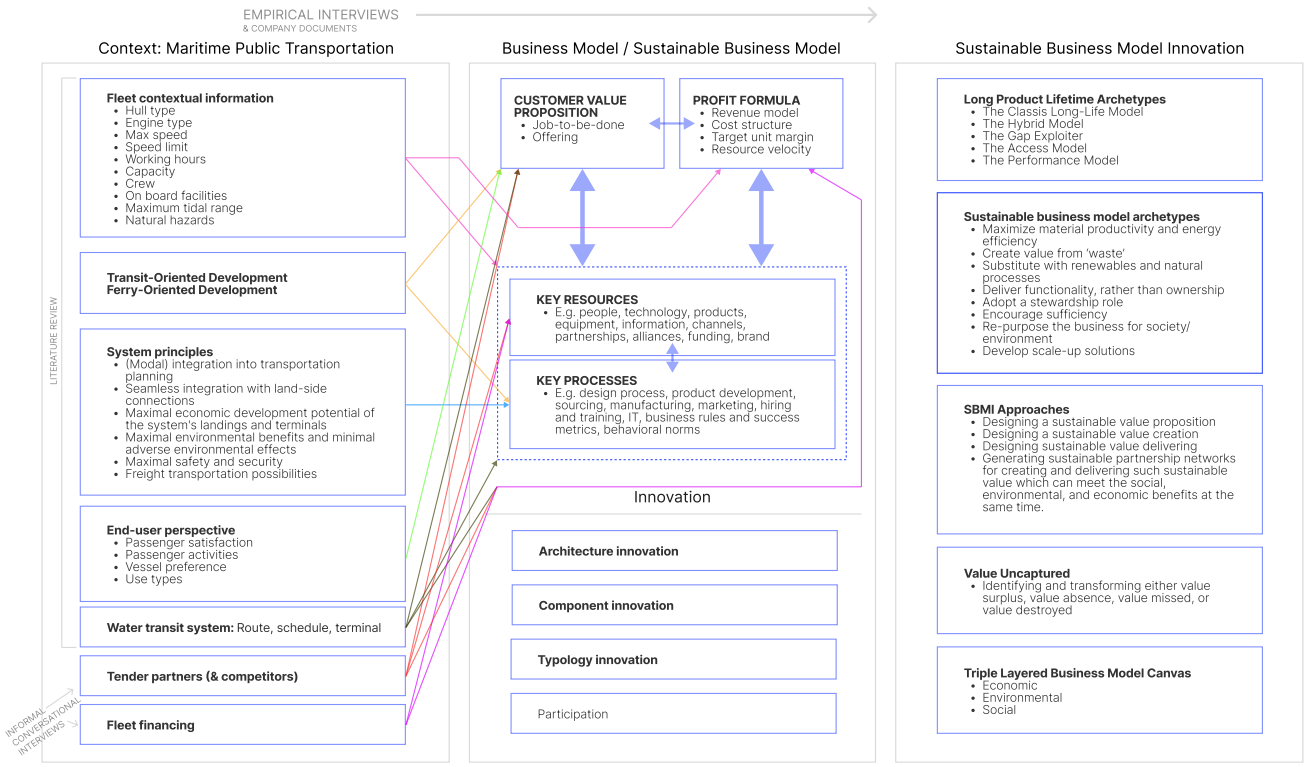
APPENDIX

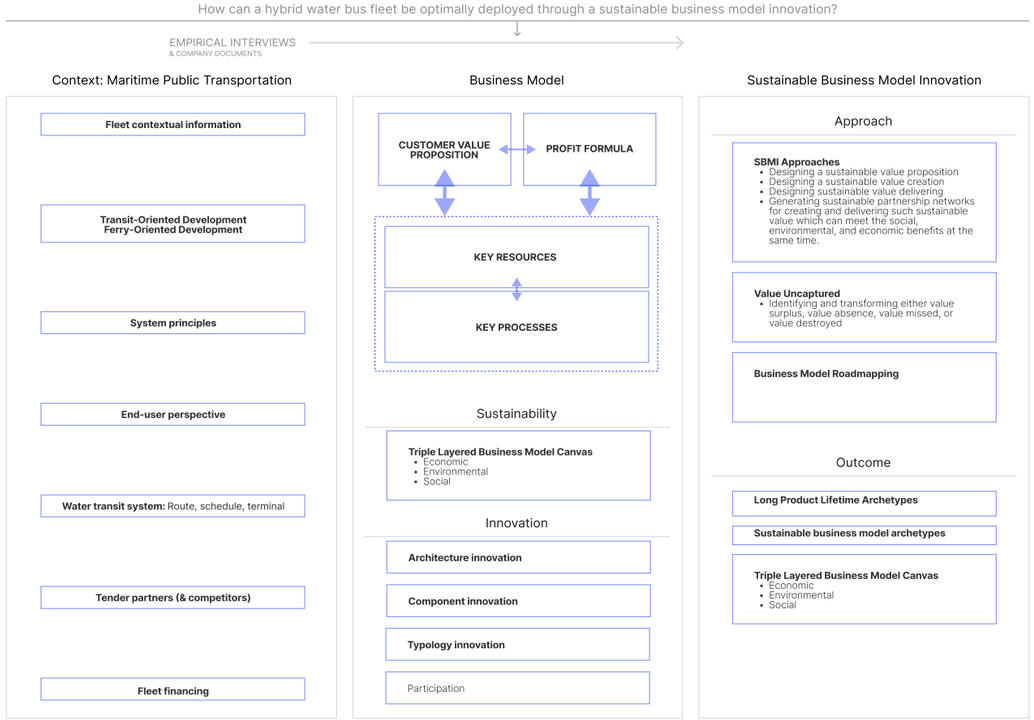
Contents

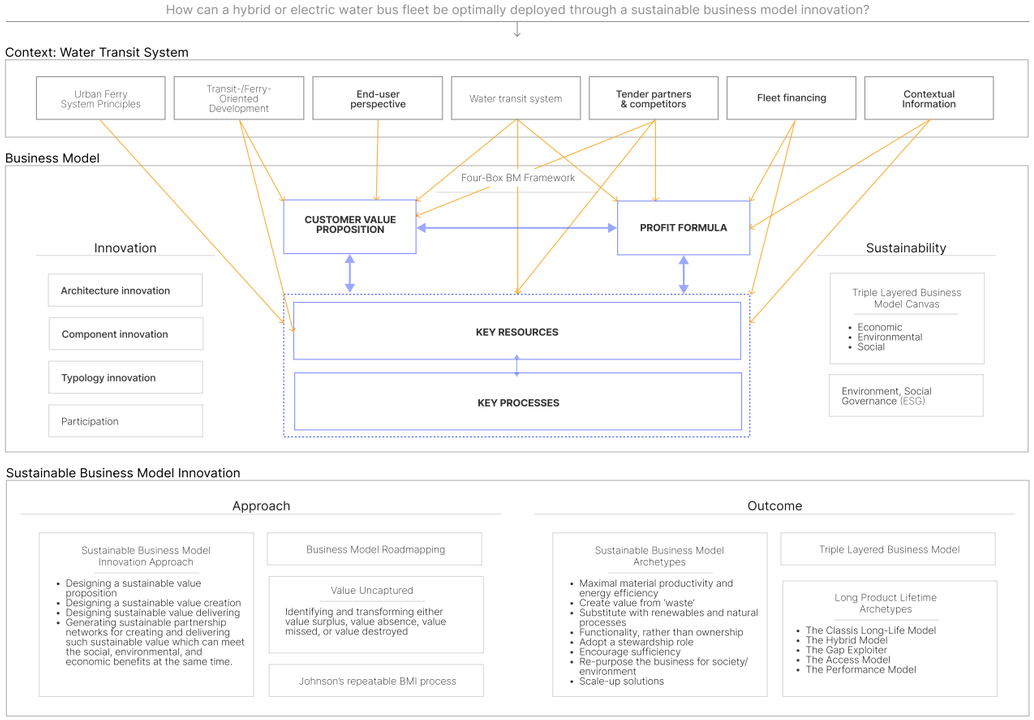
A: Theoretical framework iterations 3
B: Waterbus stakeholder map 5
C1: Interview protocol 6
C2: Semi-structured interview guide 7
C3: Informed consent form 9
D: Confirmability - researcher commentary 12
F1: Preliminary themes and coding tree 14
F2: Revised themes and coding tree 15
F3: Visual overview final coding tree 18
G: Layered pattern matching structure 19
H1: External validation interview questions 20
H2: Internal validation survey results 21
M1: New conceptual model ideation 23
M2: Pyramid Tool version 1 27
M3: Pyramid Tool version 2 29

A: THEORETICAL FRAMEWORK ITERATIONS

How can a hybrid water bus fleet be optimally deployed through a sustainable business model innovation?



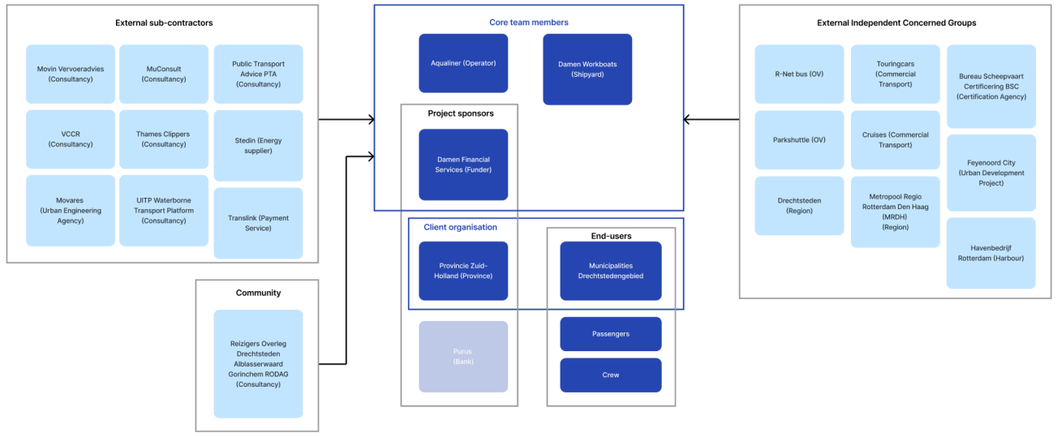




B: WATERBUS STAKE-HOLDER MAP

Rotterdam-Drechtsteden

According to stakeholder model tool from Bourne & Walker (2005)



C

C1: INTERVIEW PROTOCOL

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

This interview protocol has been set up to guide empirical research in the domain of sustainable business model innovation for the context of maritime public transportation. The qualitative semi-structured interviews in this research are part of data collection for a thesis report for the Masters Strategic Product Design of Industrial Design Engineering, TU Delft. The interviews are conducted by the lead researcher and will take around an hour each. The answers will be anonymously processed according to the HREC guidelines. The questions concern the business model of a water bus fleet, its sustainability perspectives and innovation opportunities and challenges.

The protocol states the research sub-questions that were studied for each part of the interview guide (Appendix C2).

PART 1 – Context: water transit system (10-20 min)

- Sub-question: How are the different components of a water transit system incorporated into the Waterbus maritime public transportation system?
- Sub-question: Where are opportunities to improve the maritime public transportation system?
- Sub-question: What challenges does the existing system face?

PART 2 – Theory: Business Model (10-20 min)

- How is the current business model for the water bus fleet in the Rotterdam-Drechtsteden area structured according to the various components of the Four-Box business model framework?

PART 3 – Opportunities and challenges: sustainability (10-20 min)

- Sub-question: How is sustainability currently implemented in the BM?
- Sub-question: Where are opportunities to implement sustainability in the BM based on the sustainable business model archetypes (for longer product lifetimes)?

PART 4 – Opportunities and challenges: innovation (10-20 min)

- Sub-question: What possibilities for innovation of the business model to make it more sustainable and profitable are there?
- Sub-question: What modular or architectural changes could be made to the BM to make it more sustainable and profitable?
- Sub-question: What new to firm or new to industry innovations could be implemented to make the BM more sustainable and profitable?
- Sub-question: What value uncaptured could be identified?
- Sub-question: What social, economic or environmental changes or additions could be added to the business model to make it more sustainable and profitable?

C2: SEMI-STRUCTURED INTERVIEW GUIDE

Date:
Interviewer: Lili Sanders
Interviewee(s) code:

Time: 45 min – 85 min

Transcriber: Google LLC/Microsoft Teams

PART 0 – Introduction (5 min)

The interviewer introduces the research topic to the participant: Hello, my name is Lili Sanders. Thank you for attending this interview. Your participation is appreciated and very valuable. I am a graduation intern at Damen Financial Services and I'm researching sustainable business model innovation for maritime public transportation, with regards to the waterbus fleet in joint venture with Aqualiner. I'll ask you questions about the current business model of the water busses, sustainability perspectives and innovation opportunities and challenges. The interview will take around an hour and your answers will be anonymously processed to be used to write a thesis report for the Masters Strategic Product Design of Industrial Design Engineering, TU Delft. Please state your name and the current date.

The interviewee should sign the consent form, if not done so beforehand.

Please introduce yourself and describe your role at [company/organization].

PART 1 – Context: water transit system (10-20 min)

1. Could you give an overview of the three boat types (diesel, hybrid, electric) in the water bus fleet and their operational capabilities (in your opinion)?
2. Could you describe how the water buses operate as a system?
3. How have they been integrated into the public transport system of the Drechsteden area?
4. What is the route design and how is it related to the vessel design?
5. Could you give an overview of the terminal design of the system?

PART 2 – Theory: Business Model (10-20 min)

1. What has been the value proposition for the client (municipality) of the water buses, and how has it evolved?
2. How have end-users' needs and wants been considered in the vessel and system design of the water bus?
3. What are passenger activities, preferences and use-types?
4. Can you describe the profit formula of the water bus fleet in its current application?
5. Can you describe the key resources needed at this moment for the system to properly function?
6. What partnerships and alliances are there, and how do they interact?
7. How was the (new) fleet financed and how is it currently financed?

PART 3 – Opportunities and challenges: sustainability (10-20 min)

1. How is sustainability currently implemented in the water bus transportation system?
2. What opportunities do you think are there for improving sustainability?
3. How could the system be improved to enhance environmental and/or social value?
4. What challenges do you see with regards to sustainability?

PART 4 – Opportunities and challenges: innovation (10-20 min)

1. In your opinion, how could the current water bus system be improved?
2. What challenges are there to innovating the system?

Those were all my questions. Thank you for your time and your efforts in answering them. I have learned a lot and enjoyed our conversation. Is there anything else you wish to share with me?

C3: INFORMED CONSENT FORM

Consent Form for Participation in interview about sustainable maritime public transportation

Thank you for considering participating in this research project. The purpose of this interview is to gather insights for a thesis at the Industrial Design Engineering Faculty of the Delft University of Technology. It will take approximately 60 minutes. The data will be used to support the design of a sustainable and profitable business model for the optimal deployment of a water bus fleet across diverse maritime regions. I will be asking you questions about sustainability, operational capabilities of water busses, business model innovation and/or experiences with maritime public transport.

This document outlines your rights as a participant and provides information on how your data will be handled to ensure your privacy and confidentiality.

Key Points to Note

Voluntary Participation:
Your participation is entirely voluntary. You have the right to decline to answer any question or withdraw from the interview at any time, without providing a reason or facing any consequences. Provided data can be removed from the research before publication of the thesis in the TU Delft repository.

Purpose of the Research:

The information collected will be used solely for the objectives of this research project and will not be shared or used for other purposes without your explicit consent.

Confidentiality:

All information you provide will be treated with strict confidentiality. Your identity will be anonymized in any reports or publications resulting from this research unless explicit permission is granted.

Data Storage and Use:

Your responses will be securely stored and accessible only to authorized researchers involved in this project. After the project is completed, your data will be retained or disposed of in compliance with applicable data protection laws.

Risks and Benefits:

Participation involves no physical or emotional risks. While there are no direct personal benefits to you, your input will contribute significantly to the study's success and may inform future advancements in the field.

Contact Information:

If you have questions or concerns about your participation or the research, please contact Lili Sanders at l.n.j.sanders@student.tudelft.nl.

Consent Agreement:

By signing below, you confirm that you have read and understood the information provided above and agree to participate in this research. You understand your rights and confirm that your participation is voluntary.

Participant's Name: _____

Signature:

Date:

Researcher's Name: Lili Sanders

Signature:

Date:

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated *26-03-2025*, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves audio recorded and transcribed-as-text interview, of which confidential information will be excluded from direct publication and recordings will be destroyed after thesis publication.	☐	☐
4. I understand that the study will end in July 2025.	☐	☐
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
5. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) name and email address and associated personally identifiable research data (PIRD) professional function and organization with the potential risk of my identity being re-identified.	☐	☐
6. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach: secure data storage with limited access for involved researchers and supervisors, data (pseudo-)anonymisation, and confidential information check by responsible company mentor.	☐	☐
7. I understand that personal information collected about me that can identify me, such as my name and that it will not be shared beyond the study team.	☐	☐
8. I understand that the (identifiable) personal data I provide will be destroyed after the study period ending in July 2025.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
9. I understand that after the research study the de-identified information I provide will be used for a published thesis report.	☐	☐
10. I agree that my responses, views or other input can be quoted anonymously in research outputs.	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
11. I give permission for the de-identified interview transcript that I provide to be archived in the TU Delft graduation thesis repository so it can be used for future research and learning.	☐	☐
12. I understand that access to this repository is open access.	☐	☐

D

D: CONFIRMABILITY - RESEARCHER COMMENTARY

L

#18 · Design process
Lili Sanders 1 month ago
rephrase to a concrete exmaple of an existing problem. DFS needs... is more giving invofmation rather than contextualizing the situation. It is a hope. If the aim is to make it a concrete problem it needs to be rephrased.

L

#14 · Research design
Lili Sanders 2 months ago
Include DFS employees in co-creative sessions or discussion on implementation or BMI design, so that they feel more ownership of the idea and are more likely to work with it when I've left.

L

#13 · Research design
Lili Sanders 2 months ago
discussion: doubt if I should add this. Fully based on theoretical framework and in the end this is something that I will be designing, so does it make sense to code it in retrospect of the current case? Furthermore, the theme is not based on the research ...

L

#10 · Research design
Lili Sanders 2 months ago
additions to coding tree by comparing four-box business model framework and water transit system research to the documents in the dataset

L

#6 · Research design
Lili Sanders 3 months ago
Can I make a distinction in the text/literature overview of approach-oriented research and outcome-oriented research?

L

#4 · Research design
Lili Sanders 3 months ago
Seperation of sustainability (and moving TLBMC here): iteration triggered by question of W3 during informal conversation: what is sustainability? is that only in terms of environmental impact?

L ••• ✓

#13 · Thematic pattern matching
Lili Sanders 1 month ago
maybe the difference between the client value proposition and the municipality value proposition is its level of abstractness

L

#1 · Ideation
Lili Sanders 1 month ago
implication of this direction: the connection between WTS and BM becomes implicit instead of explicit (explicit would be like direction 1 and 2, or like the theoretical framework, where all elements are clearly classified and linked to WTS and BM ...

L

#6 · Ideation
Lili Sanders 1 month ago
The principles should probably get a new name to avoid jargon

L

#16 · Ideation
Lili Sanders 1 month ago
maybe the text on the lines should only be business model component descriptions... that would make it clearer

L

#34 · Ideation
Lili Sanders 25 days ago
check whether the actor/component should be linked to each other, or whether the key resource/process/profit formula is interacting! (design decision)

F

F1: PRELIMINARY THEMES AND CODING TREE

Theme 1: Maritime public transportation
code 1: vessel design and operational capabilities
code 2: fleet contextual information
code 3: public transportation integration
code 4: terminal design - TOD/FOD
code 5: safety and security
code 6: passenger implications/use-types

Theme 2: Business model
code 8: tender publisher value proposition
code 9: client value proposition
code 10: shipyard value proposition
code 11: user value proposition
code 12: passenger value proposition
code 13: operations functional resources
code 14: partnerships and alliances

Theme 3: Sustainability
code 15: sustainability in the maritime sector
code 16: sustainability in vessel design
code 17: sustainability in fleet design
code 18: sustainability in system design
code 19: opportunities for sustainability
code 20: challenges for sustainability
code 21: social impact in MPT

Theme 4: Innovation
code 22: BM component innovation
code 23: BM architecture innovation
code 24: BM typology innovation
code 25: challenges for BMI

F2: REVISED THEMES AND CODING TREE

Theme 1: Maritime public transportation
Sub-theme 1: System components
- Vessel design and operational capabilities
- Crew implications
- Charging system specifications
- Passenger satisfaction
- Passenger implications/use types
- Route design
- Tender partners
- Legal implications
- Maritime limitations
- Fare
- Patronage
- Scheduling
- Accessibility
- Operating costs

Sub-theme 2: Ferry-oriented development
- Terminal design
- Terminal location
- Terminal marketing
- Area property value

Sub-theme 3: System principles
- Modal integration into transportation planning
- Integration with land-side connections
- Economic development of system landings
- Environmental benefits and minimal effects
- Safety and security
- Ferry systems for freight

Sub-theme 4: Tender lifetime
Sub-theme 5: Operating profile
Sub-theme 6: Fleet financing

Theme 2: Business model
Sub-theme 7: Profit formula
- Revenue model
- Cost structure
- Target unit margin
- Resource velocity

Sub-theme 8: Value proposition
- Job-to-be-done (JTBD)
  - Client JTBD
  - Operator JTBD
  - DFS JTBD
- Offering
  - Client offering
  - Operator offering
  - DFS offering
  - Workboats offering

Sub-theme 9: User value proposition
- Job-to-be-done (JTBD)
  - Crew JTBD
  - Passenger JTBD
  - Municipality JTBD
- Offering
  - Crew offering
  - Passenger offering
  - Municipality offering

Sub-theme 10: Key resources
- Partnerships and alliances
- Stakeholders
- Products
- Information
- Funding
- Brand
- Technology
- Facilities
- Equipment

Sub-theme 11: Key processes
- Financing
- Responsibilities
- Scalability
- Repeatability
- Marketing
- Design process
- Sourcing
- Manufacturing

- Training
- Business rules and success metrics
- Behavioral norms
  (approach to customers and channels, opportunity size needed for investment)

Theme 3: Sustainability
Sub-theme 12: Sustainability in the maritime sector
Sub-theme 13: Sustainability in vessel design
Sub-theme 14: Sustainability in fleet design
Sub-theme 15: Sustainability in system design
Sub-theme 16: Opportunities for sustainability
Sub-theme 17: Challenges for sustainability
Sub-theme 18: Social impact in water transit systems
Sub-theme 19: Sustainability baseline assessment
Sub-theme 20: Environment, social, governance (ESG)

Theme 4: Innovation
Sub-theme 21: Business model component innovation
Sub-theme 22: Business model architecture innovation
Sub-theme 23: Business model typology innovation
Sub-theme 24: Challenges for business model innovation

Theme 5: Sustainable Business Model Innovation
Sub-theme 25: Sustainable business model innovation approach
Sub-theme 26: Sustainable business model innovation outcome

F3: VISUAL OVERVIEW FINAL CODING TREE

EMPIRICAL STUDY

Data analysis

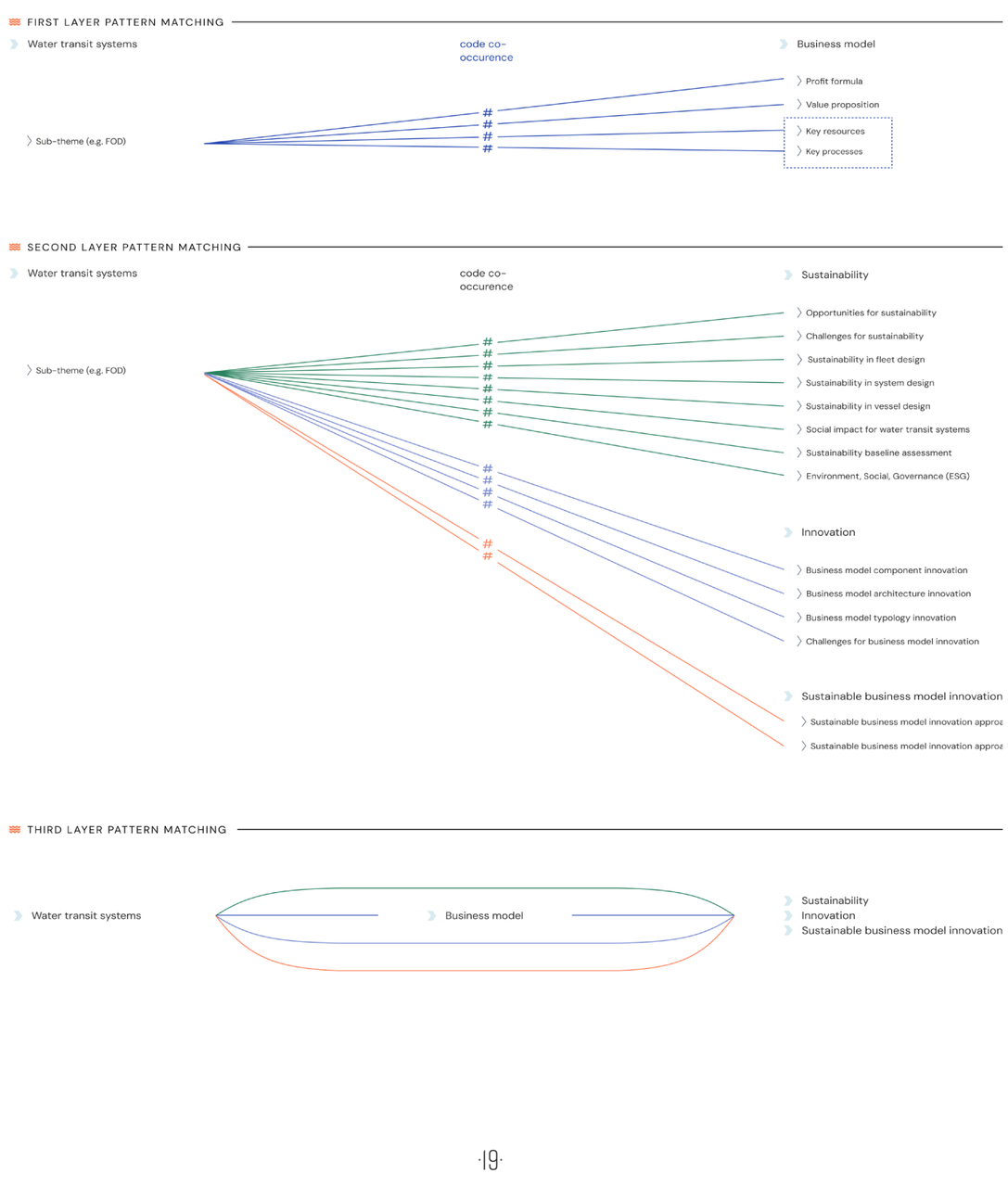
Themes	Sub-Themes	Codes
Water transit systems	System components	Vessel design and operational capabilities
		Crew implications
		Charging system specifications
		Passenger satisfaction
		Passenger implications/use types
		Route design
		Tender partners
		Legal implications
		Maritime limitations
		Fare
		Patronage
		Scheduling
		Accessibility
		Operating costs
	Ferry-Oriented Development	Terminal design
		Terminal location
		Terminal marketing
		Area property value
	System principles	Modal integration into transportation planning
		Integration with land-side connections
		Economic development of system landings
		Environmental benefits and minimal effects
		Safety and security
		Ferry systems for freight
	Tender lifetime	
	Operating profile	
	Fleet financing	
Business model	Profit formula	Revenue model
		Cost structure
		Target unit margin
		Resource velocity
	Value proposition	Client jtbd
		Operator jtbd
		DFS jtbd
		Client offering
		Operator offering
		DFS offering
		Workboats offering
	User value proposition	Crew offering
		Crew job-to-be-done
		Passenger offering
		Passenger job-to-be-done
		Municipality offering
		Municipality job-to-be-done
	Key resources	Partnerships and alliances
		Stakeholders
		Products
		Information
		Funding
		Brand
		Technology
		Facilities
		Equipment
	Key processes	Financing
		Responsibilities
		Scalability
		Repeatability
		Marketing
		Design process
		Sourcing
		Manufacturing
		Training
		Business rules and success metrics
		Behavioral norms (approach to customers and channels, opportunity size needed for investment)

EMPIRICAL STUDY

Data analysis

Themes	Sub-Themes	Codes
Sustainability	Sustainability in the maritime sector	
	Sustainability in vessel design	
	Sustainability in fleet design	
	Sustainability in system design	
	Opportunities for sustainability	
	Challenges for sustainability	
	Social impact in water transit systems	
	Sustainability baseline assessment	
	ESG	
Innovation	Business model component innovation	
	Business model architecture innovation	
	Business model typology innovation	
	Challenges for business model innovation	
Sustainable business model innovation	Sustainable business model innovation approach	
	Sustainable business model innovation outcome	

G: LAYERED PATTERN MATCHING STRUC-TURE



H1: EXTERNAL VALIDATION INTERVIEW QUESTIONS

Part 1: Explanatory quality

1. Can you describe how the Pyramid is constructed?
2. Can you describe the purpose for which the Pyramid was built?
3. What do you think of the structural presentation of the information and elements in the Pyramid?
4. What do you think of the structure of the manual? In your opinion, does it follow a logical structure and explanation?
5. Is the manual sufficient to get started with the Pyramid Toolkit?

Part 2: Implementability

1. What do you think of the applicability of the Pyramid Toolkit in the general ferry transport industry?
2. Do you find the model useful for Aqualiner as a tool to improve the current situation?

Part 3: Strategic value

1. In your opinion, is the Pyramid Toolkit a valuable addition to Aqualiner's strategy?
2. As an individual, what do you think of the design of the Pyramid Toolkit?
3. What do you think of the design of the Pyramid Toolkit as a representative of Aqualiner?
4. Do you have additional comments about the content or structure of the entire toolkit (Pyramid, manual, innovation cards, co-creation session, innovation strategy)?

Thank you for answering my questions. Do you have anything to add, or a question for me?

H2: INTERNAL VALIDATION SURVEY RESULTS

PARTICIPANT F1

Please assess the tool along the following metrics	Rating: 1 = very low, 2 = low, 3 = neutral, 4 = high, 5 = very high	Any comments?
EXPLANATORY QUALITY		
Conceptual clarity: does the tool communicate and explain the concepts on which it was built?	4	
Completeness: does the tool include and explain relevant theory and practical elements?	4	
Logic: does the tool contain logically structured elements?	4	
IMPLEMENTABILITY		
Practical usability: is the tool useful for general ferry system practice?	4	*I am sure the tool will result in more awareness, however, we will have to see if it leads to improvements in the current situation. I do believe that a major part of the strength of the tool will be in the future developments.*
Situation improvement: does the tool and its use lead to improvements of the current situation?	4	
STRATEGIC VALUE		
Business relevance: does the tool relate back to a genuine business opportunity or challenge?	4	*In my opinion, the tool will be extremely useful to create awareness of all perspectives during development of new POW (passenger transport over water) models.*
Value generation: does the tool and its implementation generate actual value for Damen?	4	
Stakeholder success: do you as an individual recognize the design as successful?	4	
Stakeholder success: does Damen as a company in your opinion recognize the design as successful?	4	

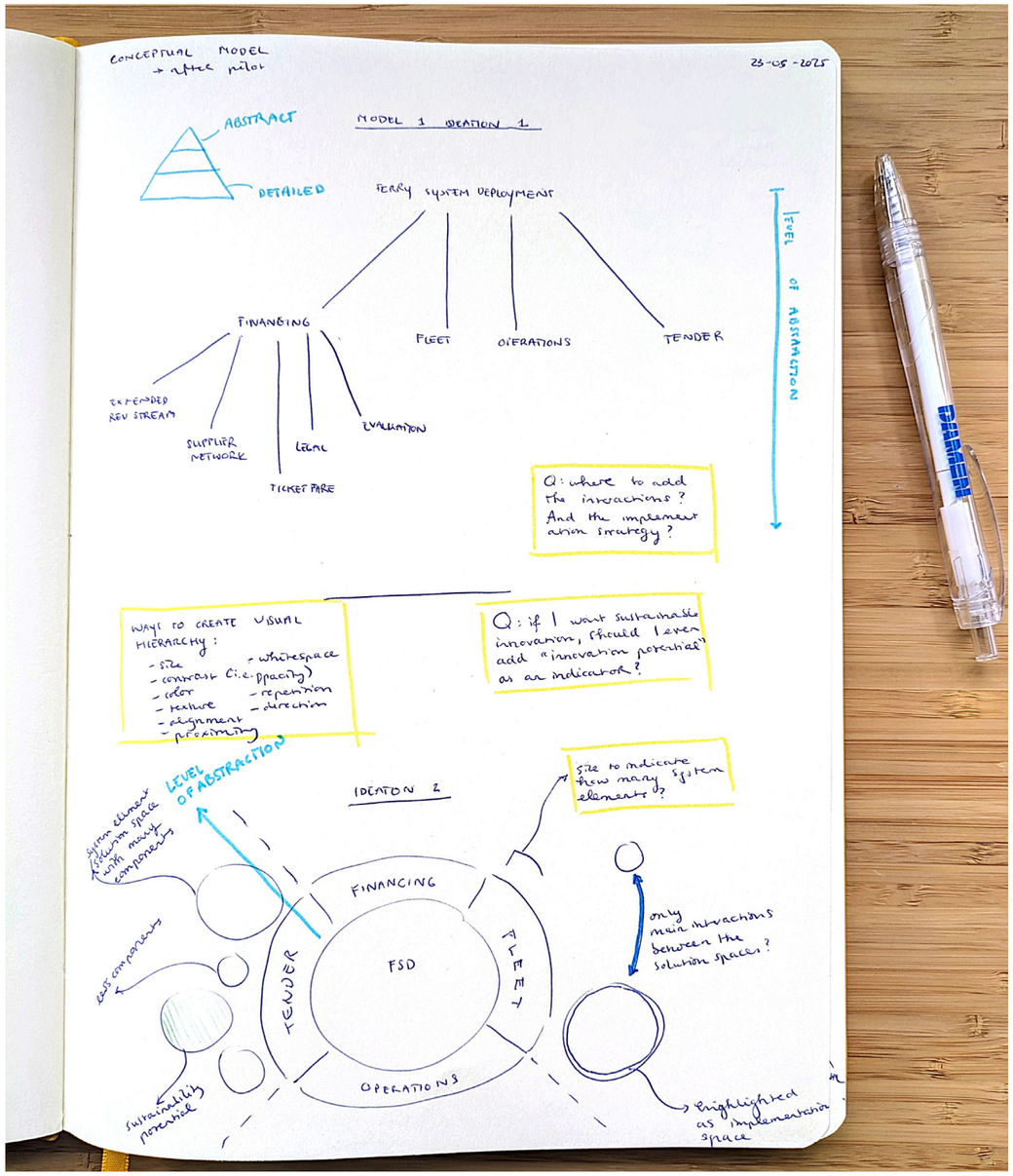
PARTICIPANT F4

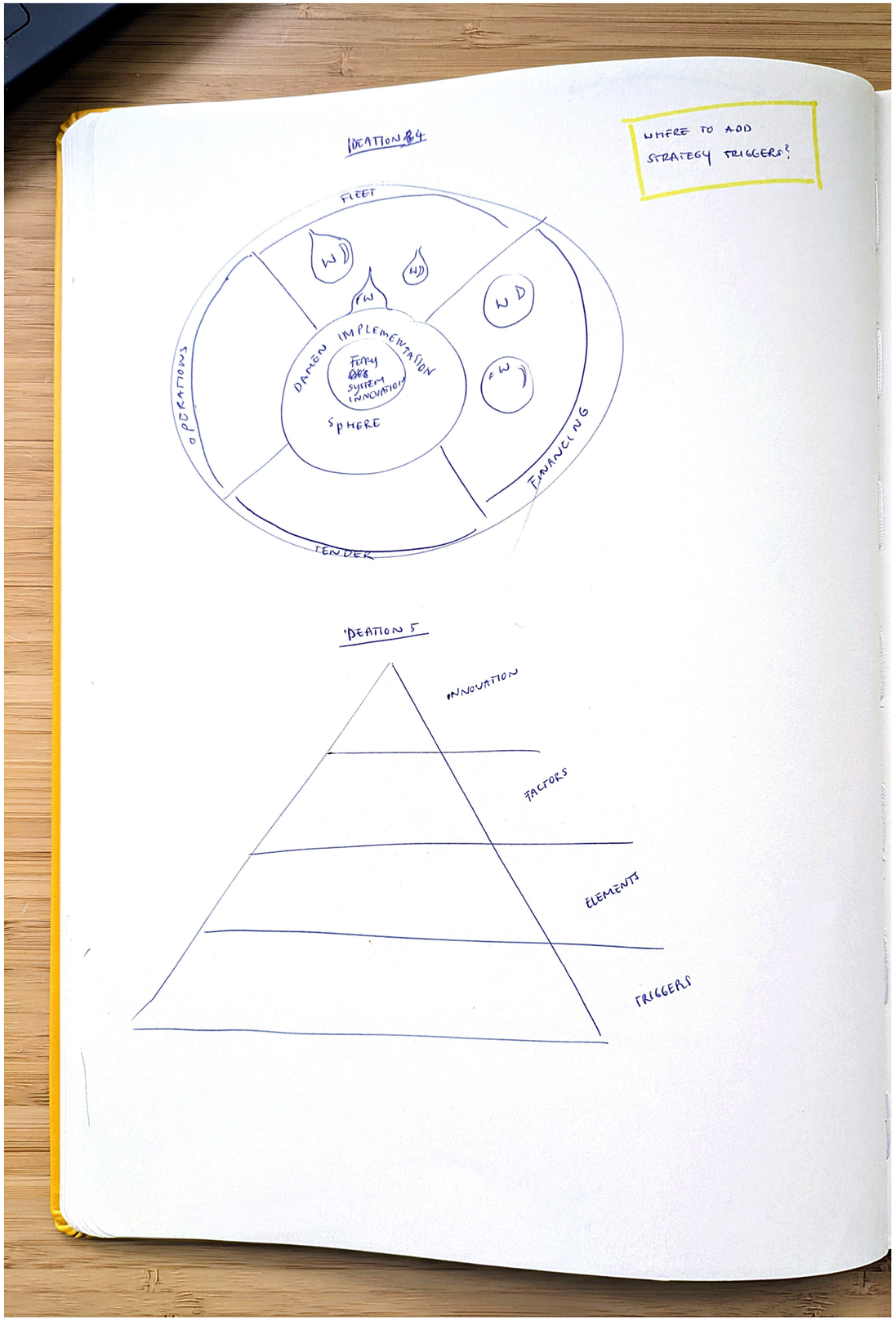
Please assess the tool along the following metrics	Rating: 1 = very low, 2 = low, 3 = neutral, 4 = high, 5 = very high	Any comments?
EXPLANATORY QUALITY		
Conceptual clarity: does the tool communicate and explain the concepts on which it was built?	5	*The concepts are clear and visually appealing. It ties together the inputs from the interviews and creative session and the theoretical framework.*
Completeness: does the tool include and explain relevant theory and practical elements?	4	
Logic: does the tool contain logically structured elements?	5	
IMPLEMENTABILITY		
Practical usability: is the tool useful for general ferry system practice?	4	*The presented solution areas require further practical detailing in order to implement them.*
Situation improvement: does the tool and its use lead to improvements of the current situation?	3	*Too soon to say if it leads to actual improvements.*
STRATEGIC VALUE		
Business relevance: does the tool relate back to a genuine business opportunity or challenge?	5	*The tool is very relevant and has the potential to generate actual value. The problem of the Waterbuses is clearly analyzed and reflected upon with the proposed solution areas.*
Value generation: does the tool and its implementation generate actual value for Damen?	4	
Stakeholder success: do you as an individual recognize the design as successful?	4	
Stakeholder success: does Damen as a company in your opinion recognize the design as successful?	4	


Key factors in water transit deployment
system element
actor/component
interaction scheme
solution space
value proposition
Financing
Tender partners
suppliers
Ticket fare
passengers
bike capacity
Legal implications
Fleet
Patronage
fleet capacity
people capacity
Vessel design
battery system
frequency
emissions
design
crew
electrification
client
Operations
Passenger satisfaction
comfort
safety
sustainable travel
Maritime limitations
external conditions
adaptation
Operating costs
fuel/energy consumption
service
labour
training
Charging system specifications
charging station
charging time
Route design
linear
cross-river
city-extended trans-river
Schedule
mooring time
public transportation planning
demand
travel time
Asset lifetime
quality protection
repair
validation
circular practice
revenue stream
barriers to acceptance
use-type and travel distance
inter-modal transport
acquiring green certification
material impact assessment
sustainability taxes
electrification compensation
space, speed and weight limitation
peak sharing and fast mooring
electric or hybrid fuel transition
design for robustness
design for automation
design for multicultural implications
design for modularity
design for ease of use
shift from operational to manufacturing impact
shift from capital to operational costs
innovative mindset
design for maritime conditions
design for area specific operational profile
electricity to fuel ratio and capacity
asset downtime
crew amount and skill level
creating technology readiness
location and ease of connection
asset downtime
multiple destinations along waterfront (zigzag or one-sided)
short distance crossing from one waterfront to the opposite side
long distance connection between remote areas
skill, maritime conditions, vessel and terminal design
integration and dependency
delays
service and repair partners
ease of repair
validation strategies in various design stages
design for modularity
on-vessel marketing
facilitating the energy transition
limited sustainable resource channels
introducing partnership requirements
affordable public transportation
dynamic pricing
compensating on quality for certification (i.e. material, assets)
sustainability regulations
implementation of unsustainable fuel tax in cost calculation for clients
asset redundancy
bike and/or battery capacity is compensated with passenger capacity
battery weight
increased fuel consumption and/or charging cycles
experts facilitate the sustainability transition but they are scarce
software settings lock to protect systems
autonomous fault finding
development of variously applicable maritime technology
automation limits employment opportunity
multicultural market acceptance
multiple tender responsibility
design for various applications is at the cost of current optimization
overall environmental impact becomes harder to assess
example: Copenhagen vs. POW
extra charge for clean and comfortable travel modes
different for various external conditions (i.e. offshore, heat)
extra charge for sustainable travel modes
reduced potential for reuse
client penalties and depreciation without revenue
retained asset ownership to ensure quality maintenance
reducing labour costs through operation automation
user manuals and training
reduced scheduling and distance flexibility
reduced scheduling and distance flexibility
vessel speed is highly competitive
high frequency
interior design for longer travel times
low passenger volumes and peak hour operations
cheap repair and maintenance inhibits sustainable practice
enabling self-service
low technology readiness level
closing the loop in multiple stages and through various channels
introducing impact assessment processes
reset and system development for return to manufacturer
no direct economic benefit
design for various applications is at the cost of current optimization
material impact assessment
reduced financial risk
fixed price to protect consumers
accessibility
operational capabilities
reduced local emissions
reduced risk of vessel damage
reduced risk of system failure or vessel damage
safety on board
uncomplicated ship handling
design freedom
protection from natural elements
design optimization
city development
high passenger capacity
urban and sub-urban connection
technology readiness

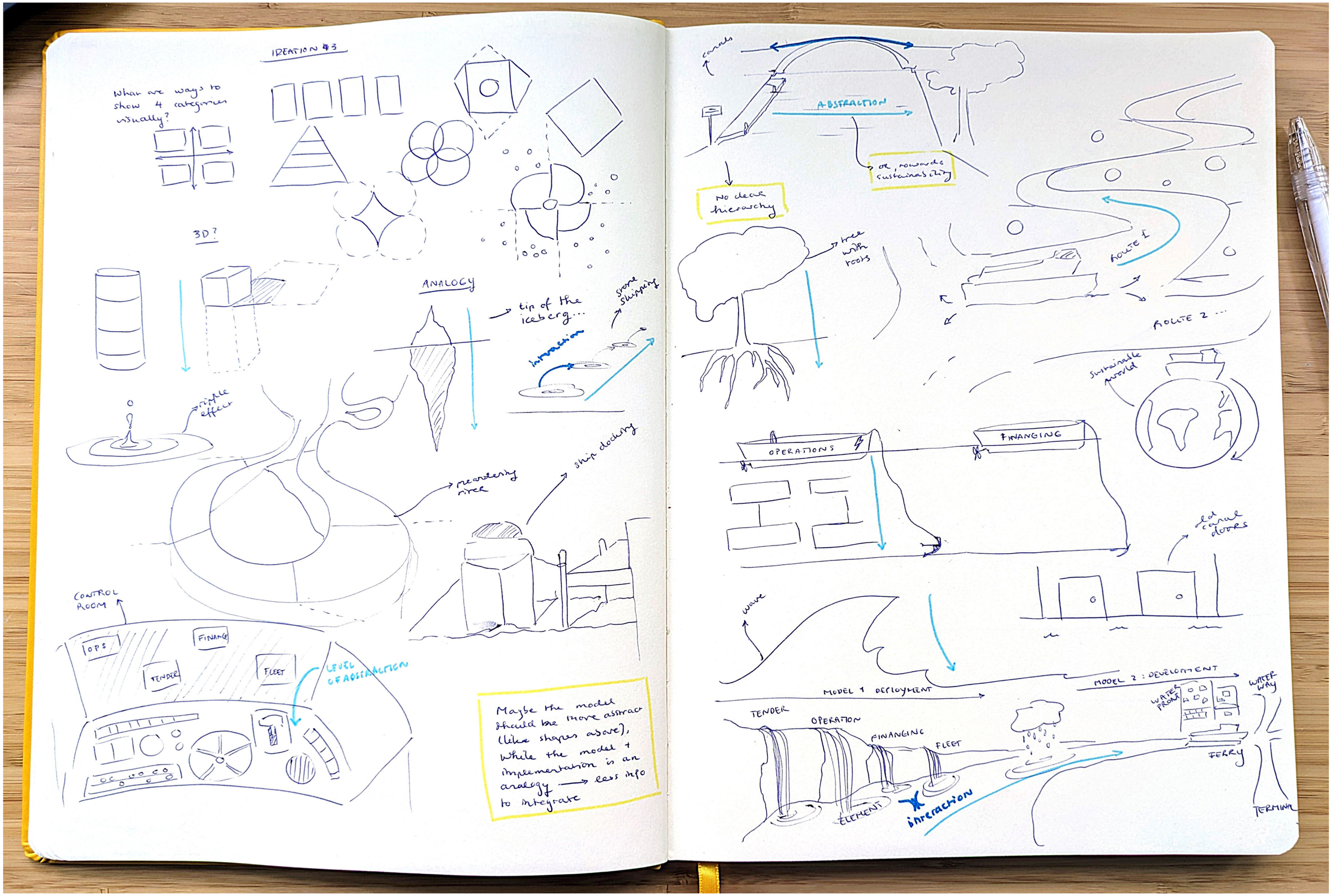
M

MI: NEW CONCEPTUAL MODEL IDEATION

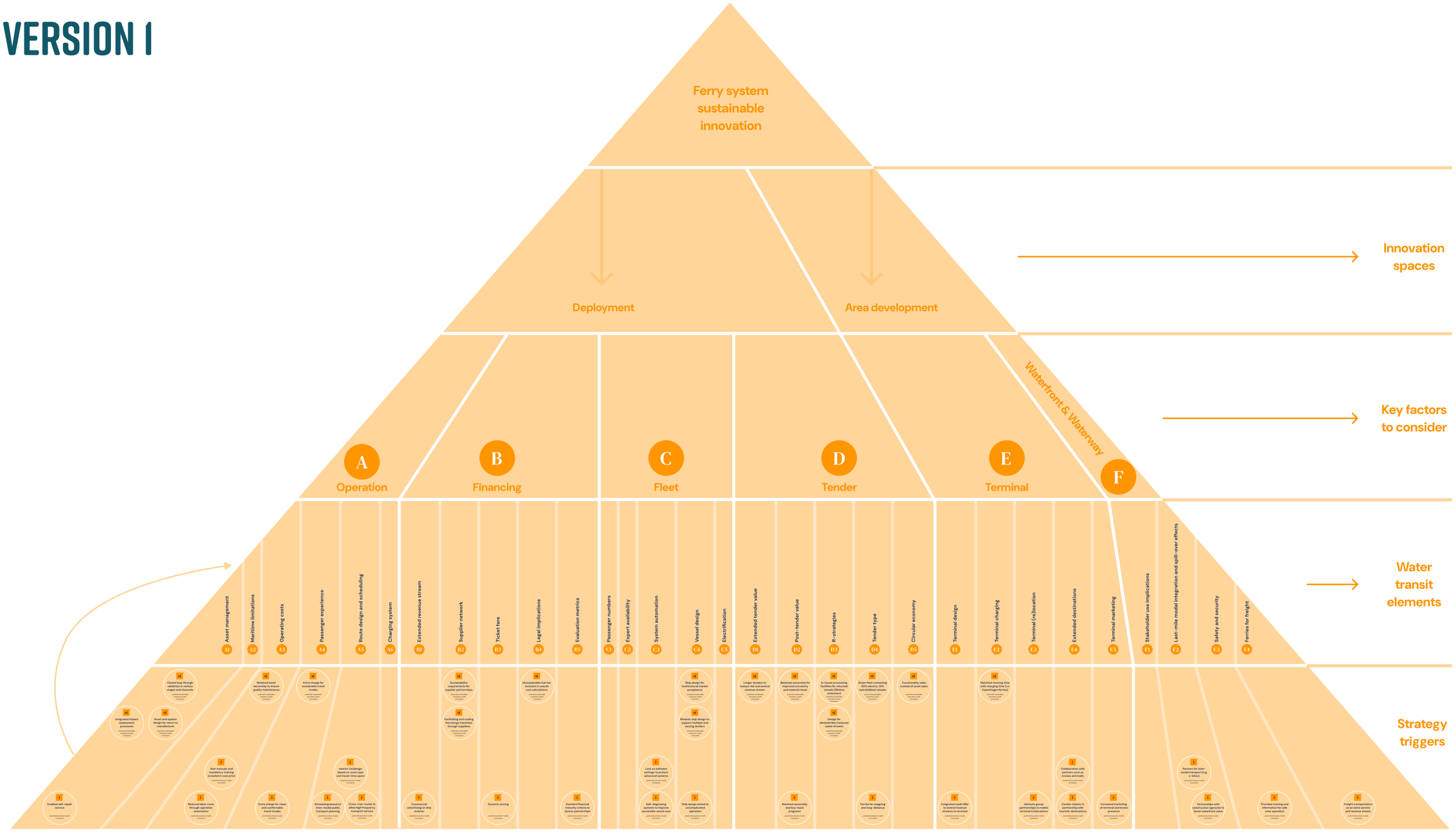




APPENDICES


IDEATION #3
What are ways to show 4 categories visually?
3D?
ANALOGY
tip of the iceberg...
stone skipping
interaction
ripple effect
meandering river
ship docking
CONTROL ROOM
OPS
FINANCE
TENDER
FLEET
LEVEL OF ABSTRACTION
Maybe the model should be more abstract (like shapes above), while the model + implementation is an analogy → less info to integrate
canals
ABSTRACTION
or, towards sustainability
No clear hierarchy
tree with roots
ROUTE 1
ROUTE 2 ...
sustainable world
OPERATIONS
FINANCING
old canal doors
wave
MODEL 1 DEPLOYMENT
MODEL 2 : DEVELOPMENT
TENDER
OPERATION
FINANCING
FLEET
ELEMENT
interaction
WATER FRONT
WATER WAY
FERRY
TERMINAL

M2: PYRAMID TOOL VERSION 1



APPENDICES

M3: PYRAMID TOOL VERSION 2

