MARITIME
MARITIME OPERATIONS

PONTOS – Open datahub for ship operational data

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Svensk sammanfattning

PONTOS – öppen datahubb för driftsdata från fartyg

PONTOS-projektet syftade till att förbättra utvecklingen och effektiviteten inom sjötransport genom att utnyttja operativ data från fartyg. Genom lanseringen av PONTOS-hubben möjliggjorde projektet öppen och fri tillgång till historisk och (nästan) realtidsdata från 18 fartyg, med planer på att upprätthålla denna tjänst åtminstone till december 2027. Plattformen ger forskare, företag och innovatörer möjlighet att utforska nya sätt att förbättra hållbarhet och effektivitet inom sjöfartssektorn.

Flera initiativ genomfördes under projektets gång för att visa värdet av operativ data. Dessa inkluderade tre masteruppsatser, två hackathons och förberedelser för en online-tävling. Trots att projektet överträffade förväntningarna i kunskapsskapande aktiviteter uppstod vissa utmaningar, såsom att det första hackathonet ställdes in och att det inte var möjligt att koppla vissa fartyg från specifika fartygsägare på grund av tekniska och resursrelaterade begränsningar.

Projektet adresserade också komplexiteten kring datadelning och utformade avtal och licenser för att möta oro hos dataägare och dataleverantörer. Dessa avtal säkerställer dataintegritet, producenternas självbestämmande och överensstämmelse med principerna för öppen tillgång. Trots framgångarna erkände projektet behovet av ytterligare utforskning av styrmodeller för att anpassa PONTOS-hubben till EU:s utvecklande datastrategier och regelverk.

Sammanfattningsvis uppnådde PONTOS-projektet sina kärnmål och lade en solid grund för användningen av operativ fartygsdata för att driva innovation inom sjöfarten. Projektets partners ser dock detta som början på en längre resa för att förverkliga EU:s vision om en mer hållbar och datadriven sjöfartssektor.

RISE uttrycker sin tacksamhet till alla partners, särskilt dataägarna, för deras ovärderliga bidrag till projektet och det bredare målet att främja öppenhet och samarbete inom branschen. Ett särskilt tack riktas även till Trafikverket för att ha finansierat PONTOS-projektet och möjliggjort detta viktiga arbete.

Nyckelord: öppna data, innovation, data delning, fartygsdata

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Content

1 Introduction

1.1 Background

The maritime industry plays a pivotal role in the global economy but faces mounting pressure to evolve in response to sustainability challenges. In a world of finite natural resources, continuous improvement in operational efficiency is not just beneficial but essential for reducing environmental impact and maintaining competitiveness in a global market. This necessity is especially evident in Sweden’s efforts to achieve the national goal of reducing greenhouse gas emissions from domestic transport by at least 70% by 2030 compared to 2010.

Efficiency improvements in the maritime sector can be approached from multiple perspectives. On a systemic level, the focus lies in optimizing the maritime logistics network, creating more streamlined and sustainable supply chains. At the level of individual vessels, significant opportunities exist to enhance operational practices, while component-level advancements target specific ship systems, such as engines or propulsion mechanisms. For shipping companies, the most accessible and impactful areas are often at the unit and component levels, where immediate operational benefits can be realized.

While advancements at the component level are typically driven by manufacturers during hardware upgrades or replacements, companies operating vessels have a unique opportunity to improve performance through continuous operational optimization. Over the past decade, many shipping companies have initiated digitalization projects to capitalize on this potential. For instance, Färjerederiet and Öresundslinjen have invested in energy measurement systems, Meriaura Group has implemented emissions monitoring systems, and Stena Line has embraced AI-assisted fuel optimization. These initiatives underline the growing recognition of digital tools as a pathway to greater efficiency.

One key advantage of digitalization is the ability to collect and analyse operational data from vessels. This data provides actionable insights into how vessels can be operated more efficiently, contributing to both environmental and economic gains. For example, a 10% improvement in vessel efficiency could reduce domestic maritime emissions in Sweden by 66,000 tons of CO_2 equivalents annually, equivalent to the emissions of approximately 13,000 cars in a year. Such efficiency gains not only lower costs for shipping companies but also yield significant societal benefits by reducing air and water pollution.

Despite the potential of operational data, many shipping companies face challenges in fully utilizing it. Extracting value from such data requires a combination of expertise in data science, programming, mathematics, and domain knowledge—skills that are often scarce within shipping companies. Consequently, external collaboration becomes crucial to effectively harness the insights that data can offer.

This challenge also highlights the growing demand for open data, which can bridge the gap between companies and external innovators. Open data enables researchers, startups, and technology developers to explore new solutions, validate concepts, and integrate data across different contexts, driving innovation in ways that individual companies may struggle to achieve alone. For the maritime industry, sharing operational data offers a powerful opportunity to accelerate progress toward efficiency and sustainability.

By making operational data openly accessible, shipping companies that lack the resources or expertise to analyse it can still contribute to industry-wide advancements. Such transparency can foster the development of new tools, improve existing systems, and ultimately enhance the maritime industry’s ability to meet environmental and economic goals.

The PONTOS project aimed to build on these possibilities, leveraging data and digital tools to support more sustainable and efficient maritime operations.

The project was financed and made possible thanks to the Swedish Transport Administration[1].

1.2 Purpose

The PONTOS project aimed to accelerate the development and efficiency of maritime transport by promoting and facilitating the use of operational data from ships. It demonstrated and implemented solutions for making such data widely accessible, openly provided data from various shipping companies, and highlighted its potential as a valuable yet underutilized resource. Additionally, the project fostered knowledge creation, supported applications in research and innovation, and explored conditions and requirements for effective data sharing, ultimately contributing to the sharing and exploitation of ship operational data in the maritime sector.

1.3 Objectives

The purpose was broken down into the following concrete objectives:

Objective 1: Deploy PONTOS-Hub

Develop and deploy a centralized access point for operational data from ships: the "PONTOS hub." The hub shall provide open access to both historical data (time series) and (near) real-time data. The hub is to be managed by RISE for at least four years, starting in the second year of the project.

Objective 2: Collect and provision ship operational data

Collect ship operational data from the participating shipping companies and provision it through the PONTOS hub. At the project start, the expected participating vessels included:

[1] *www.trafikverket.se*

- Färjerederiet: 23 ferries
- Öresundslinjen: 3 ferries
- Sjöräddningssällskapet: at least 3 boats
- MeriAura: 2 ships
- Havstens Fiskelag: 1 boat
- Väderö Fisk: 1 boat
- Öckerö municipality: 1 boat

Objective 3: Generate knowledge and demonstrate applications for operational data

Generate knowledge and demonstrate application for ship operational data through organized activities where participants use the data available in PONTOS hub. At the project start, the planned activities where:

- One (1) hackathon
- At least one (1) online competition
- At least one (1) thesis project

Objective 4: Explore suitable conditions and requirements for data sharing

Identify, develop, and evaluate the conditions and requirements necessary for shipping companies to agree to share their operational data.

Objective 5: Suggest a governance model for the future operation of PONTOS-Hub

Suggest a governance model for the operation of PONTOS hub after the project's conclusion. At the project start, the governance model was meant to include:

- Strategy and vision
- Intellectual property rights
- Prioritization of continued development

1.4 Participants

The following list outlines the participants in the PONTOS project and their respective roles *at its inception*. It is important to note that, apart from RISE, the PONTOS project partners are classified as either data producers or data providers. Data producers are shipowners whose vessels generate the operational data, while data providers are companies that hold data capture and analysis contracts with the data producers and share the data with the PONTOS hub on their behalf.

All the data producers participated in-kind, motivated by their commitment to innovation and a sustainable future.

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Act as the project coordinator and main contributor to its objectives (see Section 1.3)

- **Blueflow Energy Management (data provider)**
  Provides data on behalf of its clients, Trafikverket Färjerederiet and Öresundslinjen.

- **Cetasol (data provider)**
  Provides data on behalf of its client, Öckerö municipality, and assist RISE in the organization of the activities.

- **Trafikverket Färjerederiet (data producer)**
  Produces operational data from several ferries, which is provided to PONTOS hub through a third-party sensor platform supplied by Blueflow Energy Management.

- **Öresundslinjen (data producer) (formerly known as ForSea Ferries)**
  Produces operational data from several ferries, which is provided to PONTOS hub through a third-party sensor platform supplied by Blueflow Energy Management.

- **Havstens Fiskelag (data producer)**
  Produces operational data from a fishing boat, which is provided to PONTOS hub through RISE's proprietary test sensor platform.

- **Väderö Fisk (data producer)**
  Produces operational data from a fishing boat, which is provided to PONTOS hub through RISE's proprietary test sensor platform.

- **Öckerö redderi (data producer)**
  Produces operational data from a ferry, which is provided to PONTOS hub through a third-party sensor platform supplied by Cetasol.

- **Svensksjöräddningssälskapet (SSRS) (data producer)**
  Produces operational data from several boats through their proprietary sensor platform.

- **MeriAura Group (data producer)**
  Provides operational data from several vessels through their proprietary sensor platform.

1.5 Structure of the report

This report is structured as follows:

- **Chapter 1** gives an introduction of the PONTOS project.

- **Chapter 2** describes PONTOS hub and the data it provides. The description corresponds to the project objectives number 1 and 2.
- **Chapter 3** describes the activities organised to generate knowledge and demonstrate the application of the data in PONTOS hub. The description corresponds to the project objective number 3.
- **Chapter 4** describes the conditions and requirements for data-sharing. The description corresponds to the project objective number 4.
- **Chapter 5** describes the future of PONTOS hub. The description corresponds to the project objective number 5.
- **Chapter 6** evaluates whether the project objectives were met.
- **Chapter 7** provides some concluding remarks.

2 PONTOS hub

This chapter describes PONTOS hub and the data it provides in detail.

2.1 Key functionality

The key functionality of PONTOS hub is:

1. Provide open access to historical and (near) real-time ship operational data collected from PONTOS project participants.
2. Clearly communicate and require acknowledgment of the open licenses governing the database and its contents.
3. Enable users to select specific historical or (near) real-time ship operational data as needed.

2.2 Architecture and technical design

Figure 1 presents a diagram of the architecture of PONTOS hub. The architecture of the hub was designed to fulfil the key functionalities as efficiently and simply as possible.

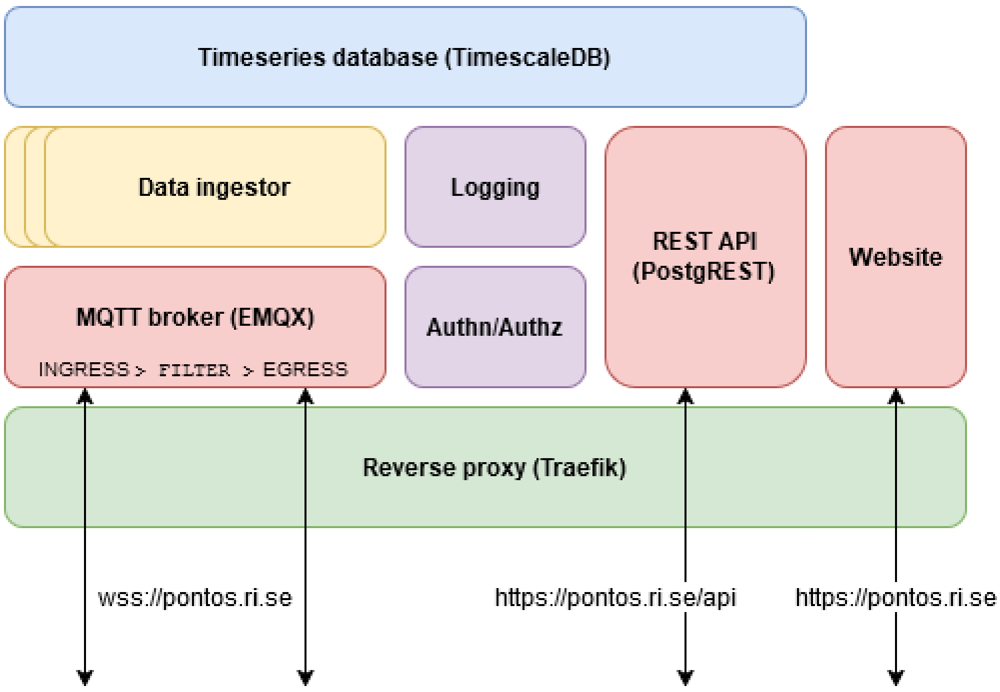

Figure 1 Architecture of PONTOS hub.

The components in the Figure 1 serve the following purposes:

- Reverse proxy: A Traefik[2] software instance that routes connections to the hub to either the REST API, the MQTT broker, or the website, depending on the protocol used and the web address. (WSS: WebSocket Secure and HTTPS: HyperText Transfer Protocol).
- MQTT broker: An EMQX[3] software instance that:
  - Allows PONTOS data providers (i.e. Blueflow and Cetasol) to publish data to MQTT ingress topics corresponding to the vessels of participating shipowners.
  - Enables the PONTOS hub users to subscribe to specific egress topics corresponding to vessels of the participating shipowners.
  - Filter specific data as requested by the data producers (see Chapter 4). The egress topics are the result of filtering the ingress topics.
- REST API: A PostgREST[4] software instance providing a REST API (Representational State Transfer Application Programming Interface) for accessing the contents of the timeseries database. The REST API also filters specific data as requested by the data producers.
- Timeseries database: A Timescale[5] instance used for storing the ship operational data as timeseries.
- Data ingestor: A multi-instance software solution developed for the hub that inserts the data published to the MQTT broker into the timeseries database.
- Logging: A software solution developed for the hub that logs the user-provided information to generate authentication/authorization tokens, as well as the usage of those tokens.
- Authn/authz (authentication/authorization): A software solution developed for the hub that:
  - Grants the data providers (i.e. Blueflow and Cetasol) explicit write access to specific topics corresponding to the ship operational data of their customers.
  - Grants the PONTOS hub users subscribe permission to the MQTT broker and read access to the REST API if they have generated a valid JWT token.
  - Generates a JWT (JSON Web Token) for the PONTOS data users once they have acknowledged the licences governing the database and its contents and provide general information for usage-statistics purposes (i.e. country, organisation type, and purpose).
- Website: An online website to (see Figure 2):
  - Describe the PONTOS project.
  - Provide an interface for the creation of user tokens
  - Provide documentation on the use of PONTOS hub.
  - Communicate news and organized activities.

2 https://github.com/traefik/traefik
3 https://github.com/emqx/emqx
4 https://github.com/PostgREST/postgrest
5 https://www.timescale.com/

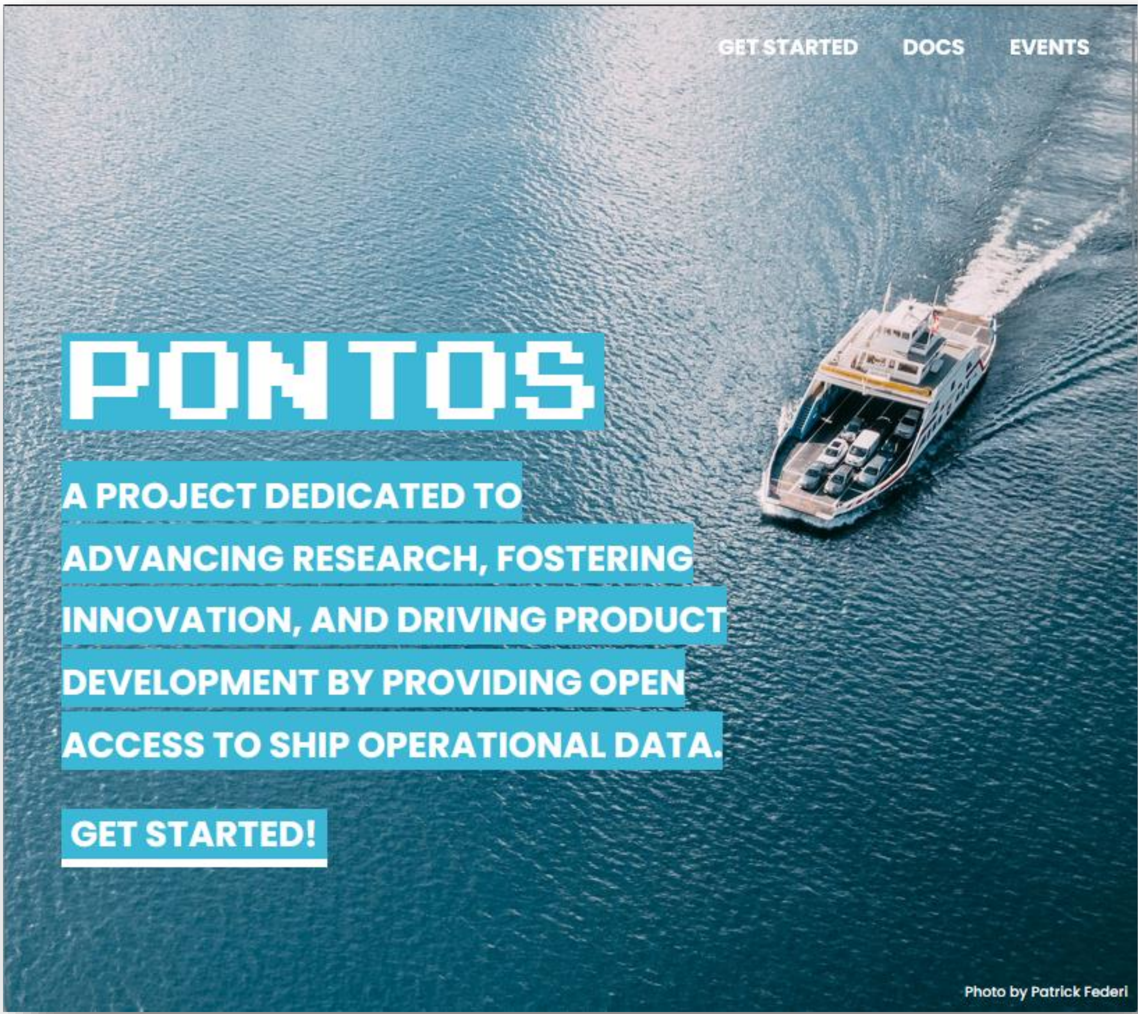

Figure 2 Landing page of the PONTOS website.

2.3 Open code

The PONTOS hub code is publicly available in a GitHub repository[6] under the open Apache 2.0 license[7]. This licensing allows anyone to replicate the functionality of the PONTOS hub or modify it for their own purposes, free of charge and without obligations. Releasing the code openly reflects the project's commitment to open access and ensuring that publicly funded initiatives result in publicly owned resources.

[6] https://github.com/MO-RISE/pontos-hub
[7] https://www.apache.org/licenses/LICENSE-2.0

2.4 Vessels

Table 1 presents a list of the vessels available in PONTOS hub, at the time of writing, as well as additional details regarding the ownership of the vessels, their type, and the format of data that is available.

Table 1 Vessels available in PONTOS hub.

Name	Owner / data producer	Type	Historical data	(near) Realtime data
Fröja	Färjerederiet	Road ferry	Yes	Yes
Skidbladner	Färjerederiet	Road ferry	Yes	Yes
Marie	Färjerederiet	Road ferry	Yes	Yes
Capella	Färjerederiet	Road ferry	Yes	Yes
Linda	Färjerederiet	Road ferry	Yes	Yes
Merkurius	Färjerederiet	Road ferry	Yes	Yes
Yxlan	Färjerederiet	Road ferry	Yes	Yes
Sedna	Färjerederiet	Road ferry	Yes	Yes
Ebba Brahe	Färjerederiet	Road ferry	Yes	Yes
Jupiter	Färjerederiet	Road ferry	Yes	Yes
Fragancia	Färjerederiet	Road ferry	Yes	Yes
Nina	Färjerederiet	Road ferry	Yes	Yes
Tycho-Brahe	Öresundslinjen	Ferry	Yes	Yes
Aurora	Öresundslinjen	Ferry	Yes	Yes
Hamlet	Öresundslinjen	Ferry	Yes	Yes
Mira	Väderö Fisk	Fishing boat	Yes	No
Fredrika	Havstens fiskelag	Fishing boat	Yes	No
Burö	Öckerö redderi	Ferry	Yes	No

Missing (near) real-time data

Table 1 indicates that (near) real-time data is unavailable for three vessels: Mira, Fredrika, and Burö, owned by Väderö Fisk, Havstens Fiskelag, and Öckerö Redderi, respectively. During the project, sensor data from Mira was collected only briefly due to the limited operational data obtainable from the vessel. Fredrika was put up for sale, resulting in the removal of its sensor platform, and Burö underwent renovations that led to the removal of the sensor platform provided by Cetasol. The operational data recorded while these vessels were connected to the PONTOS hub remains accessible;

however, no new operational data is being added. As a result, at the time of writing, (near) real-time data is unavailable for these vessels.

Missing data providers

In Table 1 there are no vessels owned by SSRS and MeriAura Group (see Section 1.4 for the PONTOS project participants list). Throughout the course of the project, these two data producers were unable to carry out the technical development to connect to PONTOS-hub due to technical delays and overwhelming responsibilities.

2.5 Operational data

All vessels are different, and so are the systems installed onboard them. Some vessels have one main engine, and others have three, some have several global positioning systems while other have one. To complicate matters further, sensors installed in these systems may provide different types of measurements on different types of units. For example, sensor measurements of pressure for one engine may be in megapascals (MPa) while for another they may be in pounds per square inch (psi).

To handle this complexity and effectively identify specific sensor measurements, the following markers are used in PONTOS hub:

- **vessel_id**: Identifying the vessel where the sensor data comes.
- **tag**: describing the type of sensor data.
- **index**: Identifying the specific entity where the measurement was taken.

The following subsections describe these markers in more detail.

vessel_id

The vessel_id marker serves as a globally unique identifier for a vessel. It follows the format <type>_<value> where:

- type: Describes the type of identifier.
- value: Describes the value of the identifier.

There three possible values for type are:

- name: Indicating that the identifier is the name of the vessel.
- imo: Indicating that the identifier is the IMO number of the vessel.
- mmsi: Indicating that the identifier is the MMSI number of the vessel.

For example, the following are valid vessel_id markers:

- name_SD401Fredrika
- imo_900711
- mmsi_265585310

While the IMO number is the preferred method of identification, not all vessels possess one. In its absence, the MMSI number is used. If neither is available, the vessel's name becomes the identifier.

tag

The tag marker describes the type of measurement and adheres to the format:

<entity>_<property>_<unit>

where:

- *entity*: describes the type of entity where the measurement is taken.
- *property*: describe the property measured in the entity.
- *unit*: describe the unit of the measurement.

For example, the following are valid tag markers:

- *propeller_speed_rpm*
- *enginemain_power_kw*

The first tag describes the measurement as the speed of a propeller in revolutions per minute (RPM), while the second one the power produced by a main engine in kilo Watts (kW).

Both data providers (i.e. Cetasol and Blueflow) where asked to map their sensor measurements to a list of predefined tags for clarity and efficiency. The complete list of tags, at the time of writing, is provide in Appendix A. The most recent list of tags is available in a GitHub repository[8] to be able to keep track of changes.

index

The index marker is a numerical value used to identify a specific entity. If a vessel has multiple entities of the same type, the index is used to distinguish them. For example, if a vessel has three main engines, there sensor measurements for main engine power will use the tag *enginemain_power_kw* and the indexes 1, 2, and 3.

[8] https://github.com/MO-RISE/pontos-data-format/blob/main/tags.md

3 Organised activities

This chapter presents the activities organised to generate knowledge and demonstrate the application of ship operational data.

3.1 Master theses

In late autumn 2023, the project partners were approached about the possibility of RISE supervising master's theses on their behalf. The aim was to leverage the ship operational data from PONTOS hub address specific questions raised by the project partners or develop data-driven solutions. Interviews were conducted with interested partners, leading to the creation of four master's thesis proposals on the following topics:

- *Anomaly detection for ship energy management systems* – on behalf of Blueflow
- *Electrifying fishing vessels* – on behalf of Havstens Fiskelag and Väderö Fisk
- *Optimizing operational strategies for energy efficiency in battery-powered ferries* – on behalf of Öresundslinjen
- *Predicting fuel consumption with machine learning* – on behalf of Cetasol

To find interested master students, the proposals were sent to Master programme coordinators at different universities and published online in the following platforms:

- PONTOS – Project website
- PONTOS – Linkedin account
- RISE – Jobb offers / Master thesis offerings website
- AI Sweden – Master thesis offerings website

Suitable candidates were found for three of the four master thesis proposals. The work of the master theses was carried out between January and June 2024. The following subsections summarize the results of the work.

"Predicting Fuel Consumption of Marine Vessels" by Karl Lundgren and Erik Norlin[9]

This thesis was based on the proposal "Predicting fuel consumption with machine learning" on behalf of Cetasol.

The aim of this thesis was to develop and evaluate machine learning models for accurately predicting the fuel consumption of marine vessels, with a focus on incorporating weather conditions. Traditional physical models often fail to account for environmental factors, leading to less reliable predictions. To address this, the work investigated the use of XGBoost, a gradient-boosted tree ensemble, and S5, a structured state-space sequence mode, on the fuel consumption prediction of Burö, a ferry operating in the Gothenburg archipelago owned by Öckerö redderi. Operational data for this ferry is available at PONTOS hub.

[9] http://hdl.handle.net/20.500.12380/307827

The results show that XGBoost delivers the highest predictive accuracy, making it a strong candidate for practical fuel optimization strategies. Additionally, the application of balanced realization significantly enhances the computational efficiency of the S5 model without sacrificing accuracy. By integrating weather data into the predictive process, this research provides actionable insights for reducing fuel consumption and greenhouse gas emissions, offering a meaningful contribution to the sustainability goals of the maritime industry.

“A Method for Determining Feasibility of Electrification of Small Fishing Vessels” by Aditya Barman and Arvid Sörfeldt[10]

This thesis was based on the proposal “Electrifying fishing vessels” on behalf of Havstens Fiskelag and Väderö Fisk.

The aim of the thesis was to develop a simple and intuitive method to evaluate the feasibility of electrifying small fishing vessels. The method was to be developed using operational data from two fishing vessels owned by Väderö Fisk and Havstens Fiskelag available at PONTOS hub. The thesis work combined operational analysis, driveline design, and life-cycle assessments to ensure that the method could be broadly applicable to other small Swedish fishing vessels.

The results highlighted that while the technical and environmental feasibility of electrification is promising, with significant potential for reducing greenhouse gas emissions, the economic and regulatory challenges remain more complex. The developed method was implemented in a user-friendly Excel tool, allowing stakeholders to explore various scenarios and make informed decisions. Ultimately, this thesis underscores the potential of electrification as a critical step in transitioning Sweden's fishing fleet towards greater sustainability while emphasizing the need for targeted support to overcome existing barriers.

“Machine Learning-based Automated Anomaly Detection System for Vessel Sensor Data” by Fathima Hisa Faiyaz[11]

This thesis was based on the proposal *“Anomaly detection for ship energy management systems”* on behalf of Blueflow.

The aim of this thesis was to develop an automated machine learning-based anomaly detection system for vessel sensor data, with a focus on improving the monitoring and reporting of energy management in marine vessels. Traditional methods, reliant on manual oversight and basic automation, often struggle to identify anomalies effectively in complex maritime systems. To address this, the research explored unsupervised learning algorithms, such as Isolation Forest, Local Outlier Factor, and XGBoost, to detect anomalies in sensor data available in PONTOS hub, including synthetic anomalies modelled after real-world scenarios. The study incorporated feature selection and data preprocessing techniques to enhance model performance and adaptability across different vessels.

The results indicated that XGBoost delivered the best predictive accuracy, making it a potential candidate for autonomous anomaly detection systems. The study also

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[10] http://hdl.handle.net/20.500.12380/309004
[11] https://urn.kb.se/resolve?urn=urn:nbn:se:hv:diva-22131

highlighted the importance of feature engineering and thresholding for improving detection performance. This research contributes to the development of smarter energy management practices and supports the industry's transition toward environmentally sustainable operations.

3.2 Hackathon

In spring 2024, the project partner Färjerederiet was invited to collaborate with RISE and Cetasol in organizing a hackathon. The general aim was to leverage the operational data available in the PONTOS hub to support and advance their efforts in energy efficiency and digitalization.

In late spring 2024, the public was invited to participate in a hackathon named "Hack-A-Fleet" taking place 21-22 of May, 2024 in Gothenburg, Sweden. The theme of the event was "innovation for sustainability in fleet management" and the public was challenged develop new tools or create new information/knowledge/insights that can help Färjerederiet to achieve its vision of becoming climate neutral by 2045 at the latest, using a real-world dataset from a subset of its fleet available in PONTOS hub. Cetasol sponsored the prizes of the event to highlight and support actions that aim for a more sustainable maritime industry.

To find participants, the hackathon was advertised in the following online platforms:

- PONTOS – Project website
- PONTOS – Linkedin account
- RISE Maritime – Linkedin account
- Cetasol – Linkedin account
- AI Sweden – Events website
- Gothenburg Artificial Intelligence Alliance (GAIA) – Slack channel

Additionally, invitations to the hackathon were sent directly to directors of relevant master programmes in Gothenburg, such as naval architecture and computer science.

Unfortunately, the hackathon had to be cancelled one week prior to the event due to the low number of registered participants. The organisers considered that the low interest was likely due to the date of the event, which took place close to examination periods and before the summer holidays.

In late summer 2024, RISE, Cetasol, and Färjerederiet decided to reformat the hackathon as a 2-week online event taking place between the 18th and 30th of November 2024. Participants from all countries in the European Union were invited to participate several seminars were arranged to accommodate the different schedules of the potential participants. The theme, challenge, and prizes of the hackathon remained the same, and so did the advertising to a great extent.

Figure 3 Poster used to promote the hackathon.

On the 18th of November 2024, RISE welcomed 21 participants divided into 8 teams to the online hackathon. As hoped, the teams included industry professionals, researchers, and students. The teams were given a dataset to complement the available data on PONTOS hub, as well as a set of software scripts to aid them in completing the challenge[12]. On the 9th of December, after careful consideration, Cetasol, Färjerederiet, and RISE announced the winners of the hackathon:

- *1st place: IoT Labbet Kalmar, led by Oxana Lundström*
  Presented innovative ideas on the use of AI agents to analyse operational data.

- *2nd place: Crossing-compiler, Sören Schenkel*
  Proposed a well thought idea for optimizing vessel operations.

[12] https://github.com/RISE-Maritime/hack-a-fleet

- *3rd place: Seas the day, led by Chelsea Alambuya*
  Presented a suggestion on how scheduling of the ferries could be optimised.

3.3 Online competition

In late 2023, RISE, on behalf of Öresundslinjen, developed a master's thesis proposal aimed at identifying optimal strategies for operating battery-powered ferries (see Section 3.1). Unfortunately, no suitable candidates were found to carry out the thesis. To address Öresundslinjen's needs, this topic was chosen as the focus of an online competition. During autumn 2024, RISE began preparations for the competition, completing them in December 2025, the final month of the PONTOS project.

The subsections below describe the purpose and development of a ferry simulator that is the main preparation for the online competition. At the time of writing, the development of the ferry simulator and the and the initial results have been communicated to Öresundslijen, but no decision has been made regarding the competition's execution.

Requirements for a ferry simulator

Öresundslinjen operates two of the largest battery-powered ferries in the world (*Tycho-Brahe* and *Aurora*). A critical aspect of ensuring energy efficiency and sustainability is determining the optimal sailing speed. A faster sailing speed allows more time for charging between departures, while a slower speed consumes less energy during the voyage. The challenge lies in identifying which strategy is more energy-efficient and under what circumstances.

To identify the best operation strategies, one must be able to thoroughly test candidates. The objective of the ferry simulator is to allow the testing of operation strategies of battery-powered ferries travelling back and forward between two locations. For simplicity, the operation strategies in the ferry simulator can be limited to:

- The sailing speed.
- The charging time at port.

If there was no variability in the environment, the optimal sailing speed and charging time at port would be fixed values. The distance travelled between the two ports or quays would always be the same and so would be the energy necessary to travel the distance. Reality, however, contains variability, and the best course of action in one situation is not the best one in another. Due to traffic, deviations may be required, extending the travelling distance at different moments along the route. Similarly, environmental conditions such as wind, wave, and currents can add considerable variation to the energy consumption of the ferry. Figure 4, 5, and 6 illustrate that, ferry tracks are never identical, power consumption fluctuates even at a constant speed, and distance travelled for a crossing is never the same.

Considering the above, the ferry simulator must:

1. Simulate variability so that the strategies' capacity of dealing with variability can be effectively tested.
2. Carry out simulations of entire days, with multiple crossings, so that the effects of sailing speed and charging time at the port are apparent.
3. Carry out fast simulations, so that the robustness of the strategies become evident.

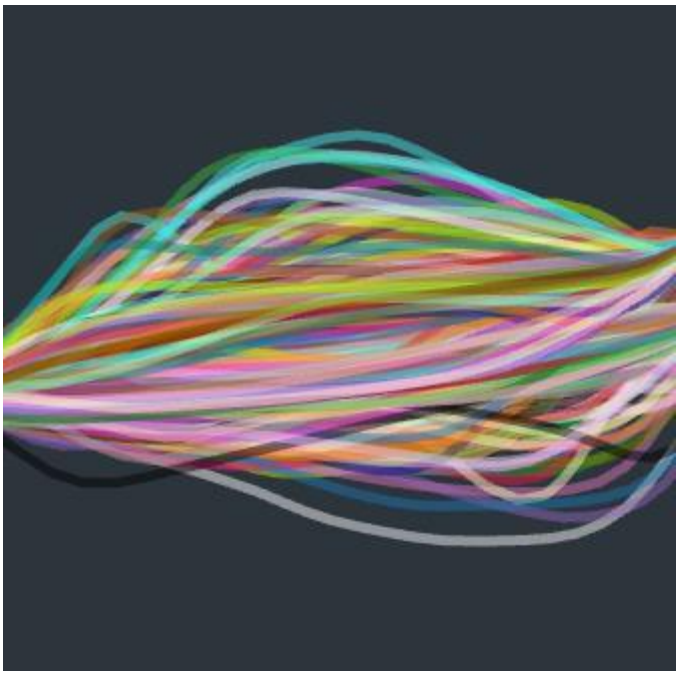

Figure 4 Plot showing the variation on the tracks of the battery-powered ferry *Tycho-Brahe* on the course of a month. (The image has been cropped to exclude geographical references in order to comply with Öresundslinjen's conditions regarding the omission of latitude and longitude data.)

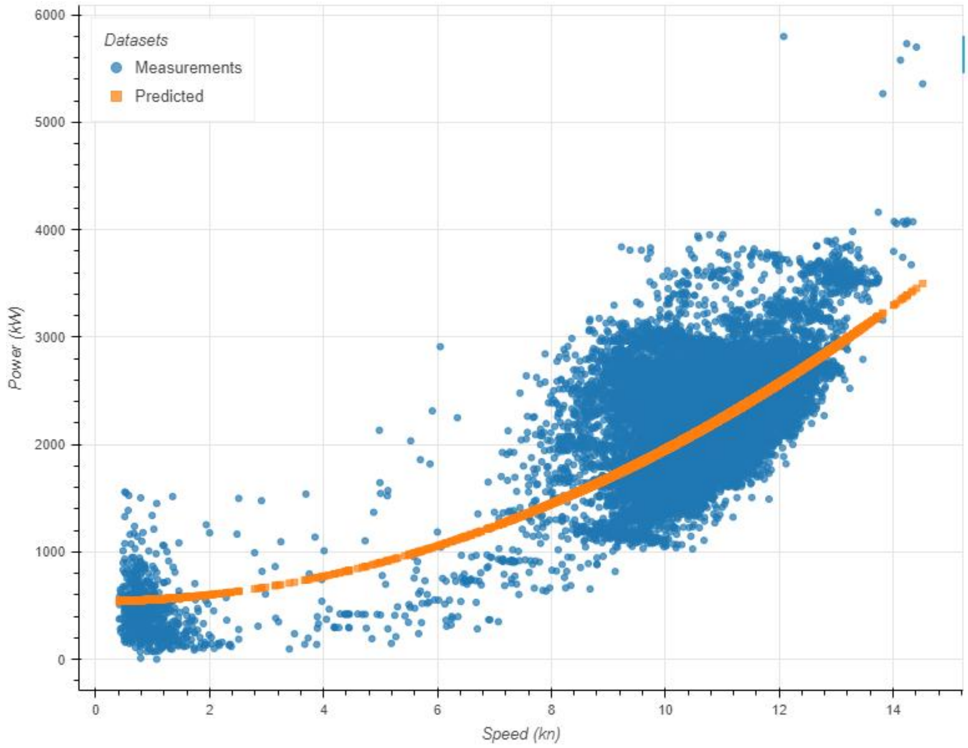

Figure 5 Scatter plot illustrating the variation between in power consumption at a constant speed for the battery-powered ferry *Tycho-Brahe*.

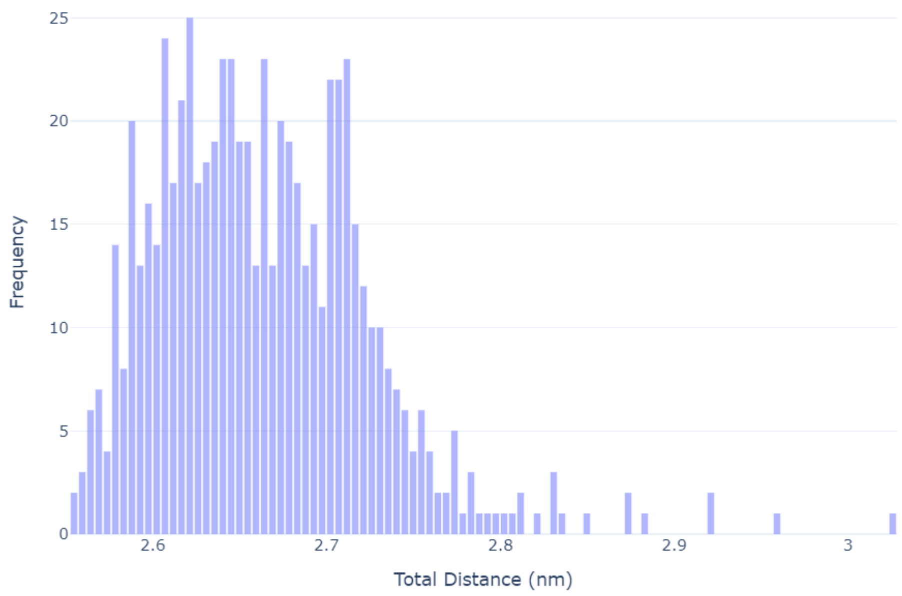

Figure 6 Histogram illustrating the variation in distances travelled by the battery-powered ferry *Tycho-Brahe* when crossing between Sweden and Denmark over the course of a month.

Description of the ferry simulator

Based on the requirements presented above, a ferry simulator was developed by RISE. Figure 7 presents an example of the ferry simulator's text output. The figure shows that the ferry simulator is capable of simulating:

- An action (e.g. "Set speed 7.66 kn").
- The crossing of a ferry between two locations (e.g. Helsingör and Helsingborg).
- The schedule of the ferry throughout the day (e.g. Scheduled arrival: 13:30:00 and Trip: 24/46).
- The state of the ferry (e.g. Speed: 7.64 kn and Energy reserve: 26.49%).
- The effect of an action (e.g. diesel consumption Value -26.67).

```
>> ACTION: Set speed 7.66 kn
|
| | | | |  --------------------------------------------------
Helsingör -------------------------------------->             Helsingborg
| | | | | |  --------------------------------------------------
Overview:
  Time: 13:27:30
  Cumulative rewards: -26874.30
  Trip: 25 / 46
  Destination: Helsingborg
  Scheduled departure: 13:10:00
  Scheduled arrival: 13:30:00

Observations:
  Speed: 7.64 kn
  Energy Reserve: 26.49 %
  At origin: False
  At destination: False
  Distance to cover: 2.60 nm
  Distance covered: 2.03 nm
  Remaining distance: 0.57 nm
  Percentage of route completed: 77.93 %
  Estimated time to arrival:  4.5 minutes
  Time left to departure: -17.5 minutes
  Time left to arrival: 2.5 minutes

Step information:
  reward - diesel consumption  Value: -26.67
  record - diesel consumption (kwh)  Value: 6.67
  reward - energy consumption at sea  Value: -18.00
Agent: at sea
```

Figure 7 Screenshot of the simulator's text output.

The ferry simulator simulates an entire day for a ferry going back and forward between two destinations according to a given schedule. Two ideal routes for crossing between the destinations are defined (i.e. A to B route and B to A route). The ideal routes have a fixed length, but to account for the effects of traffic, a random model, is used to increase or decrease the distance to be covered in each crossing. The random model is tuned to be representative of reality (Figure 8 below). Similarly, random models, tuned to represent reality, are used to simulate the variation in power consumption at different speeds and accelerations as well as changes in the base electrical load onboard the ferry.

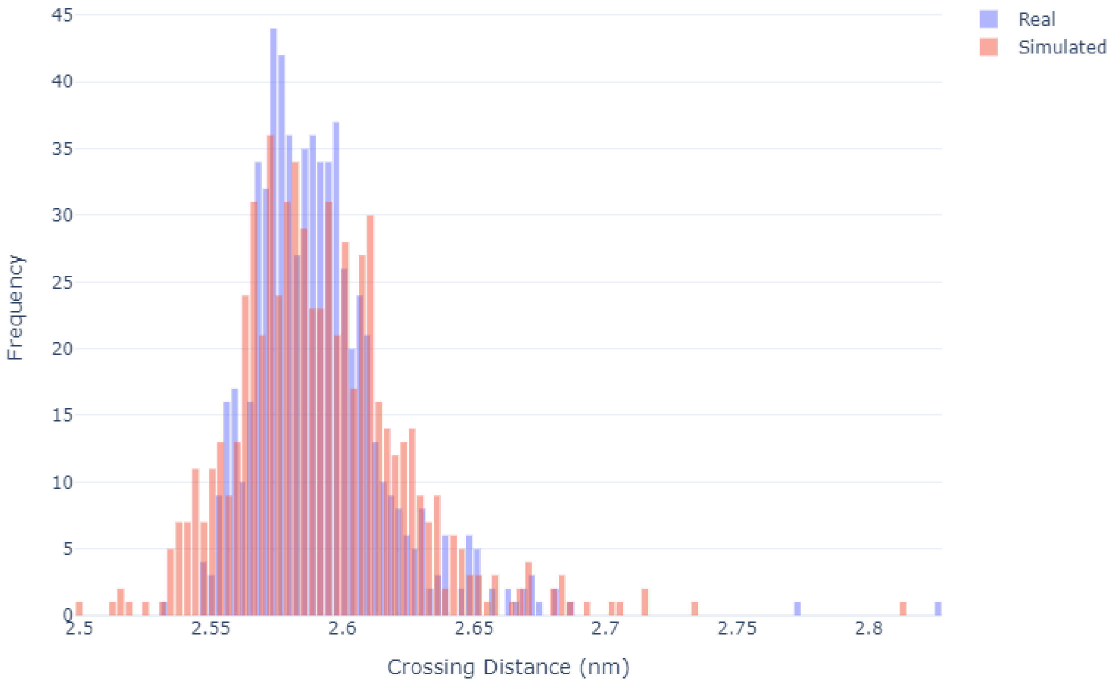

Figure 8 Histogram showing the difference between the real variation in crossing distance and the simulated one with the random model.

The ferry simulator is built as an "environment" according to the Gymnasium[13] standard for reinforcement learning environments. Reinforcement learning is a branch of machine learning aimed at teaching machines how to best act in different situations. In other words, teach them what is the best strategy. By using the Gymnasium standard, participants would be provided with an environment that represents the challenge faced by Öresundslinjen in a format that would allow them to use any of the reinforcement learning algorithms readily compatible with this standard.

Preliminary results from the ferry simulator

To demonstrate the value of the ferry simulator, some simple strategies were tested by RISE:

- **JustInTime**: Speed is continuously adjusted to ensure the ferry arrives precisely on time according to the schedule.
- **TwoMinutesEarly**: Speed is continuously adjusted to ensure the ferry arrives two minutes ahead of the scheduled arrival time.
- **TwoMinutesLate**: Speed is continuously adjusted to ensure the ferry arrives two minutes after the scheduled arrival time.

For each strategy, simulations were performed over a 30-day period. Each day consisted of 45 trips between Helsingør and Helsingborg, adhering strictly to the specified schedule. Figure 9 illustrates variations in different operational parameters for each trip.

[13] https://gymnasium.farama.org/

The results indicate that the **TwoMinutesLate** strategy achieves lower average energy consumption compared to the other two strategies. However, this reduction in energy consumption comes at the cost of increased reliance on diesel engines when battery levels are low.

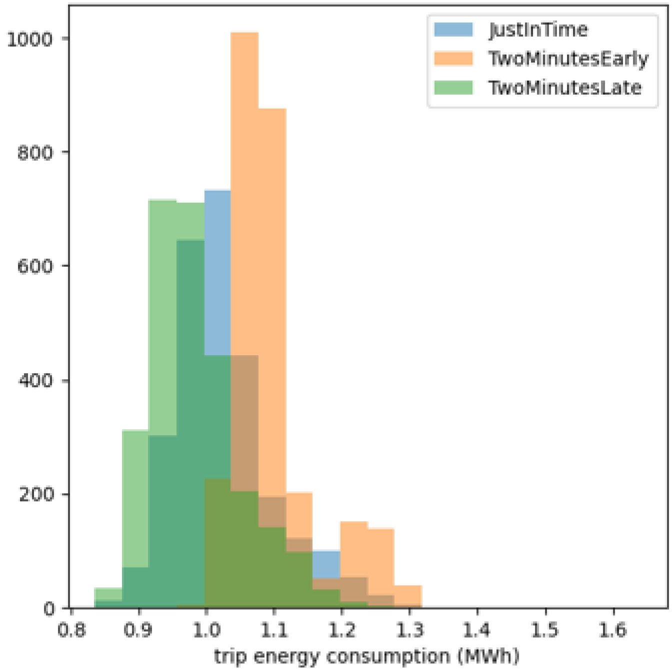

Figure 9 Histogram showing the variation on energy consumption depending on the strategy.

4 Data Sharing

The main idea of the PONTOS project was to make ship operational data openly accessible to the public. Since ship operational data is owned by the data producers (i.e. ship owners), a cornerstone of the project was to agree on the conditions on which these data can be shared openly.

Besides RISE, all project partners are either data producers or data providers (see section 1.4). Data producers produce and own the data while data providers share it with PONTOS hub on behalf of some of the data producers. RISE conducted multiple interviews to determine the conditions of sharing ship operational data openly with the public according to the data producers and providers. The following conditions were identified:

1. *Freedom to stop sharing* – The data producers emphasized the importance of having the unrestricted right to cease sharing their ship operational data with PONTOS hub at any time, without any terms or conditions.

2. *Omitting sensitive data* – Some of the data producers considered that a part of their ship operational data was sensitive or could be classified as sensitive after being shared through PONTOS hub. As a result, they requested the option of excluding specific sensor data whenever they deemed it necessary.

3. *Legal responsibility and liability* – The data providers agreed to share the ship operational data on behalf of the participating data producers, provided they were exempt from of any legal responsibilities or liabilities associated with the data sharing process.

4. *Licensing* – Some of the data producers desired that the ship operational data made available through PONTOS hub was made available under an open license that prohibited the reproduction of the data for reselling

Based on the above conditions, two solutions were outlined: data sharing agreements and the Open Data Commons licenses.

4.1 Data sharing agreements

The data sharing agreements address three of the four conditions identified for sharing ship operational data: *freedom to stop sharing*, *omitting sensitive data*, and *legal responsibility and liability*.

These agreements establish the terms and responsibilities for sharing data between RISE, the operator of the PONTOS hub, as well as data producers and providers. They ensure that data producers retain control over their data by reserving the right to specify which data may or may not be published and to request modifications or suspension of data collection or publication as needed. Data is provided to RISE free of charge, either directly or through intermediaries acting as data providers.

The agreements also stipulate that RISE is responsible for ensuring compliance with the agreed terms and conditions and indemnifies other parties against liabilities arising from any breach of these terms. Collectively, these agreements support the open-access objectives of the PONTOS hub while safeguarding the rights and interests of all stakeholders.

An example of a data sharing agreement is available in Appendix B.

4.2 Open Data Commons License

Following an evaluation of various open data licenses, the Open Data Commons Open Database License v1.0[14] was identified as the most suitable choice for PONTOS hub. This license allows users to extract and reuse all or substantial portions of the hub's content, as well as to create derivative and collective databases. It also permits the use of the data in PONTOS hub for the development of both commercial and non-commercial analyses, products, and services.

The above permissions are granted, however, under the following conditions:

- *Attribution requirement* – Proper attribution must be given to PONTOS hub.
- *Share-alike requirement* – Any public derivative or collective database created using all or a substantial portion of the content is required to be shared under the same or a compatible license.

The share-alike condition plays a crucial role in preventing the direct commercialization of the data. Public derivative or collective databases are required to remain openly accessible and cannot be monetized under the terms of this license.

After the data producers agreed on the use of this open license for PONTOS hub, the website was launched. Figure 2 shows a screenshot of the webpage where users agree to the terms of the Open Database Licence v1.0 to access the data. Note that according to the Open Database Licence v1.0 individual contents of the database are licensed under the Database Contents Licence v1.0[15].

[14] https://opendatacommons.org/licenses/odbl/
[15] https://opendatacommons.org/licenses/dbcl/1-0/

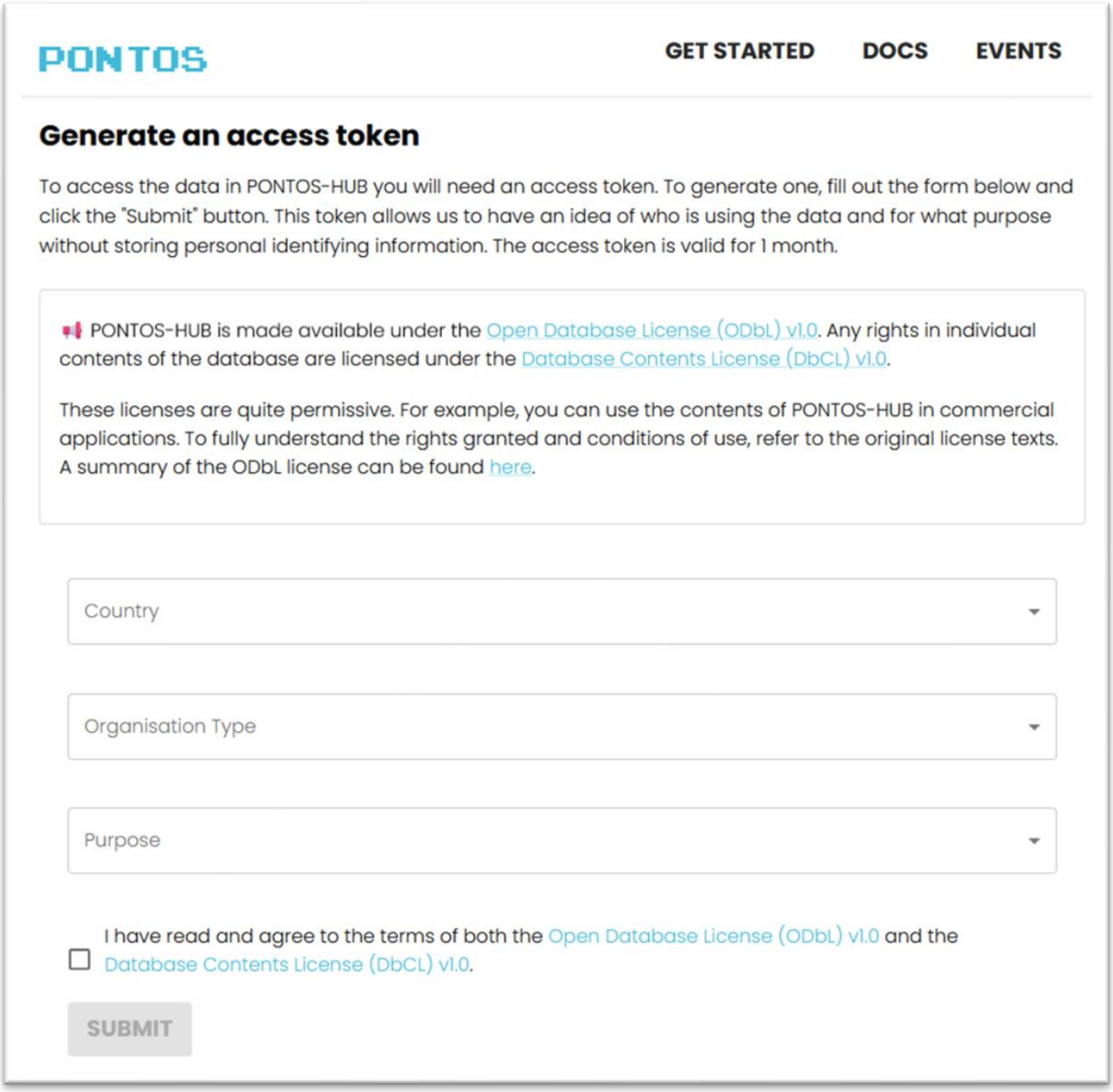

Figure 10 Screenshot of the PONTOS website where users are informed and required to agree with the licences.

5 Future of PONTOS hub

The purpose of the PONTOS project is to accelerate the development and efficiency of maritime transport by promoting and facilitating the use of operational data from ships. To do so, the project has made ship operational data openly and freely available to the public through PONTOS hub (see Section 2) and several activities to exploit the data have been organised (see Section 3).

At the time of its conception (summer 2022), the PONTOS hub was envisioned to continue operational until December 2027, two years after the project's end, with a reworked governance model. The fifth objective of the project (see Section 1.5) was to develop the reworked governance model that would include strategy, vision, intellectual property rights, and prioritization of continued development.

Nevertheless, throughout the course of the project, RISE learned about the European Union Data Strategy[16] and all the related initiatives, technologies, organisations, and legislation. These developments are of utmost relevance for services such as PONTOS hub, as they are meant to dramatically change how data is owned, shared, and used.

The following sections provide summaries of the most relevant developments led by the European Union for PONTOS hub. The last section (Section 5.6) presents a conclusion regarding the future of PONTOS hub and the fifth objective of the project.

5.1 The European data strategy

Published 19 February 2020

The European data strategy recognizes that data is an essential resource for economic growth, competitiveness, innovation, job creation, and societal progress. *The European data strategy aims at creating a single marketplace for data that will ensure Europe's global competitiveness and sovereignty*. But, in contrast with the current situation, the strategy focuses on putting people first in technology development and defending and promoting European values in the digital world.

In short, the strategy wants to give control and ownership to the data producers. Individuals and companies should be able to decide who access their data, how it is used, and in exchange for what. Furthermore, according to the strategy, data and data-services shall be decoupled. This is achieved through legislation, infrastructure, data spaces* and interoperability standards and technologies. Data service providers will not own and have control over one's data, they will only offer a service that uses it, and therefore changing data-service providers will be straightforward.

To achieve the strategy, the European commission has started the development of the *Common European Data Spaces* and approved three pieces of legislation: the *Data Governance Act*, the *Data Act*, and the *Interoperable Europe Act*.

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16 https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en

5.2 Common European Data Spaces[17]

For the EU, a data space is a digital system that has the following key features:

- Can be used to pool, access, process, and use data in a secure and privacy-preserving manner.
- Is open for the participation of all organizations and individuals.
- Guarantees that data producers, such as individuals and companies, control who has access to their data, how it is used, and in exchange for what.
- Respects the European values and laws, in particular the ones regarding data protection, consumer protection, and competition.
- Ensures that data and data-services are decoupled (i.e. data can be used by multiple services and is not owned or controlled by the service provider).
- Ensures that data can be accessed a used in a fair, transparent, proportionate, and non-discriminatory manner.

A common European data space is a data space with the following characteristics:

- Participates in the European single marketplace for data.
- Corresponds to a specific EU-wide sector or domain.
- Adheres to European rules and values.

Common EU data spaces correspond to specific sectors or domains because of the specific characteristics and regulatory environments of each sector. Currently, common European data spaces are being developed for 14 sectors or domains: agriculture, cultural heritage, energy, finance, green deal, health, language, manufacturing, media, mobility, public administration, research and innovation, skills, and tourism.

To support the development of the common European data spaces the European Commission is funding:

1. The Data Spaces Support Centre – An organisation that supports the creation of data spaces by, among other things, establishing a network of stakeholders, providing a starter kit, a blueprint, and a support platform.
2. SIMPL: an open-source technical solution that, among other things, will enable the common European data spaces.
3. Directorate-General for Digital Services (DG-DIGIT; formerly known as the Directorate-General for Informatics) – The European Commission's department responsible for digital services. This organisation provides 3 sets of services for supporting the development of data spaces: Interoperability, Trust and Identity, and Analytics.

Data spaces are not an invention of the European Commission. Other industry led organisations such as Gaia-X and the International Data Space Association are currently working on the development of data spaces.

Overall, the basic idea of a data space is a collection of multiple databases, owned and controlled by data holders, that make their data accessible through a single interface with guarantees on privacy, security, and the terms of data access and use.

[17] https://digital-strategy.ec.europa.eu/en/policies/data-spaces

5.3 Data Governance Act[18]

In force since 23 June 2022, applicable since September 2024.

The aim of the Data Governance Act is to encourage the reuse of public and private data. To do so, the Data Governance Act states rules for:

1) Reusing *protected* data held by the public sector.
2) Data intermediaries, third parties that connect individuals and companies to data users. Data intermediaries must be neutral and will not be able to use the data they intermediate for financial profit (but they can charge for the intermediation service).
3) Data altruism organisations: organisations that make data from voluntarily participating individuals and companies openly available for objectives of general interest. Such organisations will have to be non-profits and comply with a number requirements.

Furthermore, the Data Governance Act creates the European Data Innovation Board, an organisation meant to facilitate the sharing of best practices on data intermediation, interoperability standards, data altruism, and public data that cannot be made available as open data.

5.4 Data Act[19]

In force since 11 January 2024, applicable in September 2025

The aim of the Data Act is to make more data available for companies, individuals, and public administrations. It does so by laying down rules on:

- Business-to-business and business-to-consumer data sharing in the context of IoT – users should be able to have access to the data they generate and reap its benefits.
- Mandatory business-to-business data sharing – under which conditions shall data be shared between business when mandated by law.
- Unfair contractual terms.
- Business-to-government data sharing – conditions on which the public sector can demand access to data hold by the private sector.
- Switching between data processing services – meeting interoperability requirements on cloud and edge computing services to enable and facilitate switching.
- Unlawful third country government access – non-personal data stored in the EU is protected against unlawful access request by foreign governments.
- Interoperability – participants of data spaces will have to follow relevant standards and specifications for cloud interoperability.
- Enforcement and overreaching provisions – member states must monitor and enforce the Data Act.

[18] https://digital-strategy.ec.europa.eu/en/policies/data-governance-act-explained
[19] https://digital-strategy.ec.europa.eu/en/factpages/data-act-explained

5.5 Interoperable Europe Act[20]

In force since 11 April 2024

The aim of the interoperable Europe Act is to promote interoperability, the ability to share data, information, and knowledge through digital processes, between European public services. To do so, the IEA creates:

- The Interoperable Europe Board, a multi-level governance framework that defines the interoperability agenda.
- Mandatory interoperability assessments for the public sector for which the European Commission will provide guidelines.
- The Interoperable Europe Portal, a one-stop-shop for interoperability information, training, and support.

5.6 Conclusion

Since the inception of the PONTOS project, initiatives, technologies, organisations, and legislation have been created by the European Union as part of the European Data Strategy. These developments could not be ignored in the formulation of the future of PONTOS hub. At the same time, the developments are of such breadth and complexity that it was not possible to consider them appropriately within the time and budget limitations of the project. It was therefore concluded that PONTOS hub should remain as it is, until further funding is secured to investigate the role of PONTOS hub in the European Union's single market for data, as well as the technological and legal developments necessary.

From the knowledge and understanding at the time of writing, RISE considers that PONTOS hub could become a "data intermediary" or a "data altruism organisation", as stipulated in the Data Governance Act, depending on the stance of the data producers regarding the possibility of profiting from their data through Europe's single marketplace for data.

[20] https://commission.europa.eu/news/interoperable-europe-act-enters-force-today-2024-04-11_en

6 Evaluation of the objectives

The PONTOS project had five concrete objectives:

- **Objective 1:** Deploy PONTOS-Hub.
- **Objective 2:** Collect and provision ship operational data.
    - 34 participating vessels
- **Objective 3:** Generate knowledge and demonstrate applications for operational data.
    - One (1) hackathon
    - At least one (1) online competition
    - At least one (1) thesis project
- **Objective 4:** Explore suitable conditions and requirements for data sharing.
- **Objective 5:** Suggest a governance model for the future operation of PONTOS hub

The currently deployed PONTOS hub[21] (see Section 2) completely fulfills Objective 1 and largely fulfills Objective 2. PONTOS hub provides open access to historical and (near) real-time ship operational data and is expected to continue doing so until at least December 2027. However, the expectations on the number of vessels sharing their operational data with PONTOS hub were unfortunately not met due to technical and manning challenges faced by the data producers (see Section 2.4). The expected number of connected vessels was 34 and currently, PONTOS hub contains operational data of only 18 vessels, of which 3 are not longer providing new data.

The organized activities (see Section 3) largely achieved Objective 3. The number of master's theses and hackathons carried out exceeded the initial targets: three master's theses instead of one and two hackathons instead of one. However, the first hackathon was not successful (see Section 3.2). While the online competition was prepared, it was not completed before the project ended. Nonetheless, the preparation alone demonstrated an application of ship operational data and contributed to new knowledge.

The work carried out for data sharing (see Section 4) completely fulfills Objective 4. The conditions and requirements stated in the data sharing agreements the selected open license successfully address the concerns of the data producers and providers in the PONTOS project.

Finally, the discussion about the future of the PONTOS hub (see Section 5) concludes that Objective 5 could not be fully achieved. The extensive and complex developments in data governance and access driven by the European Union over the past two years were too broad to be adequately addressed within the project's time and budget constraints.

[21] https://pontos.ri.se

7 Final remarks

The purpose of the PONTOS project was to enhance the development and efficiency of maritime transport by promoting and enabling the use of operational data from ships. During the project, the PONTOS hub was launched, providing open and free access to historical and (near) real-time data from 18 vessels. This access will continue until at least December 2027. Additionally, several activities were organized to generate new knowledge and demonstrate the applications of ship operational data. Overall, the PONTOS project fulfilled its purpose.

However, the project partners recognize that this effort is only the beginning, and significant work remains to realize the vision set out in the European Union's data strategy.

RISE, the lead project partner, extends its heartfelt gratitude to all collaborators, especially the data producers, who contributed in-kind by donating their time and data. Their commitment to openness and collaboration embodies the hope of building a better future.

A special thanks is also extended to the Swedish Transport Administration for funding the PONTOS project and enabling this important work.

Appendix A

This appendix contains the complete list of valid tags used for describing sensor data in PONTOS hub at the time of writing. Note that some of these tags are not currently in use.

Anemometer

`anemometer_aws_mps`

Apparent wind speed (m/s).

`anemometer_awa_deg`

Apparent wind angle (degrees) relative to heading.

`anemometer_tws_mps`

True wind speed (m/s).

`anemometer_twd_deg`

True wind direction (degrees) relative to True North.

Ballast tanks

`ballasttank_level_pct`

Fill level (precent) of ballast tank.

Battery

`battery_soc_pct`

State of charge (percent) of battery.

`battery_soc_kwh`

State of charge (kWh) of battery.

`battery_power_kw`

Power flow (kW) into the battery. Charge is negative, discharge is positive.

`battery_temperature_deg`

Temperature (deg) of battery.

Boiler

`boiler_power_kw`

Boiler power output (kW).

`boiler_fuelcons_lph`

Boiler fuel consumption (litres per hour).

Electrical bus

`electricalbus_shorepower_kw`

Shore connection power (kW).

`electricalbus_hotelpower_kw`

Hotel load power (kW).

Engine - Auxiliary

`engineaux_speed_rpm`

Engine speed (rpm) of auxiliary engine.

`engineaux_power_kw`

Engine power output (kW) of auxilliary engine.

`engineaux_torque_nm`

Engine delivered torque (Nm) of auxilliary engine.

`engineaux_fuelcons_lph`

Engine fuel consumption (litres per hour) of auxilliary engine.

`engineaux_temperature_deg`

Engine temperature (temperature) of auxilliary engine.

`engineaux_boostpressure_bar`

Engine boost pressure (bar) of auxilliary engine.

Engine - Main

`enginemain_speed_rpm`

Engine speed (rpm) of main engine.

`enginemain_power_kw`

Engine power output (kW) of main engine.

`enginemain_torque_nm`

Engine delivered torque (Nm) of main engine.

`enginemain_fuelcons_lph`

Engine fuel consumption (litres per hour) of main engine.

`enginemain_temperature_deg`

Engine temperature (temperature) of main engine.

`enginemain_boostpressure_bar`

Engine boost pressure (bar) of main engine.

Shaft generator

`shaftgenerator_power_kw`

Power output (kW) of the shaft generator.

Fuel tank

`fueltank_level_pct`

Level (precent) of fuel tank.

Positioning system

`positioningsystem_accx_mps2`

Acceleration along the longitudinal, body-fixed axis (m/s^2). Positive forward.

`positioningsystem_accy_mps2`

Acceleration along the transverse, body-fixed axis (m/s^2). Posititive to starboard.

`positioningsystem_accz_mps2`

Acceleration along the vertical, body-fixed axis (m/s^2). Positive downwards.

`positioningsystem_accxx_radps2`

Angular acceleration around the longitudinal, body-fixed axis (rad/s^2). Positive starboard down.

`positioningsystem_accyy_radps2`

Angular acceleration around the transverse, body-fixed axis (rad/s^2). Positive bow up.

`positioningsystem_acczz_radps2`

Angular acceleration around the vertical, body-fixed axis (rad/s^2). Positive bow to starboard.

`positioningsystem_cog_deg`

Course over ground (degrees) relative North.

`positioningsystem_heading_deg`

Heading angle of vessel (degrees) relative North.

`positioningsystem_latitude_deg`

Latitudinal position (degrees).

`positioningsystem_longitude_deg`

Longitudinal position (degrees).

`positioningsystem_pitch_deg`

Pitch angle of vessel (degrees). Positive bow up.

`positioningsystem_roll_deg`

Roll angle of vessel (degrees). Positive starboard down.

`positioningsystem_rot_degpm`

Rate of turn (degrees / minute). Positive bow to starboard.

`positioningsystem_sog_kn`

Speed over ground (knots).

`positioningsystem_stw_kn`

Speed through water (knots).

Propeller

`propeller_speed_rpm`

Rate of revolution of the propeller (rpm).

`propeller_pitch_pct`

Pitch (percent) of the propeller, in case of a CP propeller.

`propeller_thrust_kn`

Thrust of the propeller (kN).

`propeller_torque_nm`

Torque of the propeller (Nm).

Rudder

`rudder_angle_deg`

Rudder angle (degrees).

`rudder_order_deg`

Ordered rudder angle (degrees).

Tunnel thruster

`tunnelthruster_power_kw`

Tunnel thruster power consumption (kW).

Azimuth thruster (mechanical or electrical)

`azimuththruster_speed_rpm`

Azimuth thruster propeller rate of revolution (rpm).

`azimuththruster_pitch_pct`

Azimuth thruster propeller pitch (percent), in case of a CP propeller.

`azimuththruster_angle_deg`

Azimuth thruster angle (degrees).

`azimuththruster_order_deg`

Azimuth thruster ordered angle (degrees).

`azimuththruster_power_kw`

Azimuth thruster power consumption (kW).

`azimuththruster_thrust_kn`

Azimuth thruster generated thrust (kN).

Voith Schneider

`voithschneider_speed_rpm`

Voith Schneider rate of revolution (rpm).

`voithschneider_angle_deg`

Voith Schneider thrust direction (degrees).

`voithschneider_power_kw`

Voith Schneider power consumption (kW).

`voithschneider_thrust_kn`

Voith Schneider generated thrust (kN).

Appendix B

Data sharing agreement

This Data Sharing Agreement ("**Agreement**") is entered into as of [Effective Date] (“**Effective Date**”), by and among

Company A, having its principal place of business at [Address of Company A] ("**Company A**"),

Company B, having its principal place of business at [Address of Company B] ("**Company B**"), and

RISE Research Institutes of Sweden, Box 857, 501 15 Borås ("**RISE**").

Collectively, Company A, Company B, and RISE shall be referred to as the "**Parties**."

1. BACKGROUND

1.1 RISE intends to publish certain ship data ("**Data**") publicly and freely online as part of the PONTOS research project (“PONTOS Project”) financed by Trafikverket (“the **Financier**”), [Project identification information]. Company A possesses the Data. Company B shall act as an intermediary in the Data sharing process between Company A and RISE. During the PONTOS Project, suitable conditions and requirements for end-use of the Data will be considered.

1.2 The Parties are all parties of the PONTOS Project governed by e.g., the financing decision, the Financiers terms and conditions for the project, and the project specifications, all attached in appendix A. Appendix A and all other documentation issued by the Financier regarding PONTOS are defined as the “**PONTOS Terms and Conditions**”.

1.3 In consideration of the mutual covenants and promises contained herein and in the PONTOS Terms and Conditions, the Parties agree as follows.

2. DATA SHARING AND PUBLICATION

2.1 Company A have agreed to provide RISE with access to the Data through Company B. Company A shall provide the Data free of charge. RISE shall according the PONTOS Terms and Conditions publish the Data provided by Company A publicly and freely online.

2.2 Company A has the right to notify RISE which Data may, or may not, be published publicly. Such notification shall be made in writing.

2.3 Company A has the right to demand that RISE without reasonable delay suspend or change the collection or publication of the Data.

3. LIABILITY AND INDEMNIFICATION

3.1 RISE shall indemnify Company A and Company B from any claims, damages, or losses arising from RISE's use, publication, or dissemination of the Data which does not comply with the PONTOS Terms and Conditions.

3.2 Company B shall be relieved of any legal responsibilities or liabilities arising from, or related to, the sharing of Data to RISE, provided Company B at any time have complied with the PONTOS Terms and Conditions or previously signed agreements between the Parties regarding sharing of the Data, e.g., Company B's own general terms and conditions.

3.3 RISE's total liability for damages, unless intentional or grossly negligent, is limited to [Maximum liability in SEK]. RISE is not liable for loss of profit or other indirect damage, unless caused by intent or gross negligence.

4. UNDERTAKING

4. 1 The Parties are aware of and accept that the PONTOS Terms and Conditions form the basis of this Agreement and undertake to comply, where applicable, with PONTOS Terms and Conditions vis-à-vis the other Parties and the Financier. In case provisions in this Agreement and PONTOS Terms and Conditions are contradictive, the provisions in the PONTOS Terms and Conditions shall prevail.

5. TERM AND TERMINATION

5.1 This Agreement shall commence on the Effective Date and shall continue in full force and effect until terminated by PONTOS project is terminated according to the PONTOS Terms and Conditions. Either of the Parties may upon thirty (30) days' written notice to the other Parties terminate this Agreement, provided the termination is complaint with the PONTOS Terms and Conditions.

6. MISCELLANEOUS

6.1 Any amendment or modification to this Agreement must be in writing and signed by all Parties.

6.2 The Agreement shall be applied and interpreted in accordance with Swedish law. Disputes in connection with the Agreement shall be finally settled by arbitration in accordance with the Arbitration Rules of the Arbitration Institute of the Stockholm Chamber of Commerce. The seat of arbitration shall be Gothenburg, Sweden. The language to be used in the arbitral proceedings shall be English unless agreed between the disputing Parties that the Swedish language shall be used. The Parties undertake and agree that all arbitral proceedings, the existence and any verdict thereof, will be kept strictly confidential.

The Parties have executed this Agreement as of the Effective Date by signing the Agreement digitally.

[RISE Authorized Signatory]

[Company A Authorized Signatory]

[Company B Authorized Signatory]

Through our international collaboration programmes with academia, industry, and the public sector, we ensure the competitiveness of the Swedish business community on an international level and contribute to a sustainable society. Our 2,800 employees support and promote all manner of innovative processes, and our roughly 100 testbeds and demonstration facilities are instrumental in developing the future-proofing of products, technologies, and services. RISE Research Institutes of Sweden is fully owned by the Swedish state.

I internationell samverkan med akademi, näringsliv och offentlig sektor bidrar vi till ett konkurrenskraftigt näringsliv och ett hållbart samhälle. RISE 2 800 medarbetare driver och stöder alla typer av innovationsprocesser. Vi erbjuder ett 100-tal test- och demonstrationsmiljöer för framtidssäkra produkter, tekniker och tjänster. RISE Research Institutes of Sweden ägs av svenska staten.

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Maritime operations
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