties for not making schedules. Further costs are made in staff, technical service, buildings, crew, depreciation and energy - depending on energy prices at locations and times, or more expensive biodiesel.

Value proposition

On the one hand, the value proposition linked to system components forms a close relation between crew, passenger and Workboats jobs-to-be-done (JTBD) and offering. The crew need easy and uncomplicated ship handling, safety on board, and software setting locks so they cannot be altered and messing with the board systems. These

are factors that Workboats can offer with vessel design. This can include autonomous fault finding, matching vessel design to operations and design for various maritime circumstances. Passenger JTBDs, like passenger satisfaction, include a comfortable and safe interior, a city view from the water, high quality transport to touristic destinations, bike room, protection from weather (i.e. rain or waves), more outdoor space in warmer locations and conversely more indoor space in colder locations. To these JTBDs Workboats can contribute by offering smooth passenger loading and unloading flow, passenger experience research, design for passenger use implications in different cultures (i.e. in Abu Dhabi, WTS passengers are almost only tourists wanting to be outside because civilians see public transport as a symbol of lower status), and reduced wake and noise for comfortable transport.

On the other hand, value proposition for system components is also found to be a close link between the JTBD and offering of the Municipality, the Client, DFS, and the Operator. The municipality and the client in the case of POW Rotterdam-Drechtsteden are separate entities, but both require a prestige project (distinguishment from other regions), connection between municipalities, minimal wake to not disturb other waterway users, multidisciplinary advice from partners, and EU regulation compliance.

The Operator and DFS – also separate entities, but closely related in value proposition due to the unique circumstances as explained in the Empirical Context – can offer attraction, connection and accessibility for tourists and commuters to use the WTS, frequent waterway transport, passenger satisfaction through product requirements for Workboats, basic vessel care and maintenance, facilitation of transition to electric or hybrid WTS, retained responsibility for vessel service and quality, and lower CAPEX and risk management.

An important potential Client offering mentioned multiple times by participants was whether they had an innovative mindset. When the Shipyard and Operator are given space to innovate for sustainable solutions without many restrictions, the probability of a successful design increases. This is visible in the relatively successful tendering process of the electric ferry service in Copenhagen, especially when compared to the relatively complex case of POW Rotterdam-Drechtsteden.

Key resources and processes

Though there is ambition for sustainable development of WTS all around the world, interviewees mentioned that the main criterium for operators to invest in assets (i.e. behavioral norm) will always be costs. Therefore subsidies and regulations are necessary to realize sustainable development. Maintenance during operation of WTS is often outsourced to cheaper partners as well, which is unprofitable for both the Shipyard and the Operator because it is a risk to the quality and useful lifetime of the ships.

6.1.3 SYSTEM PRINCIPLES VS. BUSINESS MODEL COMPONENTS

Profit formula

Connecting ferry system principles with the profit formula yields the following main insights: connecting terminal locations to commercial destinations influences the passenger usage types of the WTS and its necessary additives (e.g. rental bikes). Furthermore, collaborations with touristic destinations or transport modes (e.g. cruises) could result in higher priced combo-tickets.

Value proposition

The value proposition and system principle *modal integration into transportation planning* is found to match on Municipality and Client JTBD. They both would benefit from WTS compatibility to alternative transportation modes and existing public transport infrastructure.

The value proposition aligns with the system principle *seamless integration with land-side connections,* addressing the Municipality and Client JTBD of enhancing the region's economic value through construction, employment and connection to remote areas. In contrast, the Municipality and Province can offer biking route connections, strategically chosen terminal locations, increased passenger awareness and digital accessibility.

The third principle, *maximal economic development potential of the system's landings and terminals*, is linked to the Municipality and Client JTBD of increasing area property value. This connection includes their potential offerings such as terminal marketing to boost patronage, terminal attractiveness and commercial presence, and strategically choosing terminal locations based on touristic destinations or activities (e.g., cruise ship harbors or malls) to help create a market for WTS. This is in turn related to DFS and Operator JTBD of increased time spent at terminals for spillover activity of the WTS into alternative revenue streams.

Next, *maximal environmental benefits and minimal adverse environmental effects*, relate to Client, Operator and DFS JTBD of faster water transit than other – less environmentally friendly – transportation modes. Furthermore, Municipality and Client JTBDs include reduced traffic congestion, affordable, green public transportation, reduced local emissions, preservation of natural environments (by limiting construction projects) and increased sustainable innovation. The Client and Municipality can facilitate this through offering subsidies and waterway monopoly, publishing 'green' tenders and prescribing regulations.

Maximal safety and security can be linked to Workboats potential offering of impact assessments of assets, pilot testing, autonomous fault finding, operations automation and robust and stable concepts. Furthermore, the Operator can offer design requirements and input, high quality vessel care – outsourced if needed – and the Crew can offer intrinsic interest in new assets to create a knowledge base for handling vessels in various situations. The JTBD related to safety and security for passengers is to be protected from the elements and maritime conditions, and for the interior to be safe at various speeds. The Operator would furthermore benefit from the ability to service the vessel itself for small repairs, have access to equipment and knowledge, and affordable quality service providers.

Lastly, the principle *creating ferry systems for freight* is found to match with DFS' need for sustainable innovation in the maritime sector in terms of vessels that last beyond one tender term, so that they are available for, for example, further leasing to another client. It can furthermore be linked to the Client and Municipality JTBD of reducing traffic congestion and Workboats potential offering of modular vessel design.

6.1.4 TENDER LIFETIME, OPERATING PROFILE, FLEET FINANCING X BUSINESS MODEL

Profit formula

Interviewee W2 highlighted the complex nature of the Waterbuses' operating profile, and the need to include training for operating such new technological advancements. They emphasized how it should be included in the cost price and selling price of the vessels, as a mandatory additive for the Operator to prevent misuse and damage to the highly

innovative vessels (and therefore extra costs).

Regarding the tender lifetime, it was found that if the tender time is as traditionally, between four to six years, there needs to be a higher target unit margin because that would be too short to write off a much more expensive fully electric ferry. It is therefore found to be beneficial to increase tender periods for electric or hybrid WTS.

Fleet financing is related to the profit formula in that a balance needs to be found between OPEX and CAPEX. Financing the fleet with a DFS solution will reduce CAPEX – and spread costs over the financing period, or tender period, with reduced financial risk for the Operator and an extra revenue stream for Damen. Component replacements can in that case also be postponed to the next tender holder.

Value proposition

Extending the tender will allow spreading of depreciation of the fleet over a longer period, which is desirable for the Operator as the periodic payments will be lower. Furthermore, financing the fleet with a shipyard financier will create more financial self-sufficiency of the WTS, which is a JTBD for the Municipality and client who do not further want to invest in the system after initial subsidies. DFS' solutions can offer limitation of the financial risk of being first adapters of complex technology for both the Operator and the Client – who require sustainable solutions – by selling the functionality instead of the assets itself.

Key resources and processes

Financing the fleet with a DFS solution is for the Operator a choice based on key processes of behavioral norms and business rules: an operational lease allows spreading of costs - which makes it more accessible to acquire expensive (green) alternatives. It is also beneficial for DFS, as, after the tender lifetime, the fleet still has residual value. This will be around 25% of the original value, for which the new Operator can take them over.

Key resources funding and responsibility are closely related to adjustments of the terminal to fit WTS operational profiles. The terminals, however, belong to the Municipality, so if the new vessel operational profile requires terminal re-design, funding for this, as well as responsibility to design and construct it, is a discussion point. The Client and Municipalities only want to offer the predetermined sum for operating the WTS.

Another consideration regarding financing and partnerships and alliances is the financial maturity of the partners. Fleet financing should only be done with partners on which can be relied to perform adequate service to repay the amounts to the financier.

6.2 WATER TRANSIT SYSTEMS VS. SUSTAINABILITY, INNOVATION, SUSTAINABLE BUSINESS MODEL INNOVATION

This section discusses the results of the second layer pattern matching between sub-themes of WTS and sustainability, WTS and innovation and WTS and SBMI. The sub-themes are as defined in the theoretical framework and research protocol. Figure 13 shows the visual representation of this connection in the theoretical framework.

6.2.1 FERRY-ORIENTED DEVELOPMENT

Sustainability

An opportunity for sustainability in FOD was found to be in the fact that the system can be optimized by matching the terminal design with the ferry, by combining electric vessel charging time with mooring and passenger (un)loading as exemplified by the ferry system designed by Damen in Copenhagen.

Improved accessibility of remote areas through the implementation of a WTS could also contribute to

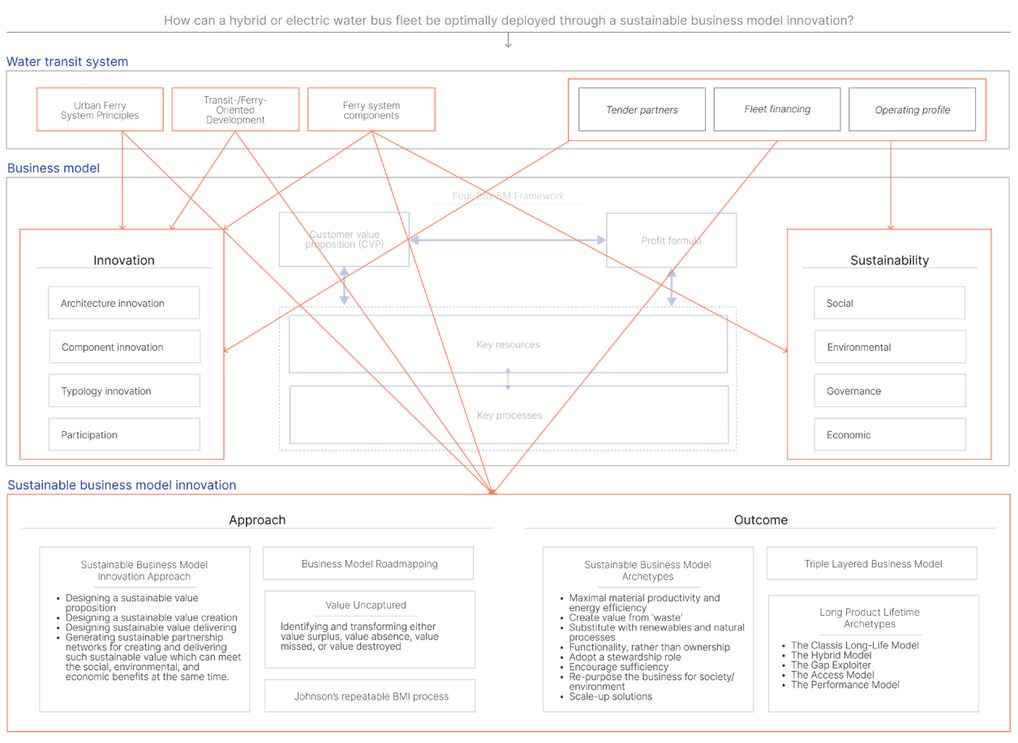

Figure 13: Second layer pattern matching

economic development of the surrounding area by increasing residential, touristic and real estate value.

Sustainability challenges related to FOD are that electrifying an existing operation is difficult as it is hard to control because people are used to terminal locations. Another terminal location related difficulty is that if stops are further apart, you need to sail faster, which requires more battery power, so longer distances along the coast are difficult to make a schedule for.

Innovation

An opportunity for business components and in this case simultaneously typology innovation was suggested by interviewee W2 as creating an integrated offer within Damen: adding a pontoon offer or a jetty or make partnerships to integrate a full systemic offer with the vessel sale.

6.2.2 SYSTEM COMPONENTS

Sustainability

Sustainability opportunities in terms of system components were found to be that electric, hybrid but even diesel-driven WTS to support a traffic flow can dampen pressure from polluting freight traffic, car traffic, public transport. Additionally, electric and hybrid vessel design is more compliant to regulations for CO2 emissions and fuel and emissions will ultimately be taxed higher than energy consumption, therefore the sustainable business case will become more attractive in terms of operating costs (even though initial investment is higher). Assessments of to what extent already existing material is recycled or reused can additionally be done to identify the largest opportunity spaces for sustainable vessel innovation. For the specific case of the Waterbus, opportunity lies in the fact that electric vessels are designed to last longer than the usual concession time and they could be modified for various maritime conditions, and they could therefore be deployed anywhere around the world.

The route will depend on available fuel locations, and whether the vessel can tank there is dependent on the quality (i.e. sustainability) of the fuel. The same holds for electrical charging stations, it reduces flexibility and influences WTS scheduling. But taking on more fuel or battery on board is heavier, which requires more energy and volume, which induces higher costs. If you then decide to compensate with extra assets, you also create redundancy.

A ship is built with various suppliers and components - they need to also be sustainable, and the sustainable materials need to have certification for ship appliance, largely because vessel design is regulation driven (i.e. Class Societies such as DNV, Bureau Veritas and Lloyds for ship appliance and Atradius Green Label for emissions). Improving the ships' sustainability might require cuts on comfortability in for example, material choice, so the balance needs to be considered as well. There also needs to be a certain degree of flexibility in vessel design to be able to reuse the vessel, but it will always be at the expense of current optimization. Furthermore, for hybrid vessels, using biodiesel (e.g. from grain fields) means tempering with the food supply, but taking from residual waste (i.e. vegetable oil), for which emissions already occured during its first use and therefore do not have to be accounted for when burned in ship engines, comes at a higher price. Finally, using lighter material will make the ship more vulnerable and expensive to repair.

Some more challenges for sustainability related to the sub-theme system components are that electric ferries have a limited range and are less flexible "en route" because a charging station needs to be placed. Additionally, adding batteries to improve flexibility is very expensive, so it needs to be compensated for with the services, weight and cost of the ship. Batteries also wear out over time, so the number of times they are running a cycle (charging, depleting), thus how the schedule is shaped influences durability and quality. A multidimensional optimization study and conceptual approach rather than simply vessel electrification is therefore needed for designing a hybrid or electric ferry system: e.g. weight, battery capacity, generator power and capacity, charging infrastructure, schedule allowance, maritime conditions, uptime, downtime, all need to be considered to assess sustainability.

Moreover, emissions and environmental impact shift from operational impact (diesel) to manufacturing impact (electric) but it is hard to map out — therefore LCAs and cross-case comparison of operating costs, production implications and end-of-life assessment need to be done to assess sustainability for different vessels. Often though, only CO2 emissions are included in regulations which leads to certain design decisions and limited improvements, while other greenhouse gases like NOx and particulate matter are also important. Consequently, ships that are discarded due to sustainability regulations in one area will still sail for long periods in other areas around the world. There they are no longer checked for quality or classifications.

Innovation

Regarding the innovation of business model components in relation to WTS components, the interview analysis yields the following results: Introducing to the business model not only assembly knowledge but also usage manuals, introducing new green vessels to existing WTSs, introducing new, heavier batteries (which might have implications for passenger capacity), changing maritime regions (which has implications for vessel and infrastructure design), and changing requirements for partnerships and alliances because tender partners need to have higher knowledge for high-end technology usage.

The interviewees mentioned various opportunities for increased revenue for WTS. It was coined that passenger satisfaction in terms of comfort and sustainability in comparison to alternative travel modes could be charged. Other alternative revenue could come from advertising on the side of the ferries or on-board product sales.

In this context, a challenge for BMI was found to be that stakeholders and partners need to also have capacity and readiness for technological innovations (i.e. grid capacity for charging electric vessels or availability of biofuel). For more sustainable solutions to be safely launched into the market, components such as training need to be given to operators and included in vessel costs, which forms an additional barrier to acceptance.

Lastly, to create sustainable solutions on scale there need to be experts available for shipyards who can develop them, and they are increasingly scarce.

Sustainable business model innovation

Two approaches to SBMI for WTS were identified by interviewee W2: either electrifying an existing operation by inserting a sustainable asset or set up an entirely new sustainably driven operation. However, converting existing unsustainable assets to sustainable assets also requires adding new resources (i.e. charging stations and ports). Another sustainability difficulty which is often related to

business model innovation is that reducing a BM resource will decrease (social) sustainability of the BM. One example is that increasing battery capacity will limit passenger capacity. Another is that reducing necessary crew size by automation for cost optimization limits employment opportunities and (re-)usability in developing regions.

The level at which companies take sustainability initiatives is largely dependent on the people it employs and whether they have personal motivation. Therefore, SBMI of WTS is largely dependent on social trends and regulatory components.

6.2.3 SYSTEM PRINCIPLES

Sustainability

The transition to green transportation with minimal environmental effects may be driven by governmental goals and personal ambitions of functionaries. On the one hand this is an opportunity, on the other WTSs dependency on initiatives and subsidies is risky because it is very susceptible to worldwide political influences.

It was also found that validation strategies in different layers of the design process - including actions to take for various situations - potentially contribute to safety and security as well as agreements on circularity. Conversely, safety and security can be inhibited by cheap, less environmentally conscious and low-quality service and repair parties.

Hybrid or electric WTS can furthermore mostly contribute to reducing local emissions - compared to global emissions - for urban areas and is in that way achieving minimal local environmental impact with passenger transportation. A social sustainability aspect of WTS system principles is modal integration into transportation planning through the connection of bike routes and high bike capacity on the ferries, which improves livability and reduces cars in the city, improved accessibility of remote areas and affordable travel. An added benefit of WTS in urban areas could be the usage of the vessels for freight transportation to further relieve pressure on conventional automotive traffic routes. Modularity in vessel design to enable reconstruction for other applications such as freight transportation will however be at the cost of the current optimization of the ship.

Innovation

Business model components such as training, operating conditions and information need to be added for sustainable innovations to be safely and securely deployed, and to create overall market and client readiness. Another innovation, to create opportunities for seamless integration with land-side connections and spillover economic activity from terminals into nearby commercial destinations, is to form new partnerships with construction agencies (e.g. Tabodin, Brunel) and commercial parties. BM typology innovation could be further realized by designing assets and a system for return and upgrades to zero-emission by the original manufacturer.

In the context of system principles, a challenge for BMI was found to be that the energy transition is believed to produce no direct economic benefits. According to participant E2, the energy transition is a regulation-driven transition and therefore a socially driven transition - because we think it is necessary, and we make the rules.

6.2.4 TENDER LIFETIME, OPERATING PROFILE, FLEET FINANCING

Sustainability

Relating sustainability to tender lifetime, there lies opportunity in increasing accessibility of WTS by making automation so functional that ferries can be used all around the world, also on continents that are technologically less advanced than others and the product's useful lifetimes can be increased beyond the tender it was built for.

Few shipyards have the knowledge and capabilities for maintenance of electric vessels, which puts the shipyard that builds them in a position to have higher design and sustainability standards, especially if they are going to be taken back after the concession. The useful lifetime of the ships and their need for repairs also depend on the crew's capabilities and the Operator's knowledge. Its serviceability after the concession determines its second-hand value as well. Designing ships and systems for return to the shipyard after tender lifetimes also enables responsibility and freedom over sustainable material choices and the ability to close the loop. For example, current practice is that smaller aluminum ships are disassembled on location and the residual material is locally sold or brought to scrap because ownership and care is lost.

Vessels at Damen are designed for easy disassembly (not necessarily for the purpose of sustainability), which is an opportunity for circularity of materials. Reusability, recyclability and up-cyclability of ship hulls however, depends on suppliers and available channels (e.g. are the ships being brought back to Damen at end-of-life and does Damen have the facilities for it?). Choices in circular material are furthermore largely dependent on suppliers and whether clients want to pay for it and take the risk because they are not proven yet. The only way to prove its effectiveness is to wait 30 years and compare it with traditional material. All around the world, there is a need for ferries, which improves the potential for reuse in other tenders with minor vessel modifications, before starting disassembly. On the flip side, careful, quality service to maintain and extend the vessel's lifetime is expensive and therefore limited in public tenders where operators have little maritime knowledge. Also, if ownership shifts over the vessel's lifetime, the new owner needs to also be willing to take responsibility for closing the loop. And, in that time, waste streams on which sustainable vessel design is currently based might not exist or be relevant in 30 years, when the ships are ready to be dismantled. New developments in general have no proof-of-concept over longer periods of time, so a client and the shipyard can only have a limited understanding of the innovative solutions and their (dis)advantages.

When looking at the operating profile, fleet management and sustainability go hand in hand: if electrical assets are used 90% of the time, but in an emergency, you have a diesel-driven asset available, that will still be a large improvement. In electric ferries the battery pack is matched to the operational profile to have just enough to do the operation safely, including the aging of the battery. Because electric systems are so inflexible and complex, it only needs to suffice for the specific operational profile it is designed for to save space and money. WTSs with longer distances along the coast, are therefore hardly doable for electric ferries because when they need to sail faster to make the schedule it will cost more battery power, for which there is no room on board. In contrast, WTSs in a city with relatively short distances in the route design and charging infrastructure when its mooring is a perfectly doable operational profile for electric ferries.

Matching fleet financing with sustainability, it is found that electric ferries require high start-up investments (CAPEX) from the client, but have low operating costs, and might be in a future positive position regarding taxing on unsustainable fuels.

However, sustainable innovation carries higher risk because it essentially has no proof-of-concept yet; the question is who is going to be responsible for that risk. Therefore, there needs to be commercial demand for emission-free ferry systems. If the government demands it, the Operator will still choose the lowest cost, most commercial vessel that meets the requirements. In this context, a full operational lease from Damen puts Damen in a position to retain an obligation for service and maintenance from the Operator, thus improving the ship's usage and value creation at end-of-life. If financed, subsidized and commercialized sufficiently, WTS can create a positive social impact with public transportation services for people who otherwise cannot afford it, because fares are set.

Sustainability

An innovation relating to tender lifetime was found to be retained product ownership to influence lifetime extension, reuse and end-of-life handling. Innovations matched to the operating profile include: developing manuals for operating complex technology and making it part of the cost structure, and developing ferries for longer distances and seagoing conditions.

With regards to fleet financing, a typology innovation was found as shifting value creation by the Shipyard from only building and selling to creating, financing and operating the vessels. DFS already offers solutions, rather than vessels, which allows revenue from financing objects and services as well as vessel sales. The circular economy could be for the Shipyard to fully shift to no longer selling a product but a function. The drawback is the complexity of partnership responsibility distribution. Another challenge related to transitioning to an electrified operating profile is that certain routes are technologically still impossible because suppliers' capacity is lacking. For example, the energy grid at the moment doesn't allow the necessary charge and discharge needed for longer electrified ferry routes and it is furthermore dependent on the operating location and impossible to verify its 'greenness'. Lastly, scaling up would be difficult because of the sensitive/inflexible timetable and operational profile of electric ferries in comparison to 'limitless' diesel-driven ferries.

Sustainable business model innovation

An approach to SBMI of existing WTSs is to draw knowledge from previously electrified, comparable services – such as buses – to innovate for an electrified operating profile. An outcome of SBMI could include retained responsibility of the Shipyard for the vessels or its components with financing solutions. That would allow it to influence initial design choices, make necessary replacements within the tender of around 10 years and after 20 years return the ships and reuse or recycle them and create new value for it.

6.3 OVERARCHING FINDINGS

Integrating the results from the first layer analysis and the second layer analysis, yields the following key insights of sustainability and innovation in the business model of water transit systems.

6.3.1 FERRY-ORIENTED DEVELOPMENT

FOD, location design and marketing, depends largely on municipality initiative and budget - even though they would benefit from more FOD with higher area property value and collaboration with touristic attractions, as well as connectivity between citizens and public institutions (e.g. hospitals or community centers). Electrifying an existing WTS operation is difficult because the stops need to be placed and designed according to the electric capacity, which requires terminal location change and additional partner responsibility. This could be tackled by integrating it into the Shipyard offering via renewed partnerships. Distances are also limited, which reduces potential offshore ferry system opportunities.

6.3.2 SYSTEM COMPONENTS

Route design, capacity (more bikes mean fewer people but higher modal value), and fare structure are interlinked to form a revenue model that, with subsidies, must exceed total costs (OPEX + CAPEX + penalties). However, sustainability improvements often shift disadvantages elsewhere—for instance, more battery capacity adds weight, reducing passenger space and revenue.

Offerings and JTBD between various stakeholders are closely related. When aligned, in most cases the offering of the one could provide a solution to the JTBD of the other. Revenue opportunities include vessel marketing or premium charges for sustainable travel. A valuable contribution of the Client in setting up the tender requirements and therefore WTS, is an innovative mindset - space for the applying parties to create and design sustainable, and feasible solutions. Too many requirements will result in promises that cannot be kept, and over-designing.

Regulations and subsidies are essential to reduce cost barriers for sustainable initiatives in WTS. Sustainability transitions are socially driven, needing employee engagement and public consensus. This however, makes it very susceptible to worldwide political views. Additionally, regulation is often one-sided (e.g. only CO2-based), and sustainability resources (like clean fuel) may not be universally available. Some practices may furthermore relocate to regions where regulations do not apply after the tender lifetime.

6.3.3 SYSTEM PRINCIPLES

Clients and Municipalities should initiate integration of WTS with land transport through construction, route design, and information provision. They can enhance terminals with strategic locations and marketing (e.g. near cruise terminals). Intrinsic environmental benefits of WTS include traffic congestion relief, environmentally friendly and affordable transport, reduced local emissions, and nature preservation (no roads/rails/bridges are necessary).

Vessel safety can be improved through crew training and sense of ownership, robust design, and autonomous fault finding. Adding freight transportation services may create additional revenue and reduce road pressure thus increasing livability, though it may compromise vessel optimization for passenger transport.

6.4 RESULTS DESIGN INTEGRATION

6.3.4 OPERATING PROFILE, FLEET FINANCING, TENDER LIFETIME

Currently, the Shipyard that builds electric ferries, which require high start-up investment but low operating costs, still has the advantage of technological knowledge and capabilities. This enables high sustainability standards, longer lifespan, and second-hand value. To transfer this to operations, training and understanding of the vessel operating profile should be included in its cost price as a mandatory additive to prevent damage and misuse.

A disadvantage of financing vessels for a specific tender period is that necessary maintenance or replacements are often postponed to the next tender holder, to reduce short-term costs or capital expenditure — even though this can accelerate depreciation.

A circular WTS model would shift from asset sales to function sales, keeping control over the vessel lifecycle. This requires design for disassembly, material flow management, end-of-life planning, client accountability, and proof-of-concept.

The results that were presented in this chapter were used to inform the design outcomes of this thesis: the Pyramid Toolkit and the Waterbus strategy. How these results were integrated into the ideation and conceptualization phases is discussed in Part 3: Design.

PART 2
MODEL

CHAPTER 7

THE PYRAMID TOOLKIT

This chapter introduces the first part of the final design outcome of this thesis: The Pyramid Toolkit. The Pyramid and the components of the toolkit (innovation cards, co-creation methodology, and innovation strategy template) are presented in the form of a user manual.

THE PYRAMID TOOLKIT

USER MANUAL

This booklet is a user manual for the Pyramid Toolkit: a business-oriented tool for driving sustainable innovation in water transit systems. The tool can be used by any organisation wanting to sustainably innovate the business model of a water transit system.

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   - Preparation
   - Idea generation

5. FROM IDEAS TO AN INNOVATION STRATEGY

The Pyramid Tool:
A business-oriented tool for driving sustainable innovation in water transit systems

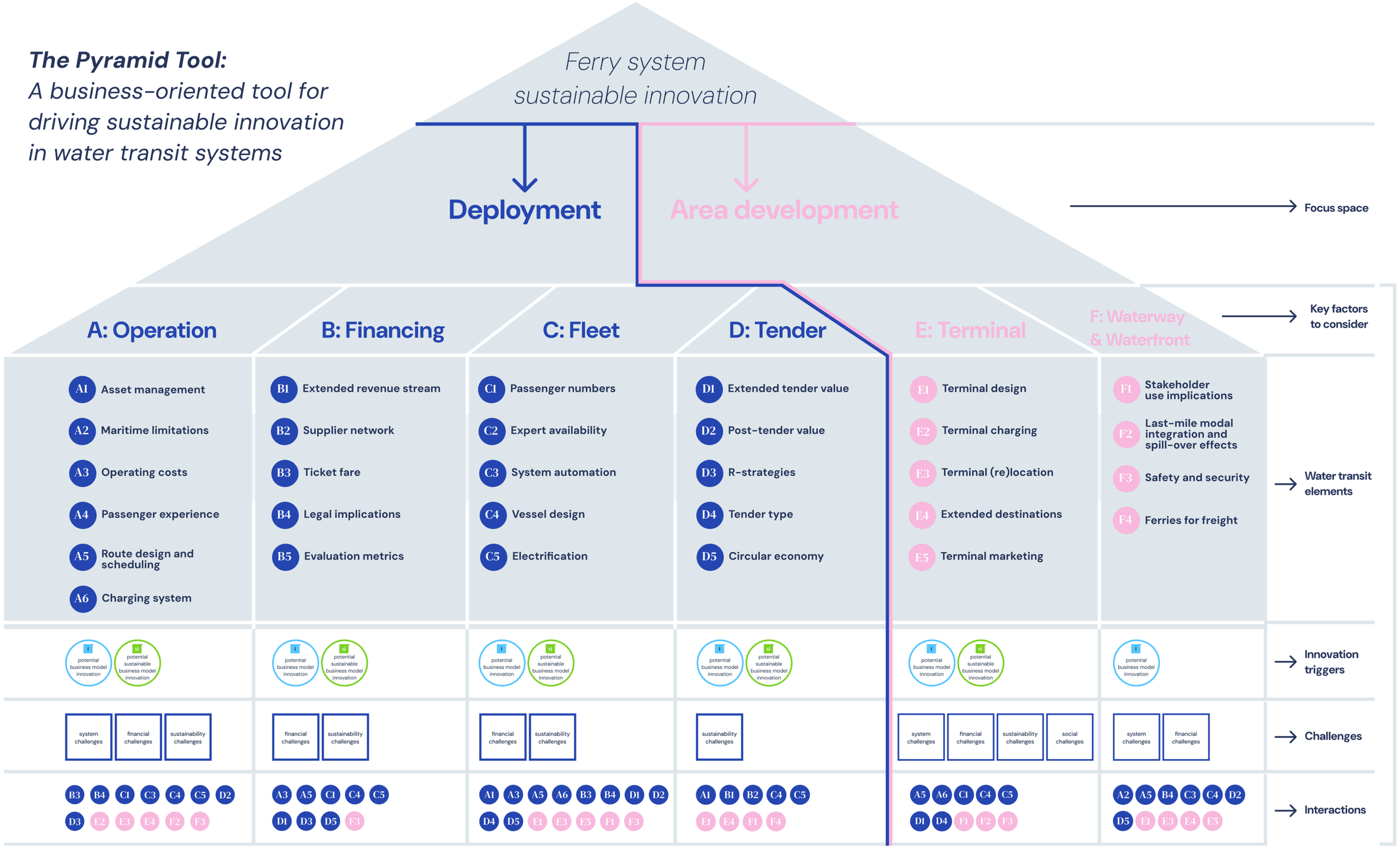


Figure 14: The Pyramid Tool: A business-oriented tool for driving sustainable innovation in water transit systems

1 ORIGIN & DESIGN

The Pyramid Toolkit originates from a Master's thesis project at Delft University of Technology, Faculty of Industrial Design Engineering. It was initially developed to support sustainable innovation in the business model of the Waterbus ferry system in the Rotterdam–Drechtsteden area, the Netherlands. However, the tool represents a broader approach to sustainable business model innovation for water transit systems, enabling its application in various maritime regions and by multidisciplinary organisations aiming to deploy or develop hybrid or electric ferry systems. The information and structures in the Pyramid are based on scientific literature and empirical qualitative research conducted as part of the Master's thesis.

The Pyramid is defined by two main things: 1) a visual model that explains the structure of passenger transport over water, from a business perspective, and 2) a tool that helps the organization that is working on water transit to innovate the system, with a focus on sustainability. The Pyramid Toolkit was developed through a rigorous design process involving multiple iterations and refinements, peer feedback, a case study, and academic review. It was made to present the systemic complexity of water transit in a visual, hierarchical format, making it more comprehensible and the information more usable for systemic innovation. The tool is intended as a foundation and starting point for innovation from within participating organisations. It is not a strategy in itself, but a driver for generating ideas toward sustainable innovation. This manual describes the various components of the Pyramid Toolkit, and explains how it can be used to co-create an innovation strategy. The user manual also contains handouts that can be printed for physical co-creation sessions.

I hope you find the Pyramid Toolkit useful, and that it yields more and improved sustainable ferry systems all around the world!

July, 2025

2 THE PYRAMID TOOL

The Pyramid Tool contains multiple components, in hierarchical order, starting from the top of the pyramid and moving down to the square foundation. These are the parts, sub-parts, and sub-sub-parts of a water transit system, originating from a business perspective. The first layer describes two 'focus spaces'. These focus the innovation strategy either towards the deployment of the system, or area development as a results of the water transit presence. The 'key factors' are factors that can be considered to innovate on within these focus spaces, and they represent what should in any case be taken into account by participating organizations. The key factors are divided into 'water transit elements'. These are more detailed components functioning as potential improvement areas. One or multiple of the water transit elements per key factor can be selected for innovation, depending on their relevance for the organization.

FOCUS SPACES

Deployment

The Deployment focus space is about everything that has to do with setting up, or managing the water transit system if it has already been set up. This includes the key factors: Operation, Financing, Fleet, and Tender. When using the Pyramid Toolkit, starting with the Deployment focus space is recommended. This will allow the organization to check whether everything that is needed for the system to properly function is in place, and whether the basis can be improved before moving towards Area Development.

Area development

The Area Development focus space is centered around the idea that the presence of a ferry system in an area has the potential to drive (economic) development of the region or city. This can be in terms of area property value, urban livability, touristic industry flourishment, environmental impact and/or commercial opportunity. The Area Development focus space is useful to investigate after deployment of the system, when the system is stable, and further innovation of it can drive overall prosperity for all stakeholders.

DEPLOYMENT KEY FACTORS

A: Operation

Operation includes the elements *asset management, maritime limitations, operating costs, passenger experience, route design and scheduling, and the charging system* (if present). This key factor describes everything that is of influence for sailing, maintaining and offering the service of the passenger transport over water. The logistics and services such as repair for the operator are included.

B: Financing

Key factor Financing includes water transit elements *extended revenue stream, supplier network, ticket fare, legal implications and evaluation metrics*. Financing is about anything that has to do with financial implications of acquiring or operating the fleet, managing the system's profitability, and financial collaborations within the system.

C: Fleet

The Fleet factor consists of elements *passenger numbers, expert availability, system automation, vessel design and electrification*. Anything that influences the deployment of vessels and how they operate by interacting with each other and the system, is included in this factor. Within it, opportunities such as modular ship design and system automation, as well as challenges like limited passenger capacity due to heavy battery integration, are included.

D: Tender

The Tender, or concession, is the formal assignment that a (public) authority, such as a province or government agency, publishes to grant an operator the right to operate a ferry service within a chosen area for a predetermined period, under specific terms and conditions. The Tender key factor includes water transit elements *extended tender value, post-tender value, R-strategy integration, tender type, and circular economy integration*.

AREA DEVELOPMENT KEY FACTORS

D: Terminal

The key factor Terminal is about implications of water transit system factors for the terminal, and how the terminal can contribute to development of the system. Terminal includes *terminal design, terminal charging, terminal (re)location, extended destinations, and terminal marketing*.

E: Waterway & Waterfront

The presence of a water transit system in the waterway and along the waterfront of a certain area can influence its economic, social and environmental development. The implications of the ferry service in terms of its waterway and waterfront use are included in this key factor. The water transit elements are therefore *stakeholder use implications, last-mile modal integration and spill-over effects, safety and security, and ferries for freight*.

3 INNOVATION CARDS

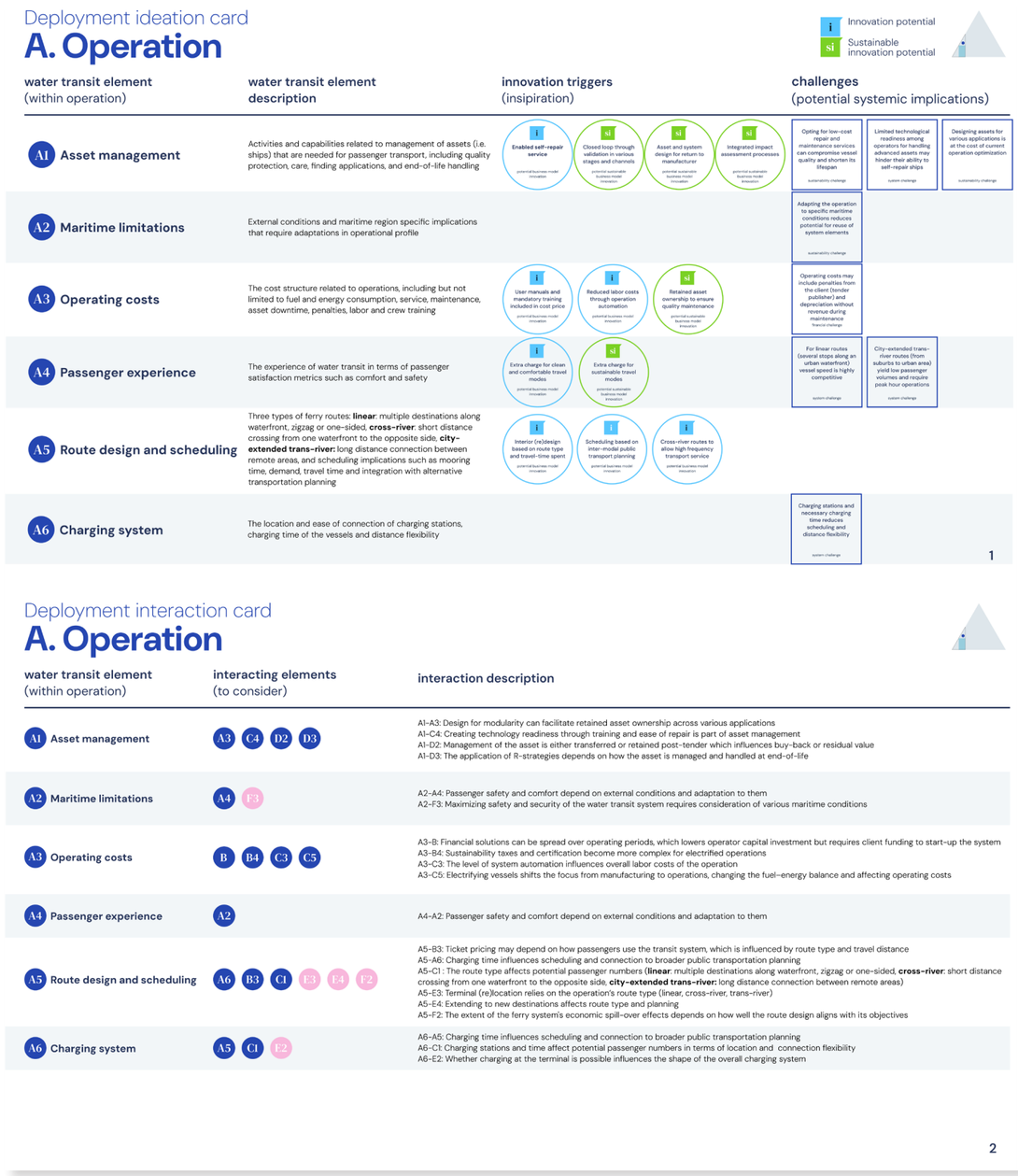
The Pyramid contains a large amount of information, so to enable more comprehensive use, the Toolkit includes two-sided ‘innovation cards’ for each key factor to consider. On the front is the ‘ideation card’, and on the back, the ‘interaction card’. These cards zoom in on the lower, square part of the Pyramid. The Toolkit provides the innovation cards to explain the water transit elements, highlight which ones to focus on, and describe their function within the entire system. They extend the information found in the Pyramid and offer a detailed overview of each element. The cards support purposeful innovation by allowing organisations to select the most relevant and realistic elements to work on.

IDEATION CARD

The front-side of the innovation card is the ideation side. This side is meant to give a broader, deepening insight into the various water transit elements that are presented in the pyramid. It includes a definition of each element, its innovation triggers and challenges. The innovation triggers are intended to inspire ideation. They present example innovations, some with an explicit sustainability focus, related to the chosen water transit element. The challenges represent potential systemic issues or implications associated with the water transit element. Some are directly linked to the innovation triggers, and others highlight separate challenges surrounding the element. The ideation card is designed to spark idea generation from a starting point grounded in literature and empirical insights, to create a meaningful innovation strategy.

INTERACTION CARD

The back-side of the innovation card is the interaction side. The interaction card shows how the water transit elements exist as part of the larger system. It illustrates how various elements within the system interact with one another and serves as a deepening exercise, to form a more comprehensive view of how these elements function as part of the whole. The interaction card emphasizes that the elements should not be considered in isolation.



Deployment ideation card

A. Operation

i Innovation potential

Si Sustainable innovation potential

water transit element (within operation)	water transit element description	innovation triggers (insipiration)	challenges (potential systemic implications)
A1 Asset management	Activities and capabilities related to management of assets (i.e. ships) that are needed for passenger transport, including quality protection, care, finding applications, and end-of-life handling	i Enabled self-repair service; Si Closed loop through validation in various stages and channels; Si Asset and system design for return to manufacturer; Si Integrated impact assessment processes	Opting for low-cost repair and maintenance services can compromise vessel quality and shorten its lifespan (sustainability challenge); Limited technological readiness among operators for handling advanced assets may hinder their ability to self-repair ships (system challenge); Designing assets for various applications is at the cost of current operation optimization (sustainability challenge)
A2 Maritime limitations	External conditions and maritime region specific implications that require adaptations in operational profile		Adapting the operation to specific maritime conditions reduces potential for reuse of system elements (sustainability challenge)
A3 Operating costs	The cost structure related to operations, including but not limited to fuel and energy consumption, service, maintenance, asset downtime, penalties, labor and crew training	i User manuals and mandatory training included in cost price; i Reduced labor costs through operation automation; Si Retained asset ownership to ensure quality maintenance	Operating costs may include penalties from the client (border publisher) and depreciation without revenue during maintenance (financial challenge)
A4 Passenger experience	The experience of water transit in terms of passenger satisfaction metrics such as comfort and safety	i Extra charge for clean and comfortable travel modes; Si Extra charge for sustainable travel modes	For linear routes (several stops along an urban waterfront) vessel speed is highly competitive (system challenge); City-extended trans-river routes (from suburbs to urban area) yield low passenger volumes and require peak hour operations (system challenge)
A5 Route design and scheduling	Three types of ferry routes: **linear**: multiple destinations along waterfront, zigzag or one-sided, **cross-river**: short distance crossing from one waterfront to the opposite side, **city-extended trans-river:** long distance connection between remote areas, and scheduling implications such as mooring time, demand, travel time and integration with alternative transportation planning	i Interior (re)design based on route type and travel-time spent; i Scheduling based on inter-modal public transport planning; i Cross-river routes to allow high frequency transport service	
A6 Charging system	The location and ease of connection of charging stations, charging time of the vessels and distance flexibility		Charging stations and necessary charging time reduces scheduling and distance flexibility (system challenge)

1

Deployment interaction card

A. Operation

water transit element (within operation)	interacting elements (to consider)	interaction description
A1 Asset management	A3 C4 D2 D3	A1–A3: Design for modularity can facilitate retained asset ownership across various applications A1–C4: Creating technology readiness through training and ease of repair is part of asset management A1–D2: Management of the asset is either transferred or retained post-tender which influences buy-back or residual value A1–D3: The application of R-strategies depends on how the asset is managed and handled at end-of-life
A2 Maritime limitations	A4 F3	A2–A4: Passenger safety and comfort depend on external conditions and adaptation to them A2–F3: Maximizing safety and security of the water transit system requires consideration of various maritime conditions
A3 Operating costs	B B4 C3 C5	A3–B: Financial solutions can be spread over operating periods, which lowers operator capital investment but requires client funding to start-up the system A3–B4: Sustainability taxes and certification become more complex for electrified operations A3–C3: The level of system automation influences overall labor costs of the operation A3–C5: Electrifying vessels shifts the focus from manufacturing to operations, changing the fuel–energy balance and affecting operating costs
A4 Passenger experience	A2	A4–A2: Passenger safety and comfort depend on external conditions and adaptation to them
A5 Route design and scheduling	A6 B3 C1 E3 E4 F2	A5–B3: Ticket pricing may depend on how passengers use the transit system, which is influenced by route type and travel distance A5–A6: Charging time influences scheduling and connection to broader public transportation planning A5–C1 : The route type affects potential passenger numbers (**linear**: multiple destinations along waterfront, zigzag or one-sided, **cross-river**: short distance crossing from one waterfront to the opposite side, **city-extended trans-river:** long distance connection between remote areas) A5–E3: Terminal (re)location relies on the operation’s route type (linear, cross-river, trans-river) A5–E4: Extending to new destinations affects route type and planning A5–F2: The extent of the ferry system’s economic spill-over effects depends on how well the route design aligns with its objectives
A6 Charging system	A5 C1 F2	A6–A5: Charging time influences scheduling and connection to broader public transportation planning A6–C1: Charging stations and time affect potential passenger numbers in terms of location and connection flexibility A6–E2: Whether charging at the terminal is possible influences the shape of the overall charging system

2

Deployment ideation card

B. Financing

i Innovation potential

si Sustainable innovation potential

water transit element (within financing)	water transit element description	innovation triggers (insipiration)	challenges (potential systemic implications)
B1 Extended revenue stream	Any alternative revenue streams beyond ticket fares and client subsidies, such as combo tickets, bonuses, or retail income	i Commercial advertising on ship exterior — potential business model innovation	
B2 Supplier network	Suppliers involved across the entire system, including manufacturing, resource supply, maintenance, facilities, and other constructions	si Sustainability requirements for supplier partnerships — potential sustainable business model innovation; si Facilitating and scaling the energy transition through suppliers — potential sustainable business model innovation	There are currently few sustainability-oriented suppliers and resource channels available — sustainability challenge
B3 Ticket fare	Price charged to passengers to access and use the water transit service	i Dynamic pricing — potential business model innovation	The client (i.e. Province) sets a pricing ceiling on public transportation to keep it affordable for the general public — financial challenge
B4 Legal implications	Certifications, regulatory requirements, compliance obligations, and taxes involved in the financing and deployment of a water transit system	si Unsustainable fuel tax inclusion in overall cost calculations — potential sustainable business model innovation	Acquiring green certification for specific system or asset elements may come at the expense of quality in other areas — sustainability challenge; Since regulations are socially constructed, the sustainable transition they drive is inherently dependent on public opinion — sustainability challenge
B5 Evaluation metrics	Criteria for evaluation of partnerships and collaborations based on financial risk	i Standard financial maturity criteria to assess partnerships — potential business model innovation	

Deployment interaction card

B. Financing

water transit element (within financing)	interacting elements (to consider)	interaction description
B1 Extended revenue stream	D1	B1-D1: Extended revenue stream through long depreciation schedules for electric vessels
B2 Supplier network	B5 C5 D3 D5	B2-B5: The choice of supplier network may be influenced by partner evaluation metrics B2-C5: Fleet electrification requires transitioning to new supplier networks B2-D3: Integration of *R*-strategies involves assessment of sustainable practices across system components including supplier networks B2-D5: Integrating circular economy principles into the system requires supplier collaboration to enable scalability and reduce adoption barriers
B3 Ticket fare	A5 C1	B3-A5: Ticket pricing may depend on how passengers use the transit system, which is influenced by route type and travel distance B3-C1: Passenger numbers and their cultural implications could influence ticket pricing
B4 Legal implications	A3 C4 C5 E3	B4-A3: Sustainability taxes and certification become more complex for electrified operations B4-C4: To justify sustainability and market hybrid or electric vessels, green certification needs to be acquired B4-C5: Fleet electrification changes overall impact assessment, which influences how compliance with sustainability regulations is approached B4-F3: Compliance to maritime safety regulations contributes to system safety and security
B5 Evaluation metrics	B2	B5-B2: The choice of supplier network may be influenced by partner evaluation metrics

Deployment ideation card

C. Fleet

i Innovation potential

si Sustainable innovation potential

water transit element (within fleet)	water transit element description	innovation triggers (insipiration)	challenges (potential systemic implications)
C1 Passenger numbers	The patronage, or total number of passengers using the water transit service, potentially in comparison with alternative (competing) public transport modes		Creating space for bikes and battery systems in electric or hybrid vessels requires trade-offs in passenger capacity — financial challenge
C2 Expert availability	Availability of expertise in specific innovation and sustainability areas, such as vessel electrification		Experts drive the energy transition through sustainable innovation, but they are scarcely available — sustainability challenge
C3 System automation	Development of software and hardware to automate processes like fault detection and sailing operations across diverse maritime applications	i Lock on software settings to protect advanced systems — potential business model innovation; i Self-diagnosing systems to improve accessible vessel care — potential business model innovation	Operation automation might limit future employment opportunities — sustainability challenge
C4 Vessel design	All aspects related to design processes and outcomes in vessel development, such as emissions, crew ease of handling, modularity, electrification, interior/exterior design and engine design	i Ship design aimed at uncomplicated operation — potential business model innovation; si Modular ship design to support multiple and varying tenders — potential sustainable business model innovation; si Ship design for multicultural market acceptance — potential sustainable business model innovation	
C5 Electrification	The process of partially or fully electrifying the fleet and its operating system		Electrifying ships makes it more challenging to assess the full environmental impact over the product lifecycle — sustainability challenge; Creating an electric fleet carries the risk of redundant asset production to compensate for vessel charging times — sustainability challenge

Deployment interaction card

C. Fleet

water transit element (within fleet)	interacting elements (to consider)	interaction description
C1 Passenger numbers	A5 A6 B3 C4 E1 E5	C1-A5: The route type affects potential passenger numbers (**linear**: multiple destinations along waterfront, zigzag or one-sided, **cross-river**: short distance crossing from one waterfront to the opposite side, **city-extended trans-river:** long distance connection between remote areas) C1-A6: Charging stations and time affect potential passenger numbers in terms of location and connection flexibility C1-B3: Passenger numbers and their cultural implications could influence ticket pricing C1-C4: Including a battery system in the vessel design, interacts with passenger numbers because of space, weight and speed limitations C1-E1: Terminal design may influence time spent at the terminal and in turn passenger numbers C1-E5: Terminal marketing influences outreach to passengers
C2 Expert availability	C4	C2-C4: An innovative mindset and presence of expertise on the client-side influence how vessels are designed
C3 System automation	A3 F1 F3	C3-A3: The level of system automation influences overall labor costs of the operation C3-F1: The level of system automation affects required crew size and skill level C3-F3: Automation of (part of) the system can contribute to maximizing transit safety and security
C4 Vessel design	A1 B4 C1 C2 C5 D2 D4 D5 E1 E3 F3	C4-A1: Creating technology readiness through training and ease of repair is part of asset management C4-B4: To justify sustainability and market hybrid or electric vessels, green certification needs to be acquired C4-C1: Including a battery system in the vessel design, interacts with passenger numbers because of space, weight and speed limitations C4-C2: An innovative mindset and presence of expertise on the client-side influence how vessels are designed C4-C5: Electrifying the fleet requires vessel innovation C4-D2: The extent to which ferries can be used for other maritime regions influences their post-tender value C4-D4: Vessel design can facilitate use across various tender types C4-D5: Integrating circular economy principles interacts with the sustainability of vessel design processes C4-E1: Vessel design and capabilities affect the terminal's docking requirements C4-E3: Vessel operational capabilities influence terminal (re)location options and decisions C4-F3: Design decisions may influence safety and security during transit or unexpected situations
C5 Electrification	A3 B4 C4 D1 D4 E3	C5-A3: Electrifying vessels shifts the focus from manufacturing to operations, changing the fuel-energy balance and affecting operating costs C5-B4: Fleet electrification changes overall impact assessment, which influences how compliance with sustainability regulations is approached C5-C4: Electrifying the fleet requires vessel innovation C5-D4: First-adopter risk and accessibility can be more prominent in *green* tenders C5-D1: Extended revenue stream through long depreciation schedules for electric vessels C5-E3: The electrification of the system may impact terminal location and potentially require relocation to optimize route efficiency and travel distances

Deployment ideation card

D. Tender

i Innovation potential
si Sustainable innovation potential

water transit element (within tender)	water transit element description	innovation triggers (insipiration)	challenges (potential systemic implications)
D1 Extended tender value	Added value that may be created, captured or delivered from extending the tender period	si: Longer tenders to reduce risk and extend revenue stream (potential sustainable business model innovation)	Extending tender periods increases the likelihood that operators will postpone component replacement and maintenance (sustainability challenge)
D2 Post-tender value	Added value that may be created, captured or delivered at the end of, or after the tender period	i: Retained ownership and buy-back programs (potential business model innovation); si: Retained ownership for improved circularity and material reuse (potential sustainable business model innovation)	Capturing residual asset value post-tender – through circular practices like reuse or recycling – relies on shifting vessel ownership (sustainability challenge)
D3 R-strategy integration	Integration of an R-strategy into the system, prioritized as follows (from highest to lowest): refuse, reduce, reuse, repair, refurbish, remanufacture, and recycle	si: In-house processing facilities for returned vessels (lifetime extension) (potential sustainable business model innovation); si: Design for disassembly (reduced waste stream) (potential sustainable business model innovation)	Applying R-strategies to the system is reliant on key suppliers and channels, as well as available information and knowledge (sustainability challenge)
D4 Tender type	Tender types can vary depending on factors such as maritime regions (e.g. distance), political ambitions (e.g. green tenders), tender publisher (e.g. commercial or public) or climate conditions	i: Ferries for seagoing and long-distance (potential business model innovation); si: Green fleet containing 90% electric, 10% hybrid/diesel vessels (potential sustainable business model innovation)	Electrifying operations yields high client costs with low proof-of-concept, and no directly identifiable economic benefits (sustainability challenge)
D5 Circular economy integration	Integration of circular economy principles such as reduced consumption and waste, longer product lifespans, product reuse, renewable energy consumption, and sustainable material use into the tender and deployment process	si: Functionality sales instead of asset sales (potential sustainable business model innovation)	

Deployment interaction card

D. Tender

water transit element (within tender)	interacting elements (to consider)	interaction description
D1 Extended tender value	B B1 C5 E4	D1–B: The tender period influences the extent of financial risk D1–B1: Extended revenue stream through long depreciation schedules for electric vessels D1–C5: Extended revenue stream through long depreciation schedules for electric vessels D1–E4: The inclusion of partner collaborations for extended destinations influences the extent of value derived from extending the tender
D2 Post-tender value	A1 D3 C3 F4	D2–A1: Management of the asset is either transferred or retained post-tender which influences buy-back or residual value D2–D3: The asset's post-tender value influences the extent to which R-strategies, such as refurbishment or repurposing, can be integrated D2–C4: The extent to which ferries can be used for other maritime regions influences their post-tender value D2–F4: The extent to which ferries can be used for other applications, such as freight transport, influences their post-tender value
D3 R-strategy integration	A1 D2 B2	D3–A1: The application of R-strategies depends on how the asset is managed and handled at end-of-life D3–D2: The asset's post-tender value influences the extent to which R-strategies, such as refurbishment or repurposing, can be integrated D3–B2: Integration of R-strategies involves assessment of sustainable practices across system components including supplier networks
D4 Tender type	C4 C5 E1	D4–C4:Vessel design can facilitate use across various tender types D4–C5: First-adopter risk and accessibility can be more prominent in *green* tenders D4–E1: Terminal design is influenced by external factors, including the maritime region
D5 Circular economy integration	B2 C4 F1	D5–B2: Integrating circular economy principles into the system requires supplier collaboration to enable scalability and reduce adoption barriers D5–C4: Integrating circular economy principles interacts with the sustainability of vessel design processes D5–F1: Social demand for zero-emission systems and affordable green transport can drive circular economy integration

Area development ideation card

E. Terminal

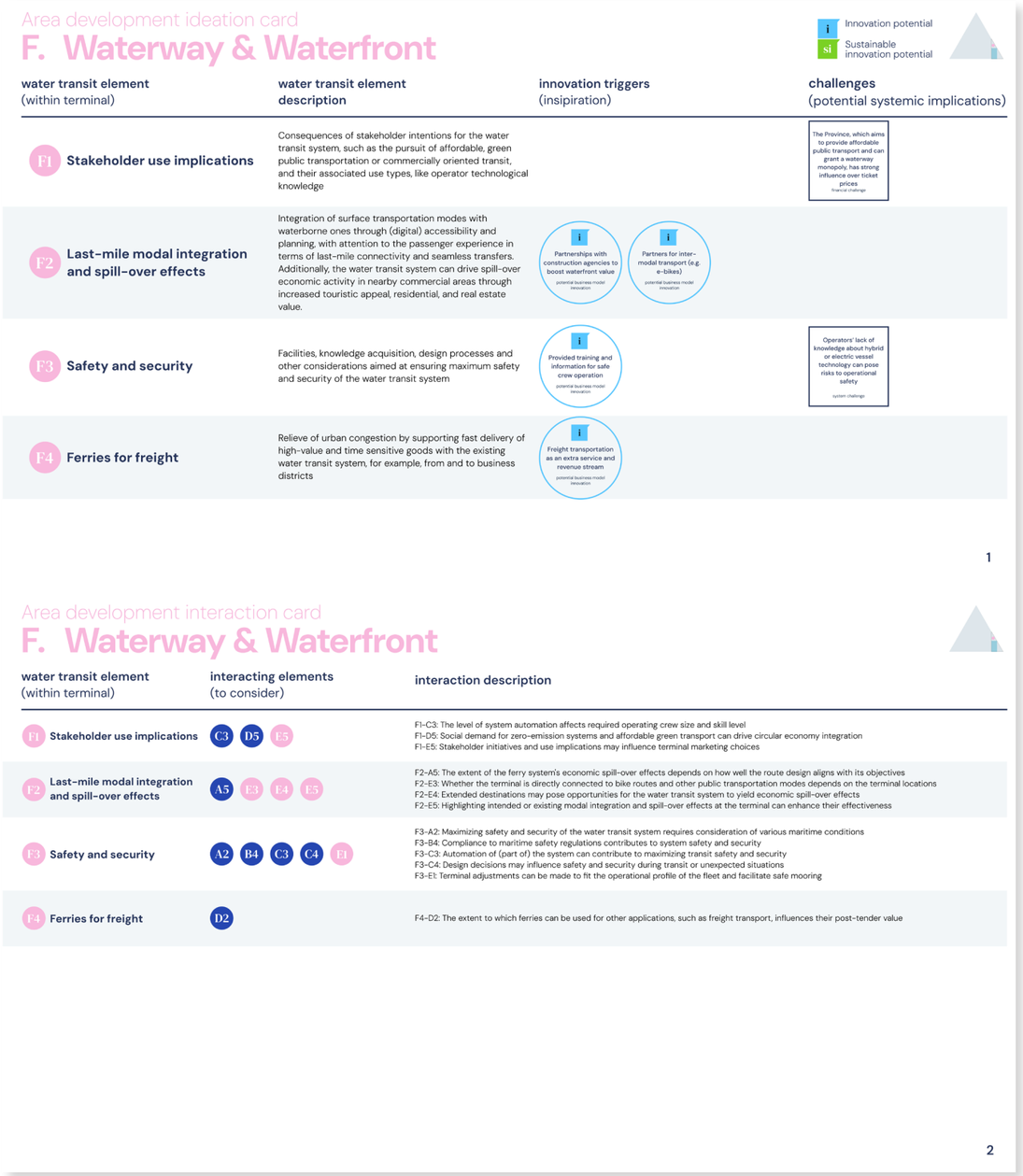
i Innovation potential
si Sustainable innovation potential

water transit element (within terminal)	water transit element description	innovation triggers (insipiration)	challenges (potential systemic implications)
E1 Terminal design	The shape of the terminal in terms of its water, ship, and land-side connections, along with its facilities and visual design	i: Integrated retail offer to extend revenue streams to terminal (potential business model innovation)	The municipality, which has a limited budget, owns the terminals and is therefore responsible for their design and development (sustainability challenge)
E2 Terminal charging	Charging facilities at the terminal, how they are shaped and their implications for the fleet or the system overall	si: Matched mooring time with charging time (i.e. Copenhagen ferries) (potential sustainable business model innovation)	Connecting remote inhabitants is limited by maritime and charging challenges because terminal distances increase (social challenge); Green energy is not universally or constantly available (sustainability challenge)
E3 Terminal (re)location	The geographical location of the terminals, and/or their potential relocation to facilitate route changes	i: Advisory group partnerships to realize terminal (re)locations (potential business model innovation)	Habitual use patterns of water transit users hinder terminal relocation (social challenge); The municipality owns the terminals but has a limited budget and unclear or complex responsibility for terminal (re)location (financial challenge)
E4 Extended destinations	Alternative transit system destinations, such as cruise terminals or touristic sites, in addition to existing public transportation stops	i: Collaboration with partners such as cruises and malls (potential business model innovation); i: Combo-tickets in partnership with touristic destinations (potential business model innovation)	Extending water transit to touristic destinations, increases dependence on external factors and therefore ticket sales volatility (financial challenge)
E5 Terminal marketing	Marketing of the water transit system at and around the terminals, as well as through additional channels such as television advertisements	i: Increased marketing at terminal and brand presence (potential business model innovation)	Who owns and carries financial responsibility terminal marketing can be ambiguous (system challenge)

Area development interaction card

E. Terminal

water transit element (within terminal)	interacting elements (to consider)	interaction description
E1 Terminal design	C1 C4 D4 E4 F3	E1–C1: Terminal design may influence time spent at the terminal and in turn passenger numbers E1–C4: Vessel design and capabilities affect the terminal's docking requirements E1– D4: Terminal design is influenced by external factors, including the maritime region E1–E4: References to extended destinations may be included into the visual design of the terminal E1–F3: Terminal adjustments can be made to fit the operational profile of the fleet and facilitate safe mooring
E2 Terminal charging	A6	E2–A6: Whether charging at the terminal is possible influences the shape of the overall charging system
E3 Terminal (re)location	A5 C4 C5 F2	E3–A5: Terminal (re)location relies on the operation's route type (linear, cross-river, trans-river) E3–C4: Vessel operational capabilities influence terminal (re)location options and decisions E3–C5: The electrification of the system may impact terminal location and potentially require relocation to optimize route efficiency and travel distances E3–F2: Whether the terminal is directly connected to bike routes and other public transportation modes depends on the terminal locations
E4 Extended destinations	A5 D1 E1 F2	E4–A5: Extending to new destinations affects route type and planning E4–D1: The inclusion of partner collaborations for extended destinations influences the extent of value derived from extending the tender E4–E1: References to extended destinations may be included into the visual design of the terminal E4–F2: Extended destinations may pose opportunities for the water transit system to yield economic spill-over effects
E5 Terminal marketing	C1 F1 F2	E5–C1: Terminal marketing influences outreach to passengers E5–F1: Stakeholder initiatives and use implications may influence terminal marketing choices E5–F2: Highlighting intended or existing modal integration and spill-over effects at the terminal can enhance their effectiveness



Area development ideation card

F. Waterway & Waterfront

i Innovation potential
si Sustainable innovation potential

water transit element (within terminal)	water transit element description	innovation triggers (insipiration)	challenges (potential systemic implications)
F1 Stakeholder use implications	Consequences of stakeholder intentions for the water transit system, such as the pursuit of affordable, green public transportation or commercially oriented transit, and their associated use types, like operator technological knowledge		The Province, which aims to provide affordable public transport and can grant a waterway monopoly, has strong influence over ticket prices (financial challenge)
F2 Last-mile modal integration and spill-over effects	Integration of surface transportation modes with waterborne ones through (digital) accessibility and planning, with attention to the passenger experience in terms of last-mile connectivity and seamless transfers. Additionally, the water transit system can drive spill-over economic activity in nearby commercial areas through increased touristic appeal, residential, and real estate value.	i Partnerships with construction agencies to boost waterfront value (potential business model innovation); i Partners for inter-modal transport (e.g. e-bikes) (potential business model innovation)	
F3 Safety and security	Facilities, knowledge acquisition, design processes and other considerations aimed at ensuring maximum safety and security of the water transit system	i Provided training and information for safe crew operation (potential business model innovation)	Operators' lack of knowledge about hybrid or electric vessel technology can pose risks to operational safety (system challenge)
F4 Ferries for freight	Relieve of urban congestion by supporting fast delivery of high-value and time sensitive goods with the existing water transit system, for example, from and to business districts	i Freight transportation as an extra service and revenue stream (potential business model innovation)	

1

Area development interaction card

F. Waterway & Waterfront

water transit element (within terminal)	interacting elements (to consider)	interaction description
F1 Stakeholder use implications	C3 D5 E5	F1–C3: The level of system automation affects required operating crew size and skill level F1–D5: Social demand for zero-emission systems and affordable green transport can drive circular economy integration F1–E5: Stakeholder initiatives and use implications may influence terminal marketing choices
F2 Last-mile modal integration and spill-over effects	A5 E3 F4 E5	F2–A5: The extent of the ferry system's economic spill-over effects depends on how well the route design aligns with its objectives F2–E3: Whether the terminal is directly connected to bike routes and other public transportation modes depends on the terminal locations F2–E4: Extended destinations may pose opportunities for the water transit system to yield economic spill-over effects F2–E5: Highlighting intended or existing modal integration and spill-over effects at the terminal can enhance their effectiveness
F3 Safety and security	A2 B4 C3 C4 E1	F3–A2: Maximizing safety and security of the water transit system requires consideration of various maritime conditions F3–B4: Compliance to maritime safety regulations contributes to system safety and security F3–C3: Automation of (part of) the system can contribute to maximizing transit safety and security F3–C4: Design decisions may influence safety and security during transit or unexpected situations F3–E1: Terminal adjustments can be made to fit the operational profile of the fleet and facilitate safe mooring
F4 Ferries for freight	D2	F4–D2: The extent to which ferries can be used for other applications, such as freight transport, influences their post-tender value

2

4 CO-CREATION SESSION

To use the Pyramid Toolkit and develop an innovation strategy for the water transit system the participating organisation is working on, a co-creation session should be held. This session enables participants to collaboratively generate ideas based on the information in the Pyramid Toolkit. The workshop should be led by a session leader who introduces the session's objective, facilitates the ideation process, keeps time, and records the results to be translated into an innovation strategy afterward.

PREPARATION

A small group of participants from the participating organization or organizations should be invited before the session. To promote creativity and various perspectives it is useful to invite participants from multidisciplinary backgrounds. For the session, 4-5 participants is sufficient. Less participants would limit the number of ideas, and more would likely create some chaos or too many opinions to reach agreement for ideas. To prepare for the co-creation session, at least six water transit elements should be selected from the innovation cards. The selection should be based on what the organization finds most relevant and realistic to innovate on for the water transit system at hand. To find these, the participants each vote on three elements per innovation card (i.e. per key factor) before the session. The session leader then prepares these for the session. The session leader also chooses a fitting 'strategic output' - a timeframe to ideate for, to give the participants some direction and to make the ideas less abstract.

IDEA GENERATION

To facilitate strategic, collaborative idea generation, the session is guided by Appreciative Inquiry. Appreciative Inquiry is a method that approaches the problem space, and ideas for its solution, from its positive core, by first identifying current positives (Discovery), then envisioning the future (Dream), creating steps to realize that vision (Design) and concluding with necessities to access that future (Destiny). This method gives the ideation more shape, and frames the session with a positive mindset. The participants start by naming positives from the current situation, and jotting them down in the respective box on the handout on page 14 (e.g. low emissions, urban connectivity). Once they have done that, the future situation can be imagined by thinking about what a dream future would look like (e.g. a car-free city). The next step is to identify steps to realize the dream. What needs to be done to achieve it (e.g. education)? The last step is to think about implementation. What external or internal necessities are there to bring the dream to a succes (e.g. recycling facilities, allocated budget).

Handout 1: Operation

Selected water transit element

Appreciative Inquiry

Strategic output: *An innovation strategy for the hybrid/electric water transit system on the short-term (e.g. before 2027).*

Dream
what might be?

envision the future

identify positives

steps to realize the dream

Discovery
what works?

Design
what should be the ideal?

necessities for future success

Destiny
how can we implement?

time: 10 minutes

start 14:35

end 14:45

Figure 15: Appreciative Inquiry handout for co-creation with the Pyramid Toolkit

5 FROM IDEAS TO AN INNOVATION STRATEGY

The ideas that were generated during the session need to be disseminated into a sustainable innovation strategy. This will help to structure them into concrete strategic steps and to ensure its implementation. For each focus space, the co-creation session should yield enough ideas per key factor to create a sustainable innovation strategy. How the results are presented is up to the participating organizationbut the following pages contain a template for formulating and visualizing. To do this, here are some tips:

Prioritize

Filter out unrealistic ideas and keep the ones with the highest potential, with a priority on sustainable ideas. Make sure to retain at least one full sequence (Discover, Dream, Design, Destiny) for each key factor.

Desribe

Ideas may be jotted down quickly and not fully formed. Therefore, it may be good to give some more descriptions and explanations to make the strategy comprehensible for the whole organization, including people that were not present at the co-creation session.

Visualize

Use the template or another format and your imagination to visualize the strategy over a timeframe. This will increase its approachability for multidisciplinary readers.

Make it concrete

What needs to happen, and who is responsible for it? Make sure everybody knows what to work on, and has the handles to start.

Key water transit system factors →	A: Operation	B: Financing	C: Fleet	D: Tender	E: Terminal	F: Waterway & Waterfront
Innovation space selection →	A9 Example water transit element					
••• (e.g. 2025) Current situation	A hybrid ferry fleet is operational in the Netherlands.					
Problem space	*The fleet faces technical difficulties*					
Innovation type	*Process innovation* *Resource innovation*					
Innovations Steps to take	**Create a problem solving scheme** • Step by step allocation of time, resources, and people that are needed in different problem scenarios					
Strategy Implementation needs	Research and development budget					
Responsible actor	*Operations manager* *Bank*					
••• (e.g. 2027) Future vision	***The ferries are succesfully operating at all times.***					

Figure 16: Strategic roadmap template and example for innovation strategies

CHAPTER 8

WATERBUS STRATEGY

The Pyramid Toolkit was used in a co-creation session at Damen (Chapter 12) to form a basis for the sustainable innovation strategy that is presented in this chapter. The presented strategy is recommended for Damen to optimally deploy the hybrid Waterbus fleet, which, at the time of this thesis, is facing financial, reputational, logistical, and sustainability-related challenges. The strategy builds upon the scientific domain of sustainable business model innovation.

Chapter Contents

8.1 DEPLOYMENT STRATEGY
- 8.1.1 Operation innovation
- 8.1.2 Financing innovation
- 8.1.3 Fleet innovation
- 8.1.4 Tender innovation

8.2 AREA DEVELOPMENT STRATEGY
- 8.2.1 Terminal innovation
- 8.2.2 Waterway & Waterfront innovation

Confidential contents

CHAPTER 9

VALIDATION

This chapter validates the design outcomes of this thesis. It contains results from two interviews: 1) an external validation interview for the Pyramid Toolkit with the Ad Interim CEO of Aqualiner, and 2) an internal validation interview of the Waterbus strategy at Damen Shipyards with the company mentor and a participant from the empirical study.

Chapter Contents

9.1 EXTERNAL VALIDATION OF THE PYRAMID TOOLKIT

9.2 INTERNAL VALIDATION OF THE WATERBUS STRATEGY

Confidential contents

PART 3

DESIGN

CHAPTER 10

DESIGN STRATEGY

This chapter outlines the steps and methods used to systematically approach the design phase. First, the design goals and requirements are defined. Next, three design directions for ideation are identified. Finally, the success metrics used to evaluate the final design outcomes are introduced and explained.

Chapter Contents

10.1 DESIGN GOALS
- 10.1.1 An integrated overview of the business model of water transit systems
- 10.1.2 An indication of sustainability potential
- 10.1.3 Spaces and approaches to innovation
- 10.1.4 An innovation strategy for Damen

10.2 LIST OF REQUIREMENTS
- 10.2.1 Functional Requirements
- 10.2.2 Contextual Requirements
- 10.2.3 Assumptions and constraints

10.3 DESIGN DIRECTIONS
- 10.3.1 Direction 1: Contemplative layered integration
- 10.3.2 Direction 2: Multi-perspective framing
- 10.3.3 Direction 3: Point-Of-View framing

10.4 SUCCESS METRICS
- 10.4.1 Explanatory metrics
- 10.4.2 Implementability metrics
- 10.4.3 Strategic value metrics

10

10.1 DESIGN GOALS

The general aim of the design phase of this thesis was to design a sustainable business model innovation for the optimal deployment of a hybrid and/or electric waterbus fleet across diverse maritime regions. The strategies in this chapter were developed and employed to structure the design process and ensure it was grounded in theory and built on strategic design practices.

To facilitate a structured strategy, four design goals were formulated. These goals formed a red thread throughout the development of the requirements, design directions, and success metrics presented in this chapter, providing the foundation for the ideation and conceptualization phase that followed.

10.1.1 AN INTEGRATED OVERVIEW OF THE BUSINESS MODEL OF WATER TRANSIT SYSTEMS

The first design goal is to create an integrated overview of the scientific domain, sustainable business model innovation, and the context, water transit systems. This goal was formed to ensure that the research in the first part of the project, both the literature review and the empirical interviews, were combined to create a meaningful product, grounded in academic research. It is easy, and sometimes necessary, to stray or wander slightly to new territory during ideation and conceptualization, and setting this goal was a reminder to return to the empirical findings for foundation and justification.

10.1.2 AN INDICATION OF SUSTAINABILITY POTENTIAL

The second design goal was to, in any case, indicate sustainability potential in the design. From the literature review it became clear that there is environmental and social impact to be made when innovating a business model, but often at the cost of economic benefits. This challenge can create the risk of the focus to unintentionally shift to solely economic impact when innovating a business model. To keep it on sustainability as well, highlighting its potential in various aspects or components of the design was taken as a prerequisite.

10.1.3 SPACES AND APPROACHES TO INNOVATION

Similar to the second design goal, focus should be kept on innovation as well. An indication of approaches and spaces for innovation was therefore included as a design goal, as a reminder that the design should enable a process of continuous development and transformation of a water transit system, independent of the specific circumstances. The design should be useful both for Damen in its current situation, as well as other entreprises or organizations in different situations.

10.1.4 AN IMPLEMENTATION STRATEGY FOR DAMEN

Slightly contradictory to the third goal, is the fourth goal of development of an implementation strategy specifically for Damen. However, to make sure that the thesis result is also useful for the circumstances that the host company is in, it has to contain an element that allows strategy formulation for the concerned party. At this moment, that is Damen Shipyards, but the method or design that is developed to enable this implementation, should also be usable in another situation, allowing general implementability and transferability of the design.

10.2 LIST OF REQUIREMENTS

To systematically approach the ideation phase, and the validation afterwards, a list of requirements was formulated. The methodology for this was adapted from the field of engineering design, as described by Pahl et al. (2006). The requirements are divided into functional demands and wishes, meaning those requirements that describe a basic function that the design should perform, and contextual demands and wishes, referring to the requirements that the design should adhere to within the constraints of its environment. For completeness, assumptions and constraints with regards to the context of the project are highlighted in this section as well.

10.2.1 FUNCTIONAL REQUIREMENTS

Functional demands

- The model must include a comprehensive overview of water transit system components
- The model must include a comprehensive overview of business model components
- The model must include sustainability
- The model must include business model innotation
- The model must include an integration of empirical case study results
- The model must include connections between various elements
- The model must include interactions between various elements
- The model must identify space for potential sustainable innovation

Functional wishes

→ The model must be visually pleasing
→ The model is cross-referential rather than hierarchical (adapted from Gigamapping Theory of Systems Oriented Design, Sevaldson, 2022)
→ The model has various knowledge and informa-

tion layers (Sevaldson, 2022)
→ The model contains various interaction types (Sevaldson, 2022)
→ The model is interactive
→ The model contains in-depth information for deepening understanding

10.2.2 CONTEXTUAL REQUIREMENTS

Contextual demands

- The model must be relevant for DFS
- The model must be relevant for the Shipyard
- The model must be relevant for an Operator
- The model must be relevant for a client
- The model must enable an improvement to the current case situation
- The model must be applicable in various maritime regions
- The model must be applicable for various fleet types (hybrid, electric)
- The model must be usable for multidisciplinary users

Contextual wishes

→ The model must be understandable for laymen/-women

10.2.3 ASSUMPTIONS AND CONSTRAINTS

Conversations with the company mentor in earlier stages of the project yielded the agreement or assumption that, at this moment, the perspective of DFS can be assumed to be in line with that of the Operator. Passenger needs were assumed based on POW documents and interviews as no passenger interviews were done during the empirical research phase. The Province's needs are assumed to be in line with those of the Municipality.

10.3 DESIGN DIRECTIONS

After defining design goals and requirements, three design directions were created to support divergent thinking and fundamentally different perspectives for the design process. Converging after this to a single direction to continue conceptualization allowed a weighed and deliberate focus. This way of approaching ideation is illustrated in the theory of design thinking as well (Brown, 2009).

10.3.1 DIRECTION 1: CONTEMPLATIVE LAYERED RESEARCH INTEGRATION

This first design direction is a direct result from the empirical research results, in which the interview findings were divided into three layers of sub-thematic integration. In this direction, the design would be contemplative, i.e. combining the two first research layers in a neutral manner, as if the whole of information and interaction between the layers is viewed from above, without focus on one or another element. To be more clear, this direction links the components of a water transit system as identified in the literature review and complemented in the empirical interviews, with business model components, innovation and sustainability without taking a central perspective or role.

10.3.2 DIRECTION 2: MULTI-PERSPECTIVE FRAMING

Inspired by the Frame Innovation method of Kees Dorst (2015), the problem was reframed to create the second design direction. The problem situation, as derived from conversations with the company mentor at Damen Financial Services, can be approached from four perspectives. Each rooting from different elements of the business model or water transit system. Approaching the problem through this multi-perspective framing, opens another way of looking at problem-solving and acknowledges the complexity of the situation. This design direction is formulated as follows:

If the problem situation of the waterbuses is approached as if it is a technical problem...

because of mooring and charging restrictions

...then the solution should be ...

The same formulation can be applied for perspectives logistical, because of too tight a schedule and too many stops; financial, due to high repair costs and insufficient revenue streams from ticket sales as well as penalties; and reputational, because the malfuctioning vessels being docked at the Shipyard's headquarters in Gorinchem clearly displays the current undesirable situation, and because its sustainability image is not complied with.

Combining these perspectives into a multi-framing forms the second design direction, which consequently focusses the ideation as such.

10.3.3 DIRECTION 3: POINT-OF-VIEW FRAMING

Another way of viewing the problem, and directing the design, is through a point-of-view framing (Dam & Teo, 2025). This centers the ideation around a single point-of-view of needs for a specific stakeholder. Instead of a neutral design, as introduced in Direction 1, it is focussed and the solution is biased. There are three points-of-view that I defined for this direction. The first is that of the client, or the Province of Zuid-Holland in this case. The second that of the end-user, and finally that of DFS.

Client point-of-view

The client needs to improve alignment between passenger demand and service provision, stimulate sustainable and innovative water-based passenger transport, and enhance the overall quality of the service, including vessels, passenger information, and terminal infrastructure.

Passenger point-of-view

Passengers need a travel service that is competitive, comfortable, affordable, clean, and frequent (with last-mile connectivity), due to increasing urbanization, road congestion, climate change, inclusive mobility needs, and the growing demand for social, touristic, and functional accessibility.

DFS point-of-view

DFS needs a way to put its waterbus fleet in service to bring about a return on investment, make up for losses, and develop its sustainable maritime solutions for division growth.

10.4 SUCCESS METRICS

To qualitatively evaluate whether the design outcome is succesful, I three types of success metrics were formulated for assessment. The first, explanatory, assesses the ability of the final design to communicate the solution in a comprehensive matter. The second metric tests implementability of the design. Last, but not least to the context of this thesis, is the third metric for assessing strategic value of the final design.

10.4.1 EXPLANATORY METRICS

The explanatory quality of the final design was assessed with the following metrics:

- Conceptual clarity: does the design communicate and explain the concepts on which it was built?
- Completeness: does the design include and explain all relevant theory and practical elements?
- Logic: does the presented design contain logically structured elements?

10.4.2 IMPLEMENTABILITY METRICS

The implementability of the final design was assessed with the following metrics:

- Practical usability: is the design useful in general ferry system practice?
- Situation improvement: does the design and its use lead to improvements of the current situation?

The implementability will be tested through implementation sessions, as explained in Chapter 11.

10.4.3 STRATEGIC VALUE METRICS

The strategic value of the final design will be assessed with metrics based on the definitions of strategic value in the Eight Essential Practices Every Strategic Designer Must Master by Calabretta et al. (2016). The metrics are as follows:

- Business relevance: does the design relate back to a genuine business opportunity or challenge?
- Value generation: does the design and/or its implementation generate actual value for the business?
- Stakeholder success: do the company and key stakeholders recognize the design as succesful?*

Further secondary strategic value metrics, loosely derived from what is considered relevant based on courses taught at the MSc. Strategic Product Design, are the following:

- Strategic fit: does the design match with the company's business practice, its mission and vision, and its norms?
- Realistic: is the design realistic?
- Long-term value: is the design applicable and relevant in the long-term?

*To be more specific: do DFS, Aqualiner, and Damen Workboats recognize the design as succesful?

CHAPTER II

DESIGN PROCESS

This chapter describes the design process, including the steps taken to use the empirical study results as the foundation for model development, the selection of a design direction, and the subsequent phases of ideation and conceptualization.

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11.1 IDEATION
- 11.1.1 Ideation direction
- 11.1.2 Ideation direction 2
- 11.1.3 Ideation direction 3

11.2 DESIGN DIRECTION CHOICE

11.3 CONCEPTUALIZATION
- 11.3.1 Iteration 1
- 11.3.2 Iteration 2
- 11.3.3 Final concept

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11.1 IDEATION

The first layer, second layer and overarching findings that resulted from the empirical research analysis formed the basis for the design phase in all directions. To actually use it as such, the results were revisited and visually labelled as either business model components, water transit system components, sustainability or innovation components, all of it or none of it. In the process, the findings were continuously checked with the theory. For example, if something was labeled as a ferry system principle, would the investigated literature support that claim? The same was done for interview quotes. If there was a indication or a seemed assumption in the text, the interview was revisited to check whether the finding fit the (underlying) message of the conversation.

To determine the design direction to continue with, the process described in the introduction of this chapter was followed and applied to the three design directions (Section 10.3). This yielded various systemic 'giga-maps' from various perspectives. Drawing the maps was done as non-structured and non-hierarchical as possible, as is fitting for the gigamapping process (Sevaldson, 2022). These maps showed interrelations, component definitions, stakeholders, clusters, and lots of chaos.

11.1 IDEATION DIRECTION 1

The first connections were those within the first layer research results. Visually connecting components in this stage helped to find overlapping results and identify inhibiting factors in the system. The amount of information was so large though, that the focus was mostly on visual conceptualization of the model, instead of on its contents. Appendix I1 shows two maps made to explore direction 1.

11.2 IDEATION DIRECTION 2

Direction 2 was focused on the various problem perspectives as identified by looking at the situation from a Frame Innovation problem-solving approach (Dorst, 2015). Appendix I2 shows a map made to explore direction 2. With this map the focus was directed away from either the system as a whole or the activities of a specific stakeholder, and more towards the problem space in order of occurrence: technical issues leading to financial and logistical problems, which in turn poses reputational challenges.

11.3 IDEATION DIRECTION 3

During ideation within the third design direction, realization came that to structure the information more clearly, it was useful to use icons to visualize the link between elements to the business model and water transit system components. Appendix I3 shows the first ideation with DFS in the center of the model, and the second version that uses iconography to identify the elements.

11.2 DESIGN DIRECTION CHOICE

After this first ideation in three directions the requirements and success metrics were revisited. The outcomes were discussed with the company mentor, whose first question when looking at the different ideation maps was what the role of DFS would be. Based on that conversation, it was agreed that it made most sense to build the model from the point of view of Damen Financial Services, who would be the first to implement it. This could help clarify DFS' role in the system as well. Additionally, the contextual requirement of understanadbility for laymen and -women was found to be more accessible in this direction.

Furthermore, focusing on this direction helped organize the elements around the core activities and concerns of DFS. In the first stages, these were 'financing', 'client', 'end-user', 'operation', and the 'fleet'. These evolved and got reshaped, which will be discussed in the next section. Lastly, design direction 3 is the most user-centered choice (DFS being the user in this case), and allows more explicit focus on the needs and wishes of Damen, therefore adhering to the fourth design goal of implementability for Damen.

In conclusion, the model development from this point onward converges within Design Direction 3: Point-of-view Framing, from the POV of DFS.

DFS point-of-view

DFS needs a way to keep its waterbus fleet in service to bring about a return on investment, make up for losses, and develop its sustainable maritime solutions for division growth.

II.3 CONCEPTUALIZATION

To get to the final conceptual model, three rounds of iterations were done on the model within the third design direction from DFS' point-of-view.

II.3.1 ITERATION I

In the first conceptualizaiton of the model, elements that were based on codes from the coding tree of the empirical research were categorized,, without making interconnections. This basic grouping can be found in Appendix I4. Doing this allowed shaping of the focus areas from DFS' point-of-view. These were in the first stage: Fleet, Client, Operations, End-user, and Financing.

After this first categorization interconnections between the elements were made by going back to the empirical results. Because these were structured based on the concepts as presented in the theoretical framework (Chapter 3), the model also took that shape, i.e. elements and their connections within FOD, within System Components and System Principles, and lastly, within Tender Partners, Operating Profile, and Fleet Financing (the last three combined because these were interrelated and less complex in comparison). This division was additionally made to attempt to manage the huge amount of information and complexity that was developing. Figure 18 shows a legend for the iconography that was used in this stage. Figure 19 shows one of the four maps that resulted from this stage, the others can be found in Appendix I5. As visible in the four maps, there was still a lot of information and interrelations overlapping and crossing.

In this stage, the arrow descriptions were primarily used to explain connections between end-points. The end-point definitions were relatively inconsistent, though related to the category they were in. They could either be activities or objects, occurrences or system actors.

- W water transit system component
- Bp business model component - profit formula
- By business model component - value proposition
- Bk business model component - key process/resource
- ch challenge
- s existing sustainability impact
- i potential business model innovation gap
- si potential sustainable business model innovation gap
- ★ example: ...

Figure 17: Initial iconography legend

II.3.2 ITERATION 2

During the first conceptualization phase it was found that there were overlapping ideas, elements and interrelations between the four 'maps' in the model. The aim of the second iteration was to find a way to connect the four maps to each other as well and to reduce redundancy and repetition. The goal was also to simplify the model as much as possible, to improve its readability and usability. The model in the first iteration was too overwhelming to use.

This was approached by first simplifying each separate 'map' and visually restructuring it. IThe system elements were centralized and actors/components (previously the end-points of the arrows in the first iteration) were connected to them. The scattered opportunities, impacts, challenges and business model components were grouped under 'solution space'. This is where the focus is again drawn to

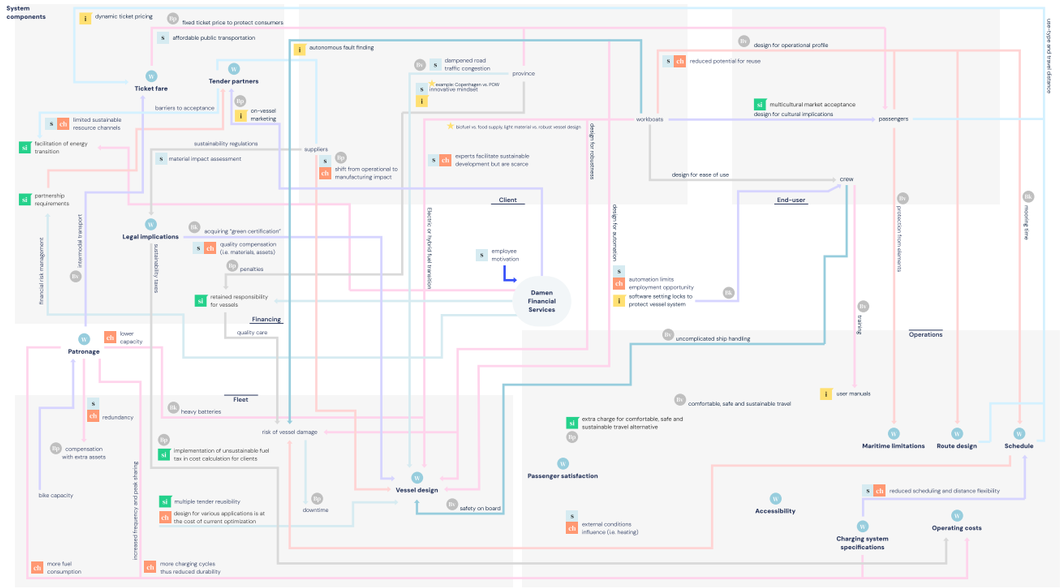

Figure 18: Initial connections and categorization of system components with sustainable business model innovation components

DFS. The solution space forms potential and context for (sustainable) innovation of the business model of WTS. To more clearly define the function of the arrows in the model, they were labeled as 'interaction scheme', where the text describes how the actor/component interacts with the solution space. Lastly, the value propositions were seperately grouped - from various perspectives, as they were related to their respective actor/component.

The first map, FOD, and the second map, System Components, were taken as starting points for simplification (Appendix I6, Appendix I7). During the first iteration, comments had been made on the maps where overlap between the other ones had been found. When looking back then in the second iteration phase, it was found that the Principles map predominantly had overlap with FOD, while the Operational Profile, Tender Lifetime & Fleet Financing (OTF) map mostly overlapped with the System components map. There was however, also overlap between Components and Principles, and FOD and OTF. The combination between 'simplified' Components and Princples, and 'simplified' FOD and Princples is shown in Appendix J. Both maps contained elements that could be categorized. The first map was found to be centered around elements related to DFS' or Damen's deployment of a WTS, i.e. Financing, Fleet, and Operations. The second map, which was found to be more focused around ferry system elements driving area (economic) development, which can

be seen as a more overarching system impact, categorizes into elements related to the Terminal, the Waterway or the Waterfront.

II.3.3 FINAL CONCEPT

The concept model that was used for the pilot session, which will be further elaborated on in Chapter 12, is shown in full in Appendix K. Figure 20 shows an extract of the Area Development model, to illustrate its structuring. In this final concept, the final map 'OTF' was also integrated in the model from the second itration. This yielded an extra category in the first model (Ferry System Development), which contained elements 'Lifetime' and 'Operating profile' related to the Tender.



Figure 19: Part of the conceptual model for Area Development

CHAPTER 12

CO-CREATION SESSIONS

Two co-creation sessions were held to refine the concept model and session methodology, validate the final model, and co-create an innovation strategy for the Waterbus. This chapter outlines the pilot session conducted with peer participants at Delft University of Technology, as well as the co-creation session held at Damen Shipyards in Gorinchem.

Chapter Contents

12.1 THE PILOT: TESTING THE METHOD
- 12.1.1 Preparation
- 12.1.2 Methodology and session materials
- 12.1.3 Pilot results

12.2 THE PYRAMID TOOLKIT
- 12.2.1 The Pyramid Tool
- 12.2.2 Innovation cards
- 12.2.3 User manual

12.3 DAMEN CO-CREATION SESSION
- 12.3.1 Preparation
- 12.3.2 Methodology and materials
- 12.3.3 Co-creation session results

12.4 REFLECTION AND CONCLUSION

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12.1 THE PILOT: TESTING THE METHOD

In this chapter, the conceptual model is tested through two co-creation sessions. The first session, the pilot, functions as a test of the methodology and usability of the model for the second session, the official co-creation session at the company. The objective of the second session was to validate the model, co-create an innovation strategy for the specific case of this graduation project - the Waterbus fleet, and in the process create idea ownership amongst the company participants. The first section outlines the pilot material and its objective, followed by an iteration of the model based on the results and peer feedback.

The second part of this chapter describes the official co-creation session at Damen Shipyards, with the improved material and final model. The chapter concludes with a reflection on this session and final thoughts on the innovation strategy that was co-created. This forms a link to Chapter 8 and 9, in which the final results of this thesis are introduced and explained. The visual in Figure 21 shows the timeline and activities around the two co-creation sessions.

The objective of the pilot session was twofold: firstly, the goal was to validate the conceptual model and its usability - based on the metrics defined in Chapter 8 - and to generate peer feedback on the overall session methodology. Secondly, the objective was to take a first attempt at co-creating an innovation strategy for a water transit system with the Waterbus fleet of DFS, using the model as a guide. In the pilot the main objective was to test the methodology of the session. Therefore, only two parts of the full model were addressed. From the first part 'Deployment', only the 'Financing' part, and from the second part 'Area Development', only the 'Terminal' part was used for co-creation. The following sections further detail the preparation of the pilot, the methodology used for the session and the results and concept iteration to perpare for the official session.

12.1.1 PREPARATION

The first concern for the pilot session was to select participants. I invited four graduating students or recent graduates of the MSc. Strategic Product Design that have experience in similar design or scientific domains. Out of the four invites, three were able to join the pilot session on the 22 of May, 2025. To familiarize the participants with Damen, the project and the problem situation, they received preparatory material one week in advance of the session (see Appendix L1). This material included three personas, each of which they were asked to represent and empathise with during the session. The personas were the following:

- Managing Director Financial Services
- Product Director Workboats
- ESG Manager

These personas were based on the roles of the participants that would be present at the official co-creation session at Damen. The pilot participants were asked to represent them to create a diverse and multidisciplinary point-of-view which was most similar to the official session. Furthermore, as Sanders and Stappers (2013) explain, empathizing with a persona generates a narrative that enables participants to more easily engage with the situation and ideate more creatively, thereby increasing their immersion in the project and participation in the session. Figure 22 shows the first persona and its descriptions and key concerns for the session.



Figure 20: Timeline model development and co-creation sessions

12.1.2 METHODOLOGY AND SESSION MATERIALS

To guide the pilot session, I made a presentation and a set of handouts. The presentation kicked off with an explanation of the objective of the session, and space to ask questions about the preparatory material or the project (Appendix L2). The second step was to introduce the model and to start co-creation, guided and facilitated with handouts. The session concluded with an overall reflection and time for feedback.

The conceptual models for the pilot

To make the conceptual model, as presented in Chapter 9, more maneagable and understandable for the session, in which there was limited time to explain it, investigate it and implement it, I went through several iterations and user tests. Appendix L3 shows the first iteration of the 'Financing' part

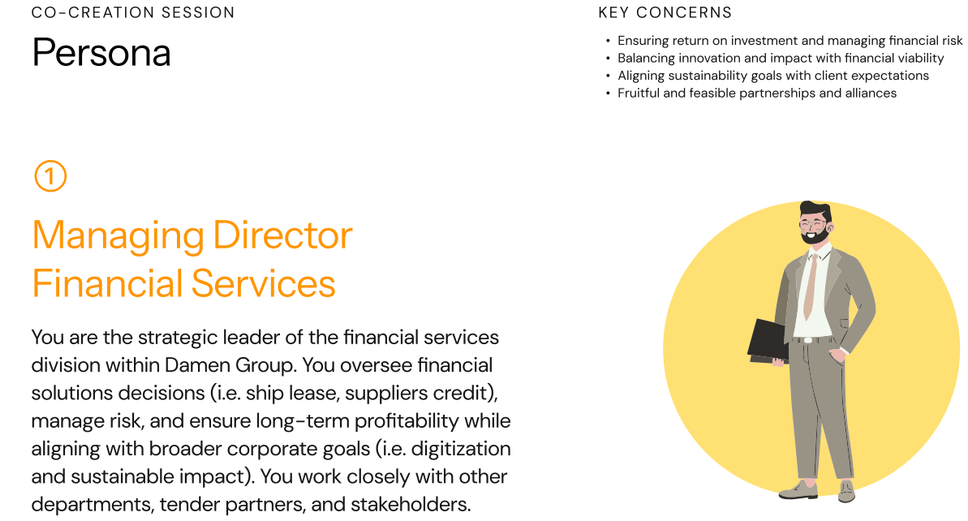

Figure 21: Persona 1: Managing Director Financial Services

of model 1, that was prepared for the presentation. This image was shown to a friend, who was asked to describe what she saw and how she understood it. She gave the following feedback: the meaning of the actor/component column was unclear. The function and direction of the arrows were also not clear, and the column indicating which business model component was being referred to was considered irrelevant and initially overlooked when scanning the image. Furthermore, she was unfamiliar with the term 'value proposition,' and its reference did not make immediate sense. Lastly, the horizontal relationship between the elements was not understood; it seemed more likely that the right column represented a vertical list of values.

Appendix L4 hows the second version, on which another user test was done. In this version 'Dot Voting' was added; a methodology referred to in the Policy Co-Design Playbook for co-creation sessions (STBY et al., 2021). This method was added to allow the participants to choose the solution space that they deemed most relevant and realistic to innovate for the problem at hand.

The user (with the preparatory material as prior knowledge) gave tge following feedback on this second version: the Dot Voting seemed hierarchical, like giving less or more dots to one solution space would allow the user to indicate its relative importance, while instead three dots were meant to be divided across three different solution spaces. Furthermore, the 's + ch' combination (sustainability challenge) was not understood. The descriptions within the solution space were found to contain too much jargon and too little description (e.g. 'limited sustainable resource channels'). Additionaly, the system elements that were left out in this version, were found to be of use after all, since the user requested the common dividers of the components in the various solution spaces. It would help him choose better. This feedback yielded another iteration and the final concept that was used for the pilot session (Figure 23).

The pilot handouts

The model functioned as a guide to co-create an innovation strategy to improve passenger transport over water through sustainable business model innovation. To facilitate the co-creation between the participants, they received handouts containing adapted version of the 'Appreciative Inquiry' method for idea generation (Cooperrider et al., 2008). Appreciative Inquiry is a method that approaches the problem space, and ideas for its solution, from its positive core, by first identifying current positives (Discovery), then envisioning the future (Dream), creating steps to realize that vision (Design) and concluding with necessities to access that future (Destiny). This method was chosen to give the ideation more shape, and to prevent the discussion to revert back to repetitions of previous conversations and a negative mindset between the participants. Since the problem at hand had been ongoing for some time, involved participants with divergent stakes, and was urgent within the company, there was a risk of tension. Therefore, this method helped frame the session with a positive mindset. Figure 24 shows the handout that the pilot participants used to ideate for the chosen solution space.

12.1.3 PILOT RESULTS

Figure 25 shows an overview of the findings and feedback from the pilot session. These cover the presentation, the Appreciative Inquiry idea generation method, Dot Voting, the conceptual model and general ideas for improving the session structure. The following sections present insights from the pilot.



Figure 22: Presentation of conceptual model (key factor Financing) for the pilot session

Presentation insights

For the sake of session comprehensibility and improved time management, the following points were identified:

- Include parameters to rate the problem situation before the session compared to after
- Manage expectations and improve understanding of the session's objective by first presenting the methodology using an example case
- Introduce the positive perspective before the model introduction and idea generation
- Include visuals and photographs to spark ideation and allow empathizing with the solution space

Dot Voting insights

The Dot Voting method was found to benefit from two improvements. Firstly, the participants preferred to vote on a single item in the solution space, instead of a whole solution space (e.g. Supplier network). Secondly, the participants preferred to be able to cast a vote of importance, i.e. using more or less dots for a single solution space to indicate their rating of it.

Appreciative Inquiry insights

Though the Appreciative Inquiry method was well understood, i.e. the participants were able to ideate in the various quadrants (Discovery, Dream, etc.), they indicated that examples from another case would help them get started and inspired. Furthermore, it was found that defining a 'strategic output', meaning a perspective on what timeframe or impact they were ideating for, would be helpful.

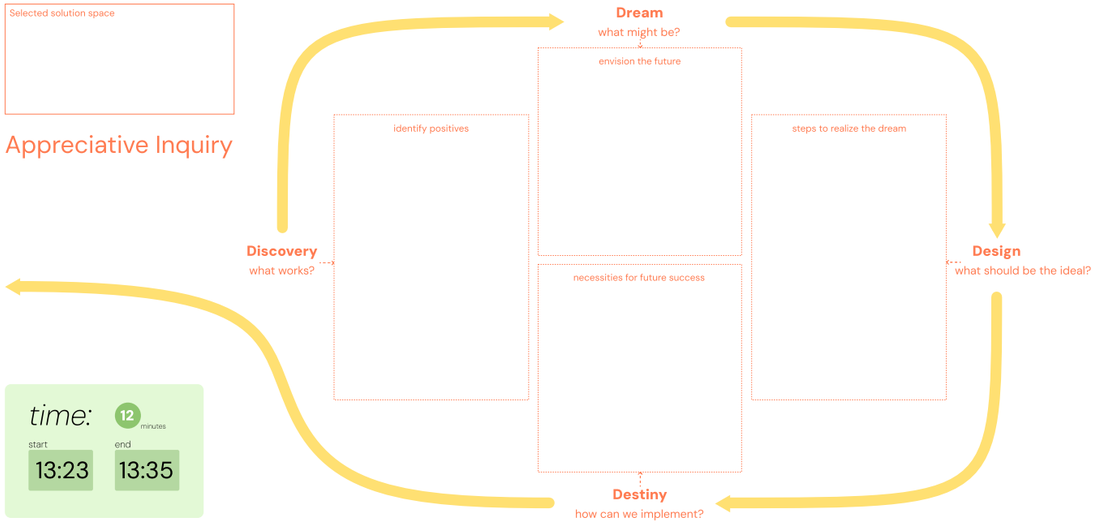

Figure 23: Handout for Appreciative Inquiry (for key factor Financing) during the pilot session

Conceptual model insights

The main insights from the participants analysing and applying the model to co-create an innovation strategy for 'Financing' and the 'Terminal', are listed below:

- Reduce complexity and explain origin of terminology used in the model
- Only ideating for two parts of the model (Financing and Terminal) was already a high mental strain and took around 45 minutes
- The colors in the model seem to imply a scale of desirability of the items - good, medium or bad. For example, the yellow 'i' for innovation potential was interpreted as less preferable, because the 'ch' for challenge is marked in red and the 'si' for sustainable innovation potential in green
- For readability, understandability and ease of use, introducing a hierarchy would be helpful

Additionally, the following areas of improvement were found when evaluating the conceptual model against the success metrics in Section 10.4, after its first use in the pilot:

- Explanatory success: the theory and concepts that the model were built on were inquired after by the participants, indicating a lack of conceptual clarity. However, because of their background in the field, it is to be expected that they are more sensitive to test the origin and academic rigour of the model than the company participants. The logical structure of the model could be improved by introducing a hierarchy to it.

- Implementability: the ideation yielded various realistic ideas for strategic improvement of the chosen solution space. In that area it can be considered succesful. However, situation improvement has not been empirically tested, meaning that the participants were not asked to rate the situation before and after the session. This is something to add onto the official session evaluation.

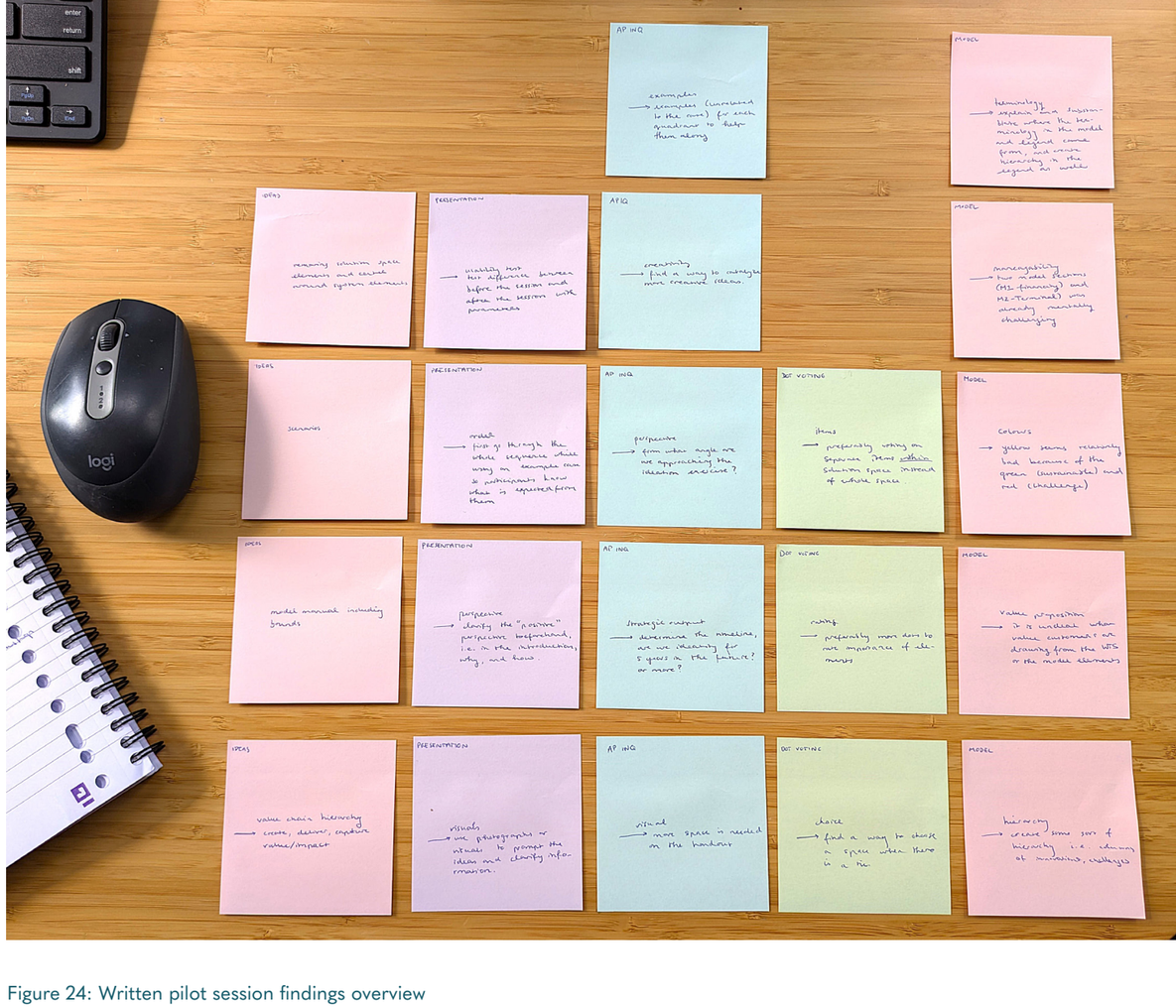

Figure 24: Written pilot session findings overview

- Strategic value: this metric is more difficult to test by evaluating the pilot, as the participants were not business employees. It was found however, that the long-term value of the implementation strategy could be improved by introducing and explaining a notion of strategic output to the idea generation.

Concluding take-aways

Though there is a lot of information behind the model that is showed during the co-creation session, it is not necessarily vital to be available to facilitate ideation for the innovation strategy. Additionaly, leaving out some information and adding hierarcy to others, will likely allow further generalization of the model and reduce mental strain in applying it during the session. Furthermore, using examples, color theory and common language has the potential to increase clarity, understandability and manageability of the conceptual model.

The changes that were made to the conceptual model that was used for the official co-creation session at Damen Shipyards are explained and shown in the next section.

12.2 THE PYRAMID TOOLKIT

The pilot session yielded the realization that the conceptual model up to that point was not sufficiently a 'design outcome'. It presented information in an abstract, linear way. While the information was still relevant—and largely necessary for conducting the co-creative session—it had not been structured or designed as a tangible product, which is what the output of a thesis in Industrial Design Engineering should be. Not in a physical sense, but as a novel approach to addressing an identified need. A product derives its value from its ability to perform a desired function. The non-interactive, static conceptual model did not meet this requirement. This realization led to two redesign objectives:

1) The design outcome should speak for itself: the most relevant information should be structured so that the user can instantly grasp its relationships and origins.
2) The design outcome must include a *something* that will allow any organization wishing to use it to extract its function independently.

To do this, ideation on shapes and ways to create hierarchy, such as sizing, contrast, colors, texture, and proximity was done. Additionally, ways to present the most relevant information at once to reduce complexity, but to allow for deepening when desired, were explored. Better definitions and clarifications of information origins were ideated on. And lastly, ideation was done to make the product interactive to be usable without verbal explanation. Appendix M1 shows drawings and questions of this stage. It was found that the most comprehensive way of creating hierarchy and structured information was through a triangle shape (Appendix M2). The full redesign process resulted in The Pyramid Toolkit, which includes The Pyramid Tool, Innovation cards, and a user manual. At the co-creation session at Damen the Pyramid in Appendix M3 was used. After that followed one last iteration which was used for validation and presented in Chapter 7.

12.2.1 THE PYRAMID TOOL

The primary purpose of The Pyramid Tool is to form a basis to create an innovation strategy on. Its elements are aimed at providing guidance and inspiration to generate ideas on how to innovate the water transit system. Consequently, combining the ideas that are generated when using the pyramid tool in a co-creation session, will result in a strategy to improve the current situation or to design a new system.

Using the triangle shape also allowed integration of 'Deployment' and 'Area Development' into one model. This creates more overview of the entire system, in one glance. Furthermore, an important addition to this new conceptual model is the component labeling. It clarifies what level of abstraction is being referred to when moving down the Pyramid.

12.2.2 INNOVATION CARDS

There is still a lot of information in the Pyramid. So, to allow more comprehensive use, the Toolkit includes two-sided 'Innovation cards' for each key factor to consider. On the front is the 'ideation card' and on the back the 'interaction card. The cards zoom in on the lower, square part of the Pyramid. All six innovation cards can be found in Appendix N.

12.2.3 USER MANUAL

To allow any organization the ability to use The Pyramid Tool in a co-creation session to generate an innovation strategy for any water transit system, a user manual was added to the Toolkit. This user manual was not used for the session at Damen, as I was there to guide the session and explain the material. For any other situation, where this type of guidance is lacking, but the tool is still wished to be used, the user manual clarifies the Pyramid Toolkit, guide the session approach, and insruct the preparatory steps as well as how to disseminate the session results into a tangible innovation strategy. The user manual is based on my own process, including both co-creation sessions, their preparation and their result dissemination.

Chapter 7 shows the The Pyramid - with extensive explanations of its layers -, the Innovation cards and the guidelines for the co-creation session in the form of a User Manual.

12.3 DAMEN CO-CREATION SESSION

The official co-creation session at Damen Shipyards in Gorinchem, like the pilot session, served multiple purposes. The first was to apply The Pyramid Toolkit to collaboratively generate ideas for an innovation strategy for the Waterbus fleet, with the final goal of improving the current system or repurposing it. This in order to gather more data to answer the research question of this thesis: *"How can a hybrid or electric waterbus fleet be optimally deployed through a sustainable business model innovation?"*.

The second purpose of the session was to test the Toolkit by the success metrics for the design outcome of this thesis, as defined in Section 10.4. To do this, the participants received a short survey - to be filled out in person at the end of the session. Lastly, the session served to create idea ownership within the company to increase likelihood of its implementation at the end of the thesis project. According to Hansen et al. (2019) working in a participatory manner through workshops, such as 'Inspiration Card Workshops' to co-create a solution, will promote ownership of the design ideas and understanding of the domain and its identified opportunities and challenges.

12.3.1 PREPARATION

Four Damen employees were chosen and asked to participate in the official co-creation session. Two of them had already participated in the interviews during the empirical research part of this thesis and were involved with the design and production of the Waterbus (participant codes W2 and W3). They represented the product division. To create a multidisciplinary group, and to include the current problem owners, two DFS employees were asked to join as well. The first is the Managing Director of DFS (participant code F2), who has a lot

of experience with financial solutions as well as the Waterbus case. The second is the Teamlead ESG and Digital of DFS (participant code F3), chosen to highlight the sustainability focus of the session.

To prepare for the session, the participants received the innovation cards, the session agenda (Appendix P1) and the presentation per mail three days in advance, with a homework assignment. The participants were asked to vote for three water transit elements per key factor (e.g. Operation: A1, A2, A5) that they wanted to tackle during the session. A translation of this e-mail can be found in Appendix P2.

Assigning this as homework ensured that the participants went through the material in advance, knew what to expect during the session, and would be working on the elements of the Pyramid Tool that they found most relevant for the problem at hand - the Waterbus. The participants succesfully voted for the water transit elements, and from the elements with the highest amount of votes, I made a selection to tackle during the session. Consequently, the ideation was focused around the following water transit elements: *A1) Asset management, B4) Legal implications, C4) Vessel design, D3) R-strategy integration, E3) Terminal (re)location,* and *F2) Last-mile modal integration and spillover effects*.

12.3.2 METHODOLOGY AND MATERIALS

The session was guided by The Pyramid Tool, the innovation cards, the Appreciative Inquiry method handouts and the presentation. The 15 minute introduction included a short explanation of the

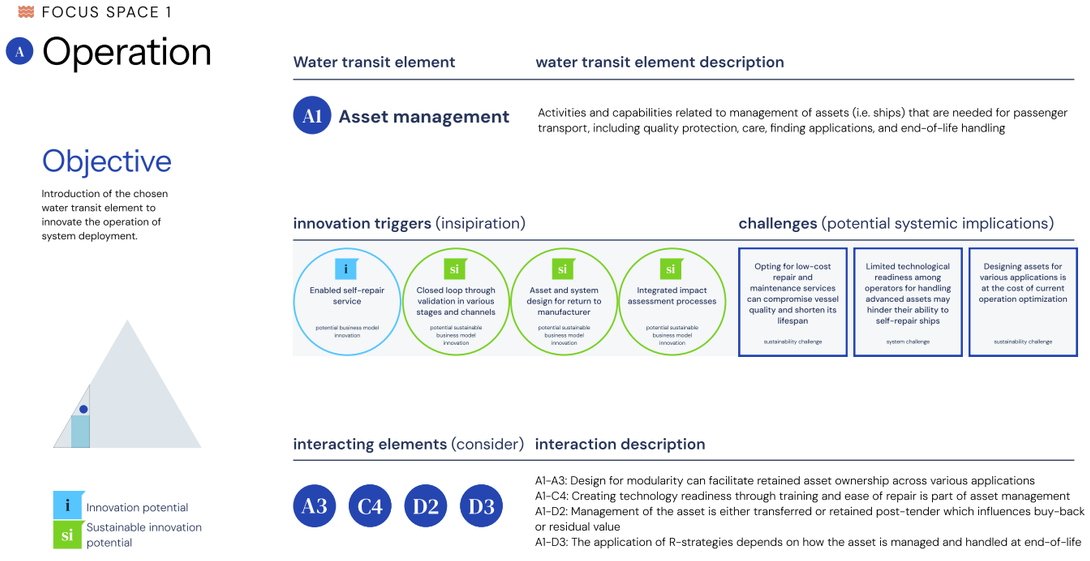

Figure 25: The chosen water transit element for key factor Operation as presented during the co-creation session

problem situation and the focus of the thesis research - though all participants were familiar with it or had been interviewed on it - and an explanation of the co-creation session objectives. Then the Pyramid Tool was shortly introduced. Lastly, the Appreciative Inquiry method was explained through an example case. After that 60 minutes of ideation on the six selected water transit elements followed (i.e. 10 minutes per element). The session concluded with any questions, next steps for the project and a short survey to rate The Pyramid Toolkit and the session according to the earlier defined success metrics. Figure 26 shows slide 10, which guided the co-creation for the 'Operation' part of the innovation strategy. The full presentation can be found in Appendix O3.

An addition to the Appreciative Inquiry method for the official session, was the note: ***Strategic output***: *An innovation strategy for the Waterbus fleet to be repurposed on the short-term (e.g. before 2027).* This was added in response to feedback from the pilot session: to give the participants more concrete direction for their ideation. A 1.5-year period from the co-creation session was chosen as the short-term strategic timeframe to emphasize that the ideation should focus on improving the current situation and thinking systemically about the existing Waterbus fleet, instead of thinking in terms of newbuild, as is more familiar to a shipbuilding company.

12.3.3 CO-CREATION SESSION RESULTS

During the session, the participants wrote their ideas on the Appreciative Inquiry handouts (Appendix P1). The session was recorded as well. The findings from the discussions combined with the ideas that were written down by the participants yielded the results for each key factor (Appendix P2). These ideas are the basis to the innovation strategy in Chapter 8 for Damen to optimally deploy the Waterbus fleet. The participants were asked to fill out a survey to rate The Pyramid Toolkit by the earlier defined success metrics (Chapter 10) for the thesis design outcome. The accumulated ratings and comments are shown in the Table 12.

Table 12: Accumulated ratings for the Pyramid Toolkit after the co-creation session at Damen Shipyards

EXPLANATORY QUALITY		
Conceptual clarity: does the tool communicate and explain the concepts on which it was built?	4,25	*A bit more background on the tool could be helpful, although it did not hamper the use.*
Completeness: does the tool include and explain relevant theory and practical elements?	4,25	*Visuals look good.*
Logic: does the tool contain logically structured elements?	4,5	*It needs explanation.*
IMPLEMENTABILITY		
Practical usability: is the tool useful for general ferry system practice?	4,75	*I am hopeful. Looking forward to the results.*
Situation improvement: does the tool and its use lead to improvements of the current situation?	4,25	*At least the discussion started, now implement.*
STRATEGIC VALUE		
Business relevance: does the tool relate back to a genuine business opportunity or challenge?	4,75	*Remains to be seen of course, but looking good!*
Value generation: does the tool and its implementation generate actual value for Damen?	4,25	*Good to strategically discuss challenges.*
Stakeholder success: do you as an individual recognize the design as successful?	4,5	
Stakeholder success: does Damen as a company in your opinion recognize the design as successful?	4,75	

12.4 REFLECTION & CONCLUSIONS

During the preparation phase, concerns arose that managing the time and slightly rushing the session to at least tackle all six key factors, would limit the quality of the discussion and the ideas. The company mentor therefore suggested that quality should go over quantity, meaning that in case certain discussions took longer that would have to take priority over tackling every single point.

However, during the session it appeared that, because this topic had already been extensively discussed in the past, extending the time would only dredge up old arguments rather than generate new or better ideas. Slightly rushing the session therefore forced the participants to focus only on relevant ideas, without going too much in depth — that is, into specific details that could reduce the systemic quality or overall overview.

The session could potentially have been further improved by adding some kind of visual ideation tool - to draw out more creative out-of-the-box ideas. The participants were inclined to lean on ongoing developments or ideas that had already been coined before or been set in motion. This might also have to do with the fact that it is an existing fleet that was being worked on, as well as the short time span that was chosen as strategic output timeframe (i.e. before 2027).

CHAPTER 13

CONCLUSION

The concluding chapter of this thesis summarizes the answer to the research question and outlines the thesis' contributions to the scientific domain and the context of water transit systems. Furthermore, practical contributions to the ferry industry, potential other industries and the field of strategic product design are defined. The chapter ends with a discussion on limitations, further study recommendations, and a personal reflection.

Chapter Contents

13.1 THEORETICAL CONTRIBUTIONS

13.2 PRACITCAL IMPLICATIONS

13.3 LIMITATIONS & FURTHER STUDY

13

13.1 THEORETICAL CONTRIBUTIONS

The aim of this thesis was twofold. Firstly, to explore what defines the business model of an urban water transit system through a literature review and a case study at shipbuilder Damen Shipyards in Gorinchem, and secondly, to examine how sustainable innovation of the business model of water transit systems can catalyze optimal deployment of ferry systems in diverse maritime environments. This was summarized in the following research question: How can a hybrid or electric waterbus fleet be optimally deployed through a sustainable business model innovation?

The research question was first investigated through a literature review of sustainable business model innovation and water transit systems. It was found that the main components of a business model are the customer value proposition (CVP), the profit formula, the key resources, and the key processes. The main components of a water transit system were found to be System Principles (e.g. ferries for freight, safety and security, etc.), Ferry-Oriented Development (i.e. residential and commercial development centered around the ferry system), System Components (contextual factors such as route design, vessel design, scheduling), the tender and its duration, financing of the fleet, and the ferry operational profile. Secondly, the business model components — and their innovation and sustainability potential and challenges for water transit systems — were investigated through a qualitative empirical study of the Waterbus in the Rotterdam-Drechtsteden area in the Netherlands.

The cross-over from theory and research findings to a practical design solution for water transit yielded two design outcomes: the Pyramid Toolkit, a tool and methodology to drive sustainable innovation of the water transit business model, and the Waterbus strategy, which is the result of applying the Pyramid Toolkit method at the thesis client: Damen Shipyards.

Investigating the literature on sustainable business model innovation and water transit systems, and further empirical study of the resulting theoretical framework as presented in this thesis yields the following contributions to the field.

1) *The WTS client (and its value proposition)*. Identifying a client in a water transit system is complicated. A governmental body might publish a concession, for which the winner gets a subsidy to operate it. However, the Operator that applies to the concession will employ the Shipyard. When the system is in service, passengers pay for tickets, making them indirect clients as well. This complex client structure influences (financial) responsibility within the system of stakeholders. The municipalities own the terminals, which gives them high influence in decisions and budget for terminal location and design, which influences the vessel design process for the shipbuilder. The governmental body is responsible for the waterways, which influences scheduling and route design. The Operator sails the ships which the Shipyard builds and need to align with the operational profile of the concession. Therefore, it was found that the governmental body make a significant contribution to system success through involvement in the design process with all stakeholders and an innovative mindset.

2) *The profit formula*. Income that is dependent on route design, ship passenger capacity, fare structure and subsidies must together cover total costs, which include maintenance and operating costs, capital investments in the ships, and potential penalties from the governmental body, since the service is public. Design for additional revenue streams like freight transportation services or touristic routes may both compromise vessel optimization for public passenger transportation and not be allowed within the concession, making it difficult for an Operator to run a profitable service. Furthermore, when the Operator must finance vessels for a specific tender period – which is the case for more expensive hybrid or electric ferries – the risk of maintenance or replacements being postponed to the next tender holder to reduce short-term costs or capital expenditure grows, which can accelerate depreciation.

3) *Sustainability in water transit systems*. It was found that intrinsic environmental benefits include traffic congestion relief, environmentally friendly and affordable transport, reduced local emissions, and nature preservation. Considering the business model, a circular shift from asset sales to function sales requires design for disassembly, material flow management, end-of-life planning, client accountability, and proof-of-concept. But mostly, regulations and subsidies are essential to reduce cost barriers for sustainable initiatives, which makes the sustainability transition dependent on public consensus because political decisions are socially driven.

4) *The Shipyard's role*. The Shipyard can take a leading role in the maritime sustainability transition, as it has the advantage of technological knowledge and capabilities for building and financing hybrid and electric vessels. This enables high sustainability standards and a unique selling point for concession holders. The Shipyard can also take a more prominent role as integrator of the water transit system. Financing solutions as well as vessel design processes can could be leveraged to influence the concession requirements, the operational profile, system marketing, vessel maintenance and sustainable quality control.

13.2 PRACITICAL IMPLICATIONS

The primary design outcome of this thesis, the Pyramid Toolkit, has various practical implications. Firstly, as a tool for the ferry industry, secondly, as a potential cross-over solution for other (mobility) industries, and thirdly, as a contribution to strategic design practice.

1) *A tool for the ferry industry*. The Pyramid provides a systemic, holistic overview of the business model of a water transit system and its challenges, as well as opportunities for sustainable innovation. It offers users a comprehensive 'checklist' and a tool for prioritizing the elements that should be considered for service deployment and area development around it. Whether it is the Operator, the shipbuilder, the governmental body, or another entity, the Pyramid Toolkit gives a structure to analyze current practice and strategy, and a methodology for approaching innovation. The Pyramid Toolkit also highlights sustainability as a fundamental part of water transit systems – how it is already present, how it can be introduced, what difficulties arise, and how it can be improved or leveraged for stakeholders. The various layers of the Pyramid allow for a holistic, yet detailed and dynamic approach to sustainable business model innovation of water transit systems across different maritime regions and cultural and environmental contexts. Especially considering current developments in the maritime sector's energy transition, the Pyramid Toolkit offers guidance for implementing highly innovative technology and system engineering.

2) *Cross-over potential to other industries*. The Pyramid Toolkit currently contains elements specific to ferry transportation. However, its components – focus spaces, key factors, water transit elements, innovation triggers, challenges and interactions – structured in a hierarchical pyramid shape, and its implementation methodology – including the co-creation session and innovation strategy template – could be adapted for use in other indus-

13.3 LIMITATIONS & FUTURE STUDIES

tries as well. This could include mobility sectors, such as train networks or bus transportation, but any service-oriented industry with a complex array of multidisciplinary stakeholders with intersecting and diverging interests could benefit from this approach to sustainable business model innovation.

3) *Strategic design practice*. The thesis and its design outcome offer contributions to the field of strategic product design. Firstly, the Pyramid Toolkit and its application for the Waterbus strategy were developed through a rigorous Double Diamond design process, including the development of design directions, requirements, and success metrics. As strategic product design and its value can be abstract at times, this thesis makes the process of model design, grounded in empirical insights, tangible. Furthermore, the design of the Pyramid was done through a process of Gigamapping – a systemic design approach – and multiple iterations to build a hierarchical structure and visual clarity. The methodology of Appreciative Inquiry and its adaptation for the Pyramid to facilitate co-creation of an innovation strategy is a contribution to the field of participatory and democratic design. Lastly, the innovation strategy was developed based on principles of design roadmapping, making a contribution to the development of that design domain as well.

In this section, the limitations of the thesis are recognized, and recommendations for future research are made. One limitation of the thesis is that interviews were predominantly conducted at the shipbuilding company, Damen Shipyards. Though there were some participants at the Operator level, it was not possible to interview individuals from the client organization: the Province or one of the municipalities within the POW concession. Adding interviews from these perspectives could have improved generalizability and transferability of the design outcome and validated the findings from Operator and Shipyard interviews. Related to the limited timeframe of the thesis, additional co-creation sessions – especially with the Operator or client organization – could have diversified idea generation and created a more complete and dynamic innovation strategy.

Another limitation of the thesis is that it studied a single case on which the Pyramid Toolkit was based. To improve the model, and validate its contents, a multiple-case study is recommended to acquire more knowledge of sustainable business model innovation for water transit systems and verify the current findings.

A further constraint is that the thesis research was conducted and reported by a single researcher, on assignment from a single stakeholder within the studied water transit system. Therefore, even though peer reviews, supervision from the Delft University of Technology and other validity procedures were included throughout the project, there is a higher risk of researcher bias. This could be mitigated through further studies from different perspectives and academic review of the current thesis research.

Lastly, Damen Shipyards – who assigned the project and is at the core of the problem situation that was studied and worked on for this thesis – holds a unique role that is specific to this particular water transit system and is unlikely to be found in other water transit systems. Damen functions as shipbuilder, financier and owner of the Waterbus, which makes their role more complex. Therefore, the extent to which they can and should apply innovation strategies differs from that of a more traditional shipbuilder in a water transit system.

PERSONAL REFLECTION

At the beginning of my thesis I had four learning goals. Firstly, to work on my deductive qualitative research skills. I think this thesis, approaching and managing it on my own, taught me a lot about both academic methodology and project management. Secondly, I wanted to explore the intersection between sustainability and business model design and innovation. My main takeaway here is that implementation and development of sustainability in any business is highly context-dependent. There are guidelines and frameworks to be known and applied, but the real value and complexity of sustainability lies in its situational specificity. The Pyramid Tool was designed with this in mind. Thirdly, I wanted to improve my visualization skills. During the project, there were many moments in which I struggled with this, but effective visual communication was also one of the most important design steps I made: going from the linear, flat conceptual model to the pyramid-shaped final tool. This again highlighted the importance of good visual storytelling. Lastly, my aim for this thesis was to test, and maybe prove, the capability of the strategic product design discipline to bridge social and sustainability objectives with business and industry needs. I have found it to be true and valuable, but mostly fun to do.

DESIGN OUTCOME VALUE FOR DAMEN SHIPYARDS

The design outcome of this thesis: the Pyramid Toolkit and the Waterbus strategy, contribute to the situational improvement at Damen Shipyards in four main areas:

1. The Pyramid Toolkit, and by extension the Waterbus strategy, provide the people at Damen Financial Services and Aqualiner with an extensive, comprehensive, and holistic overview of the Waterbus case. It explains the situation as it currently is, which also makes it more accessible for new actors to join the project.
2. The Waterbus strategy identifies the most relevant and realistic innovation spaces for DFS and Aqualiner to work on to improve the current business model of the Waterbus. Though it may be ambitious, the identified opportunities can be used as drivers for system innovation. The challenges, in turn, provide handles for caution and may prevent future difficulties.
3. The Pyramid Toolkit and Waterbus strategy provide DFS with a handle to further develop their *vessel-as-a-service* solution, because it shows all necessary elements and implications of operating a water transit system, which can therefore be translated to client needs.
4. Ideally, the co-creation and validation sessions at Damen and Aqualiner, will have created idea ownership and therefore a higher likelihood of implementation of the thesis design outcome.

REFERENCES



Artemis Technologies. (2025). Hydrofoil EF-24 Passenger Ferry. https://www.artemistechnologies.co.uk/ef-24-passenger-ferry/?_gl=1*1kie4m3*_up*MQ..*_ga*MjA1MjEzMjU2NC4xNzQyODA4OTAy*_ga_B4362P90D3*MTc0MjgwODg5OS4xLjAuMTc0MjgwODg5OS4wLjAuOTM0NTAwODE2

Baden-Fuller, C., & Morgan, M. S. (2010). Business models as models. Long range planning, 43(2-3), 156-171.

Bellone, M., Lundh, M., Wahde, M., & MacKinnon, S. (2019). Electrification and automation in maritime applications: Employing AI techniques for energy optimization and efficiency. IEEE Electrification Magazine, 7(4), 22-31.

Bocken, N. M., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. Journal of cleaner production, 65, 42-56.

Bocken, N. M., Niessen, L., & Short, S. W. (2022). The sufficiency-based circular economy—an analysis of 150 companies. Frontiers in sustainability, 3, 899289.

Bourne, Lynda & Walker, Derek. (2005). Visualising and mapping stakeholder influence. Management Decision. 43. 649-660. 10.1108/00251740510597680.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101.

Brown, T. Change by design: how design thinking transforms organizations and inspires innovation. Harper Business, New York, 2009.

Business MakeOver (2018). Business MakeOver. https://businessmakeover.eu/

Business Model Toolbox. (2020, 10 december). Business Model Toolbox. https://bmtoolbox.net/?_gl=1%2A1z0kvvs%2A_up%2AMQ..%2A_ga%2AMTg2MzA4ODY3OS4xNzQwNzUyMDQw%2A_ga_VRRXHH7S2L%2AMTc0MDc1MjAzOS4xLjAuMTc0MDc1MjAzOS4wLjAuMA..

Calabretta, G., Gemser, G., & Karpen, I. O. (Eds.) (2016). Strategic Design: Eight Essential Practices Every Strategic Designer Must Master. BIS Publishers.

Cheemakurthy, Harsha & Tanko, Michael & Garme, K.. (2018). Urban waterborne public transport systems: An overview of existing operations in world cities.

Cooperrider, D. L., Stavros, J. M., & Whitney, D. (2008). The appreciative inquiry handbook: For leaders of change. Berrett-Koehler Publishers. https://www.involve.org.uk/resource/appreciative-inquiry

Creswell, J. (2014). The selection of a research design. In: Research design. Qualitative, Quantitative and Mixed Methods Approaches (pp.3-21). Thousand Oaks: SAGE publications

Dam, R. F. and Teo, Y. S. (2025, March 3). Stage 2 in the Design Thinking Process: Define the Problem and Interpret the Results. Interaction Design Foundation - IxDF. https://www.interaction-design.org/literature/article/stage-2-in-the-design-thinking-process-define-the-problem-and-interpret-the-results

Damen Shipyards. (2025). About Damen Shipyards. Damen. https://www.damen.com/about

De Reuver, M., Bouwman, H., & Haaker, T. (2013). Business model roadmapping: A practical approach to come from an existing to a desired business model. International journal of innovation management, 17(01), 1340006.

Dorst, K. (2015). Frame innovation: Create new thinking by design. MIT press.

Enchandia. (2023, 24 augustus). Damen Shipyards Copenhagen. Echandia. https://echandia.se/projects/copenhagen/

Foss, N. J., & Saebi, T. (2017). Fifteen years of research on business model innovation: How far have we come, and where should we go?. Journal of management, 43(1), 200-227.

Geissdoerfer, M., Vladimirova, D., & Evans, S. (2018). Sustainable business model innovation: A review. Journal of cleaner production, 198, 401-416.

Hansen, N. B., Dindler, C., Halskov, K., Iversen, O. S., Bossen, C., Basballe, D. A., & Schouten, B. (2019, December). How participatory design works: mechanisms and effects. In Proceedings of the 31st Australian conference on human-computer-interaction (pp. 30-41).

Johnson, M. W. (2010). Seizing the white space: Business model innovation for growth and renewal. Harvard Business Press.

Kühn, W. J., & Louw, L. (2017) BUSINESS MODEL INNOVATION FOR SEIZING WHITE SPACE OPPORTUNITIES: A DESIGN FRAMEWORK.

Lindgardt, Z., Reeves, M., Stalk, Jr, G., & Deimler, M. (2012). Business model innovation: When the game gets tough, change the game. Own the future: 50 ways to win from The Boston Consulting Group, 291-298.

Mitra, S., Choudhury, B. K., Sengupta, P., & Agrawal, K. M. (2019). Assessment of Environmental Sustainability of Maritime Sector. TERI Information Digest on Energy & Environment (TIDEE), 18(4).

Nosratabadi, S., Mosavi, A., Shamshirband, S., Zavadskas, E. K., Rakotonirainy, A., & Chau, K. W. (2019). Sustainable business models: A review. Sustainability, 11(6), 1663.

Osterwalder, Alexander, and Yves Pigneur. Business model generation: A handbook for visionaries, game changers, and challengers. John Wiley Sons, 2010

Pahl, G., Beitz, W., Feldhusen, J., & Grote, K. (2006). Engineering design: A Systematic Approach. Springer Science & Business Media.

Pamucar, D., Deveci, M., Gokasar, I., & Popovic, M. (2021). Fuzzy Hamacher WASPAS decision-making model for advantage prioritization of sustainable supply chain of electric ferry implementation in public transportation. Environment, Development and Sustainability, 1-40.

Patton, M.Q. (2002). Qualitative Different types of interviewing. In: Qualitative research & evaluation methods develop good interview (3rd ed., pp. 339-380). Thousand questions Oaks: SAGE Publications.

Patton, M. Q. (2014). Qualitative research & evaluation methods: Integrating theory and practice. Sage publications.

Provincie Zuid-Holland. (2018). Beleidskader Personenvervoer over Water Rotterdam – Drechtsteden. https://www.zuid-holland.nl/publish/pages/23147/beleidskaderpersonenvervoeroverwaterrotterdam-drechtsteden.pdf

Ravitch, S.M., & Carl, N.M. (2015). Validity: Processes, strategies and considerations. In: Qualitative research: Bridging the conceptual, theoretical, and methodological. London: SAGE Publications.

Sanders, E., & Stappers, P. (2013). Convivial Toolbox: generative research for the front end of design.

Schaltegger, S.; Hansen, E.G.; Lüdeke-Freund, F. Business Models for Sustainability: Origins, Present Research, and Future Avenues; SAGE Publications Sage CA: Los Angeles, CA, USA, 2016.

Sevaldson, B. (2022, December 13). How to Gigamap. Systems Oriented Design. https://systemsorienteddesign.net/how-to-gigamap/

Shafer, S. M., Smith, H. J., & Linder, J. C. (2005). The power of business models. Business horizons, 48(3), 199-207.

Shaheen, M., & Pradhan, S. (2019). Sampling in qualitative research. In Qualitative techniques for workplace data analysis (pp. 25-51). IGI Global.

Simonse, L. W., Hultink, E. J., & Buijs, J. A. (2015). Innovation roadmapping: Building concepts from practitioners' insights. Journal of product innovation management, 32(6), 904-924.

Sipe, N., & Burke, M. I. (2011). Can River Ferries Deliver Smart Growth? Experience of CityCats in

Brisbane, Australia. Transportation Research Record, 2217(1), 79-86.

Smal, E., & Beunderman, M. (2025, 29 maart). De Amerikaanse revolte tegen duurzaam beleggen stuit op verzet in Europa. NRC, 14–15. https://www.nrc.nl/nieuws/2025/03/28/de-amerikaanse-revolte-tegen-duurzaam-beleggen-stuit-op-verzet-in-europa-a4887998#:~:text=Op%20het%20kantoor%20van%20BlackRock,hebben%20voor%20klimaat%20en%20duurzaamheid.

Sorescu, A., Frambach, R. T., Singh, J., Rangaswamy, A., & Bridges, C. (2011). Innovations in retail business models. Journal of retailing, 87, S3-S16.

STBY, Design Council, UK, Fonemo Colectivo, Alucina Studio, British Council México, Ministry of Culture of Jalisco, & Aura Cultura. (2021). Getting Started with Policy Co-Design (1st ed.). British Council. https://www.stby.eu/2021/09/09/playbook-getting-started-with-policy-co-design/

Tanko, M., Burke, M. I., & Cheemakurthy, H. (2018). Water transit and ferry-oriented development in Sweden: Comparisons with system trends in Australia. Transportation Research Record, 2672(8), 890-900.

Tanko, M., Cheemakurthy, H., Kihl, S. H., & Garme, K. (2019). Water transit passenger perceptions and planning factors: A Swedish perspective. Travel Behaviour and Society, 16, 23-30.

Taran, Y., Boer, H., & Lindgren, P. (2015). A business model innovation typology. Decision Sciences, 46(2), 301-331.

The Official Portal of the UAE Government. (2024, 9 juni). Modes of water transport | The Official Portal of the UAE Government. The Official Portal Of The UAE Government. https://u.ae/en/information-and-services/transportation/waterways/modes-of-water-transport-#:~:text=Abu%20Dhabi%20Maritime%20operates%20ferry,Mina%20and%20Louvre%20Abu%20Dhabi

Varpio, L., Paradis, E., Uijtdehaage, S., & Young, M. (2020). The distinctions between theory, theoretical framework, and conceptual framework. Academic medicine, 95(7), 989-994.

Waterbus. (n.d.). Waterbus dienstregeling - Waterbus. https://www.waterbus.nl/actueledienstregeling

Weisbrod , R.E. & Lawson, C.T. (2003) Ferry systems: Planning for the revitalization of U.S. cities, Journal of Urban Technology, 10:2, 47-68,

Wirtz, B. W., Pistoia, A., Ullrich, S., & Göttel, V. (2016). Business models: Origin, development and future research perspectives. Long range planning, 49(1), 36-54.

Yang, M., Evans, S., Vladimirova, D., & Rana, P. (2017). Value uncaptured perspective for sustainable business model innovation. Journal of Cleaner Production, 140, 1794-1804.

Zott, C., & Amit, R. (2010). Business model design: An activity system perspective. Long range planning, 43(2-3), 216-226.