

Modeling the icebreaker operational process for enhanced understanding and efficiency in winter navigation

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Motivation

- Icebreakers are essential for safe winter navigation
- Lack of machine readable documented and structured knowledge
- limits opportunities for automation, optimization, training, and risk

A growing demand for better understanding icebreakers' operational behavior



Research Gap:

- Prior studies focus on **isolated tasks** or functions
- Lack of **integrated, system-level** process representation
- How does the process happen in **real-world?**
- A **step-by-step** representation of **sequence** of **tasks** and **events**

Lack of Big Picture and Systems Thinking Perspective

Perspective Matters

- **Data vs. Process View**

- Data Mining focuses on
 - **Patterns within data**
 - **What is happening in the data?**
- Process Mining looks at
 - **processes as systems**
 - **How do processes work, and where do they fail?**
 - Helps **explain** and **visualize** patterns and **behaviors over time**

**Analyzing and Detecting Bottlenecks
Leads to Operational Optimization**

Hypothesis:

Using Process Modeling as a System Thinking Approach

- **Shifts** from analyzing **isolated parts** to understand the **whole system**
- Focuses on **interconnectedness** and **interactions** within a system



Problem Statement

Creating a Structured Model to Understand Icebreaker's Operational Process

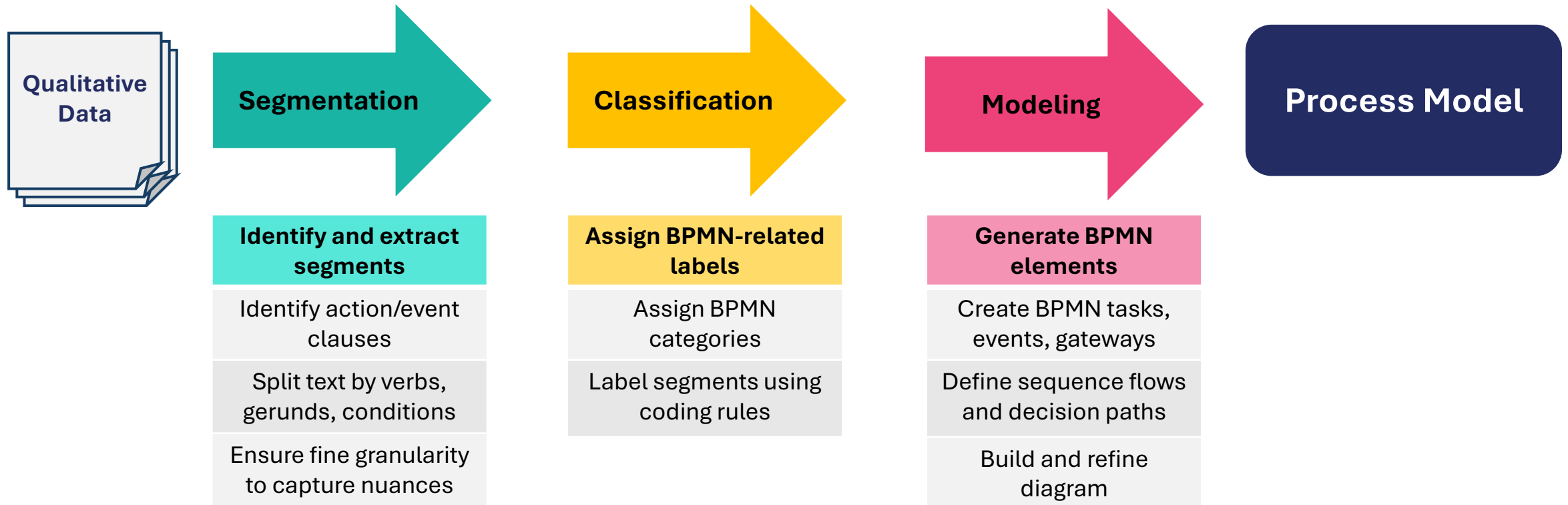
1. How can we systematically **document** and **model** the entire icebreaker **operational process**?
2. What **modelling method** can capture the **sequence**, **interaction**, and **decision points**?
3. Can **qualitative data** from real missions be transformed into structured, **formal models**?

Case Study



- Data collection (10-day expedition)
 - Interviews & observations
- Text Mining to extract process elements
 - Based on segmentation and proposed classification rules
- Creating the process model
 - Based on proposed modeling rules

Method Overview

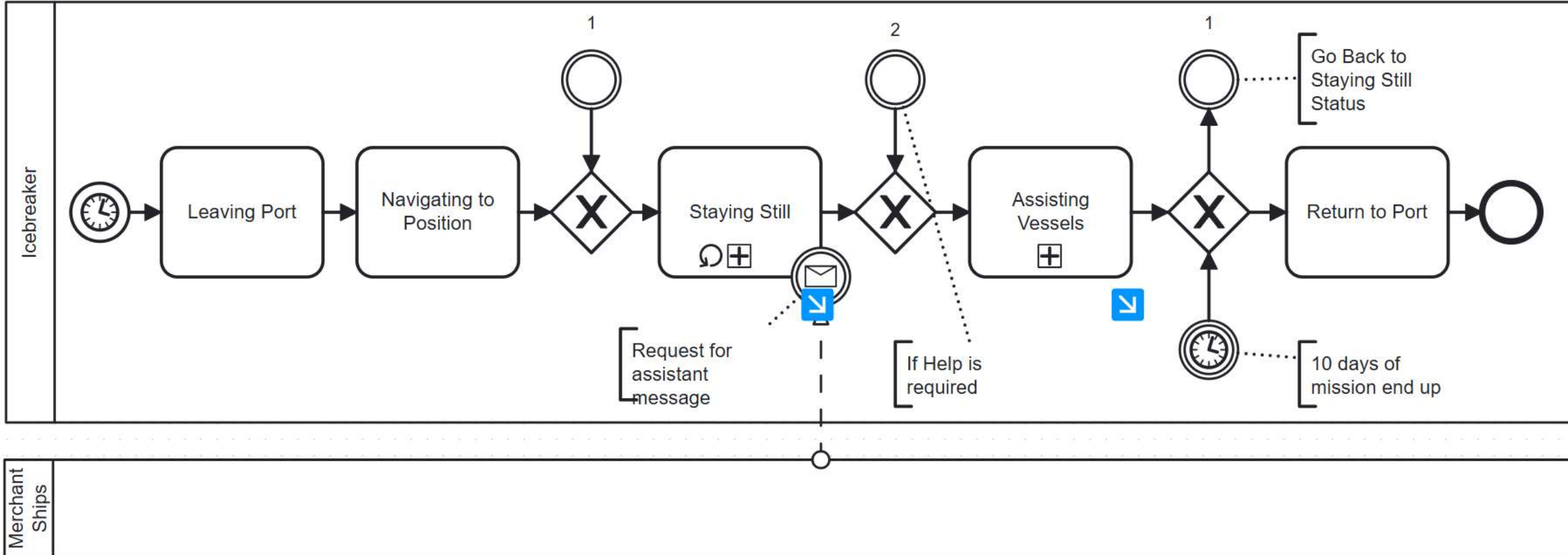


Law, Y. C., Wehrt, W., Sonnentag, S., & Weyers, B. (2023). Obtaining semi-formal models from qualitative data: From interviews into bpmn models in user-centered design processes. *International Journal of Human-Computer Interaction*, 39(3), 476-493.

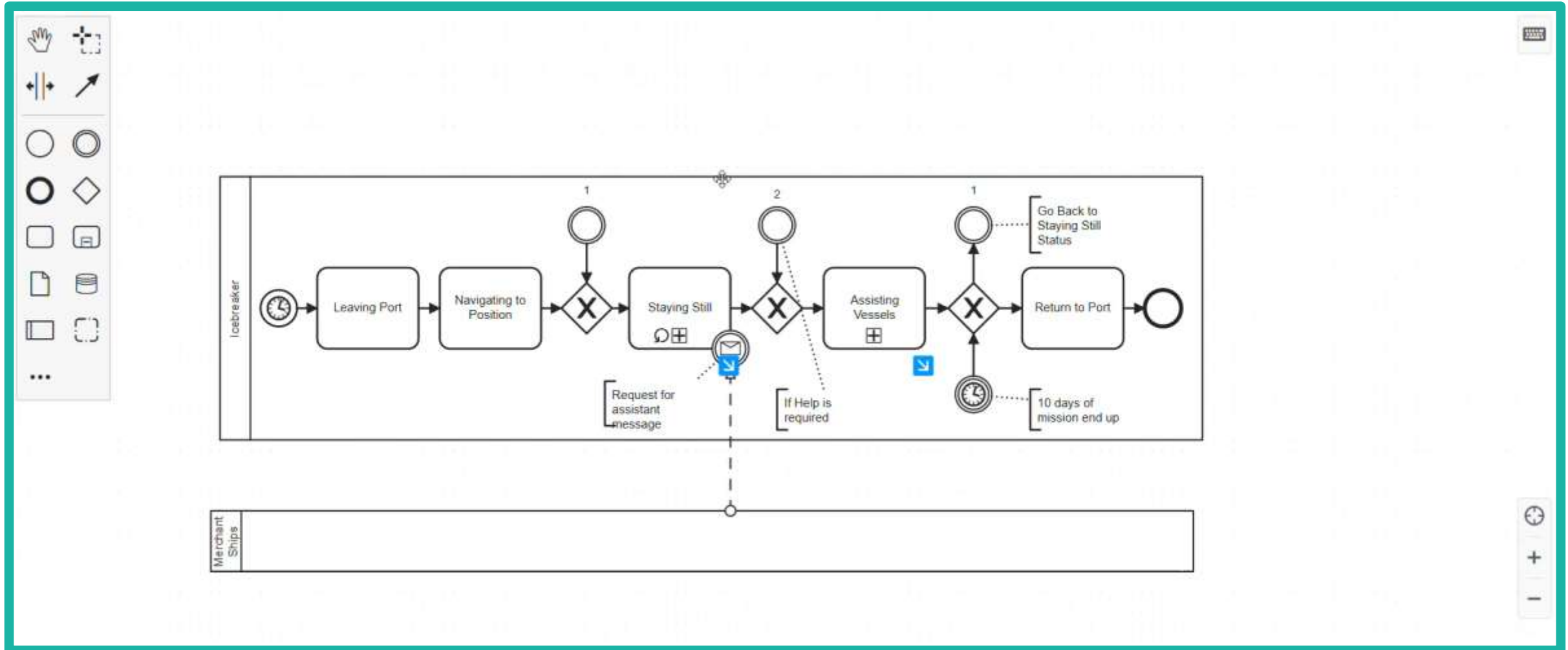
Segmentation and Classification

<p>A sample part of data</p>	<p>Traffic condition monitoring:</p> <ul style="list-style-type: none"> • Connection with the pilot systems – when the IB stays in the fairway to track inbound/outbound vessels and track which vessel would need help and when. • Observation - About the vessels in the sea • IBNET also has traffic information and detailed ship operation for specific ships
<p>Results of applying Segmentations and Classification Rules</p>	<p>1. Traffic condition monitoring: (MT) Subtask Segments 2. Connection with the pilot systems – (ST) 3. when the IB stays in the fairway (S) 4. to track inbound/outbound vessels (SST) 5. track which vessel would need help and when (SST) 6. Observation – (ST) 7. About the vessels in the sea (Aref) 8. IBNET also has traffic information (ST) 9. detailed ship operation for specific ships (SST)</p>

The BPMN Model of the Operational Process



The BPMN Model of the Operational Process



Model Elements Detected

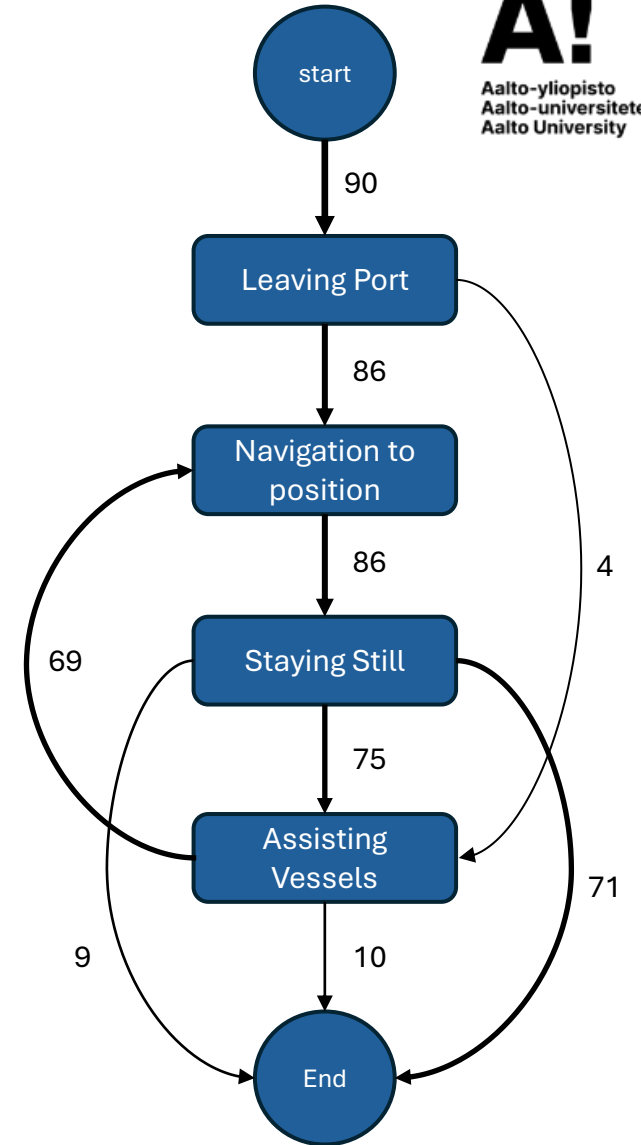
Category	Count	Description
Total textual segments	68	Segments extracted from observations
Main Tasks (MT)	5	High-level phases (e.g., Leaving Port; Navigating; Staying Still; Assisting; Return)
Subtasks (ST)	7	Mid-level actions within main tasks
Secondary Subtasks (SST)	16	More granular actions under subtasks
Events (En)	4	Environmental or temporal events (e.g., Reached Position; Ice Update; Assist Completed)
Conditions/Gateways (C)	23	Decision points (e.g., Need Assistance?; Ice Severity Check)
Settings/Annotations	11	Context notes, descriptive clauses
Looped Tasks	2	Loop back to “Staying Still”

Implications & Future Work

- Using in simulation, training, and resource or process optimization
- Process mining and detecting bottlenecks and risk points
 - Integrate AIS/GIS data (spatiotemporal data)
 - Extend to multiple icebreakers
- Comparing and analyzing “work as done” versus “work as imagined”

Each blue box = a major operational phase
 Each arrow = a transition between two phases
 Each number = frequency of that transition

To-be mined
 process
 model



Team Intelligence in Marine Systems



Mashrura Muhsarraf

Assistant Professor

Expertise: Human-centred automation



Mahsa Khorasani

Postdoc

Expertise: ML, AI, Process Mining
Project: WATERWAYS



Cong Liu

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Expertise: Data mining, ML, Winter Navigation
Project: Human-centered automation



Adanna Okonkwo

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Expertise: Maritime, Energy management, Optimization
Project: FUSE



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PhD Student

Expertise: Product Development, Quality Management, Optimization
Project: Human-centered automation

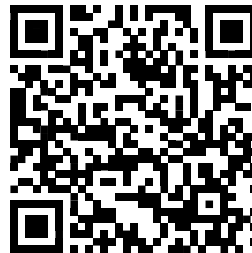


Anas Rizwan

PhD Student

Expertise: Data analytics, Sustainability, Optimization
Project: WATERWAYS

Acknowledgement and Thank You



<https://waterways.projectsites.aalto.fi/project-overview/>

Reference: Khorasani, M., Liu, C., Banda, O. V., Suominen, M., & Musharraf, M. (2025). Using Process Modelling Approach and Qualitative Data to Build a Unified Understanding of Icebreaker Operations.