Health Management – Anomaly Detection and Classification
Preliminary Project Plan

Version 1.0

Revision history

Date	Version	Description	Author
22/01/24	0.1	The initial draft of the preliminary project report.	Harald W Fredriksen, Even J. P. Haslerud, Jørgen Finsveen
24/01/24	0.2	Elaboration of problem statement, outcome measures, and execution	Harald W Fredriksen, Even J. P. Haslerud, Jørgen Finsveen
25/01/24	0.3	Inclusion of tables and figures, attaching appendix, improvement of the risk assessment.	Harald W Fredriksen, Even J. P. Haslerud, Jørgen Finsveen
26/01/24	1.0	Final revision and text enhancement.	Harald W Fredriksen, Even J. P. Haslerud, Jørgen Finsveen

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1. Goals and frameworks

1.1 Orientation

Health Management is a bachelor project at the Norwegian University of Science and Technology (NTNU) presented and given to by Kongsberg Maritime. This project addresses a genuine issue faced by maritime vessels, a challenge that Kongsberg Maritime previously attempted to resolve in 2018. The project is focused on automation of vessel monitoring using machine learning algorithms.

Given the advancements in information and resources currently available, Kongsberg Maritime is making another attempt at this problem, seeking fresh perspectives to approach it. Each member of the bachelor group has an interest in machine learning. Consequently, when the group initiated contact with Kongsberg Maritime regarding a potential project for the bachelor's degree, the suggested case was found particularly compelling.

1.2 Problem statement / project description and objectives

The Health Management venture is intended as a series of preventative measures focusing on providing customers with operational stability. The objective is to monitor critical vessel machinery through collecting data logged from various sensors measuring different aspects of a given unit, and to analyse said data for detection and classification of anomalies as well as maintenance prediction. By utilizing condition monitoring, it is expected to help:

- Avoiding unplanned maintenance and keep critical assets operating.
- Predict maintenance needs which can be planned accordingly.
- Reducing the total cost of asset ownership.
- Maximizing the operational profitability.
- Ensuring sustainable maintenance and optimized machinery performance.

Kongsberg Maritime are already collecting and monitoring data from vessels at sea, however, they seek to find ways to automate the monitoring and classification of the data. In order to achieve this, Kongsberg would like to approach the problem as a subject to machine learning implementation. A satisfactory solution would be to implement machine learning techniques which makes an autonomous system capable of investigating machinery data in order to:

1. Detect anomalous long-term trends.
2. Classify detected anomalies.

The present Health Management service utilizes Failure Mode analysis of machinery data, which includes recognizing familiar failure patterns in operational data. Kongsberg Maritime has previously given a significant effort attempting to utilize machine learning for anomaly detection, but their approach of trying to detect instantaneous anomalies rather than long-term trends proved to be insufficient to the requirements of equipment condition monitoring. As of date, detected anomalies are investigated and diagnosed by product experts, even upon recurring anomalies in the same unit.

As there has been a vast number of technological advancements since the previous attempt to automate the Health Management service, Kongsberg Maritime seeks to approach the problem again with new insight and perspectives. The formulation of the goals and objectives of this project forms the basis for defining the following problem statement:

How can machine learning be implemented in order to detect and classify anomalous behaviour in machinery of various nature?

The problem statement describes the fundamental question which Kongsberg Maritime would like to find answers to, and which introduces the process of designing a machine learning model which can be considered to be an acceptable solution to the problem. The problem demands a concrete solution which can be applied to the most critical units subject to condition monitoring. Therefore, the following assumptions and delimitations are made:

- A trained machine learning model should be able to detect and classify long-term anomalies in engines, low- and high-speed rotating machines.
- Different pieces of machinery may require monitoring of different parameters describing important aspects of the condition of the machine.
- Anomaly classification must be based on an initial classification by a product expert.
- The machine learning model must have a sensitivity-level for anomaly detection which is appropriate for the significance of the given anomaly.

In order for a solution to be recognized as satisfactory for the problem, it should be capable of achieving the following results:

1. Detect anomalous behaviour in various machinery with a reasonable accuracy and sensitivity.
2. Correctly classify various different sorts of detected anomalies.
3. Prove to be more efficient than manually detecting and classifying potential anomalies from data.

By the end of the project, the developers aim to provide the client with a solution which fulfils these criteria, and which may exert an impact on the products and services of Kongsberg Maritime. The solution should provide new insight and value to the Health Management venture and enable the client to adopt a sophisticated condition-based maintenance strategy for their maritime services.

1.3 Outcome measures

In the course of this bachelor's project, the group aims to deepen their understanding of machine learning and gain proficiency in agile methodologies within the context of collaboration with a major corporation. Partnering with Kongsberg represents a strategic opportunity to acquire practical skills and valuable insight that will significantly enhance the group's professional competencies. The project is centred around a challenge previously addressed by Kongsberg; therefore, a successful resolution on the student's part could result in the development of an advanced model capable of seamless integration into Kongsberg's existing systems. Such an achievement would enable Kongsberg to enhance their offerings and deliver superior value to their clientele.

Furthermore, Kongsberg Maritime has defined a model known as the "Data Value Chain" which describes the process of processing data to gather insight which can produce value to the company.

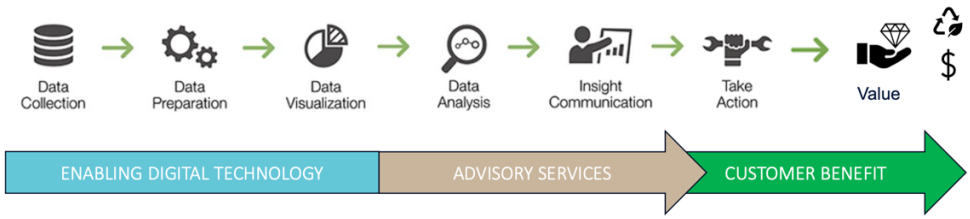

Figure A1 – Data Value Chain

(ref. David Vågnes from Kongsberg Maritime [Unpublished PowerPoint slides])

As seen in Figure A1, Kongsberg defines the three sub-chains marked with different colouring in the data value chain as subject to three different services. From left to right, these services are:

- **Enabling digital technology**: Health Management
- **Advisory services**: Marine & DP Operations
- **Customer benefit**: Eco Insight

Of these sub-chains, the first three links regarding data collection, preparation, and visualization are of most relevance for the health management service and therefore for this project. However, data

analysis is a crucial part of the machine learning process and will therefore also be of relevance to the project.

It is believed that a satisfactory solution to the project's problem would provide the necessary resources to enhance the insight communication link and the following links in the data value chain as well as streamlining the health management and condition monitoring services which Kongsberg provides for their customers.

1.4 Boundaries

In the development of the machine learning algorithm, the needs are primarily software, eliminating the necessity for physical materials. This aspect significantly enhances the cost-effectiveness of the project. Presently, the group do not anticipate the need of greater investment in additional software solutions to facilitate the completion of the task.

The primary constraint is time. Given the complexity of the problem at hand, the group must allocate substantial time to research and planning prior to development of the solution. Furthermore, the processing of extensive datasets in machine learning is time consuming. Therefore, strategic planning is imperative for the effective utilization of the time resources in model experimentation and refinement.

A potential need which may be encountered during the execution of the project is a means of storing data which will be used to train the machine learning models. The data may be extensive, which may require the group to store it externally in a cloud solution or a database. This could be relevant if the data is of sensitive nature, or if it is so extensive that it would be difficult to store it locally.

2. Structuring

The project is being conducted under the auspices of a collaborative effort between Kongsberg Maritime and the Norwegian University of Science and Technology (NTNU). Kongsberg Maritime, a renowned industry leader in maritime technology, functions as the primary client for the project, providing the projects problem and corresponding datasets.

NTNU, among the largest of the Norwegian universities, is the secondary client and the educational facilitator of this project. This project will serve as a demonstration of what the team has learned so far from their bachelor's programme in computer engineering.

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Name	Affiliation	Role
David Vågenes	Kongsberg Maritime	Client
Saleh Abdel-Afou Alaliyat	NTNU	Supervisor

Student team developer	Roles/Responsibilities
Even Johan Pereira Haslerud	Team leader
Harald Wangsvik Fredriksen	Project coordinator, Quality assurance
Jørgen Finsveen	Lead developer, Scrum master

3. Execution

3.1. Main activities

Setup

During the initial week, the group conducted introductory meetings with representatives from Kongsberg and the supervisory team. These sessions provided a valuable opportunity for all project participants to meet face-to-face, fostering personal connections and facilitating a discussion of the project's objectives and requirements.

In preparation of the forthcoming stages, the group dedicated some time for establishing and familiarizing themselves with various systems essential for effective collaboration and documentation. The group prepared environments such as Confluence for project management and documentation, Jira for issue and project tracking, Discord for real-time communication and GitHub for source code management, preparing the team for the development phase.

Documentation

Documentation is a crucial part of the project deliverable, describing the terms, theory, and the overall execution of the project. As there is continuously a series of events which is subject to documentation, the works of writing this will be an activity which runs in parallel throughout the project's lifetime. Several aspects of the project could also be prone to be updated dynamically, and such will therefore be documented in living documents.

The responsibility for clear and sufficient documentation lies on all members of the group. If necessary, a group member may be delegated the overall responsibility of project documentation, though neither of the other group members will be freed of responsibility in such an event.

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The process of writing high quality documentation requires a structured way of working. In order to ensure this, the group intends to invest time in creating an organized work environment both physically and digitally, applying agile development strategies such as Scrum and Lean scheduling principles such as Kanban. Combining the above principles with regular meetings with the client and the supervisor as well as logging produced information and protocols using the online software tools Jira and Confluence will facilitate for an organized project execution.

Research and planning

As the project group considers to be flat organization where each member equally wants to learn and contribute, the research needed for the project will be a mutual responsibility. In order for the group to be able to work in harmony while working on a solution to the project, it is important that all members have a general understanding of the subjects. The amount of quality research may prove to be a crucial factor to whether the project culminates in an acceptable solution to the project problem or not. Planning will naturally be of just as much importance.

Research and planning will be conducted when the need arises, and in the planned time slot between the middle of January and the middle of February. As the group intends to adopt the Scrum framework to this project, planning of which issues from the product backlog are to be included in the upcoming sprints will also take place regularly throughout the project execution.

Development

The development will start early in February and continue towards the start of May. Although every group member will actively contribute to the development, it may be necessary to delegate a group member with more responsibility for report writing, documentation, etc., as several of these activities coincide during this phase of the project. In such a scenario, it may be applicable to utilize role rotation.

In the event that a group member falls ill or is somehow unable to contribute to the development, will the group conduct an extraordinary meeting where the alternatives for adjustment will be discussed.

Finalization

As the project approaches completion, it may be wise to divide the group into smaller units, where different units have different jurisdictions such as testing, documentation, refactoring, report

writing, and other activities. This will ensure that no activity is overlooked, and that the group is more flexible in this time-sensitive phase.

Project report

The task of compiling the project report is an ongoing task that spans the entire duration of the project. This approach is adopted to guarantee a comprehensive and detailed report while preventing overwhelming volume of work as the project nears completion. The report is a collaborative effort among all team members, to ensure that all aspects and insights are included. This collaborative process will be facilitated through either joint authorship or through a systematic and continuous peer review mechanism, ensuring that the report reflects the collective expertise and contributions of the entire team.

3.2. Milestones

Week	Project steps	Date
4	Preliminary Project Plan submission	26.01.2024
-	Oral Presentation	April (To be determined)
21	Bachelor Project submission/presentation	21.05.2024

4. Follow-up and quality assurance

4.1 Quality assurance

To ensure that the work conducted during the project meets the expected degree of quality, the group will implement quality assurance strategies, including:

- Regular peer reviews of code and execution.
- Consultation with Kongsberg Maritime's experts to validate approaches and findings.
- Implementation of comprehensive testing protocols to ensure the reliability and accuracy of the machine learning models.

The practice of peer code review among team members significantly contributes to maintaining the highest standards of code quality and ensures that all developers remain abreast of the latest developments within the application.

Furthermore, the team are supported by an exceptional partner. The close collaboration with Kongsberg affords the team with the opportunity to consult with their experts. This collaboration facilitates the validation of the team's methodologies and enables them to receive insightful recommendations as necessary, thereby enhancing the overall quality and efficacy of the project.

To safeguard against bugs and uphold the reliability and accuracy of the machine learning models, the team will institute a thorough testing framework. This framework will encompass a variety of testing methodologies tailored specifically to the unique challenges presented by machine learning systems.

4.2 Reporting

The group will report regularly to both Kongsberg Maritime and the supervisor at NTNU. These reports will include progress updates, challenges encountered, and preliminary results. Reporting will be bi-weekly with additional updates as needed. These activities will also be a means of receiving feedback and advise from both the client and the supervisor.

In addition to reporting to Kongsberg Maritime and the supervisor, there will be reporting in the developer team internally. The group members will be committed to report to each other regarding current status in their activities. Such communication will be conducted on a daily basis during stand-up meetings in accordance with the Scrum framework.

5. Risk assessment

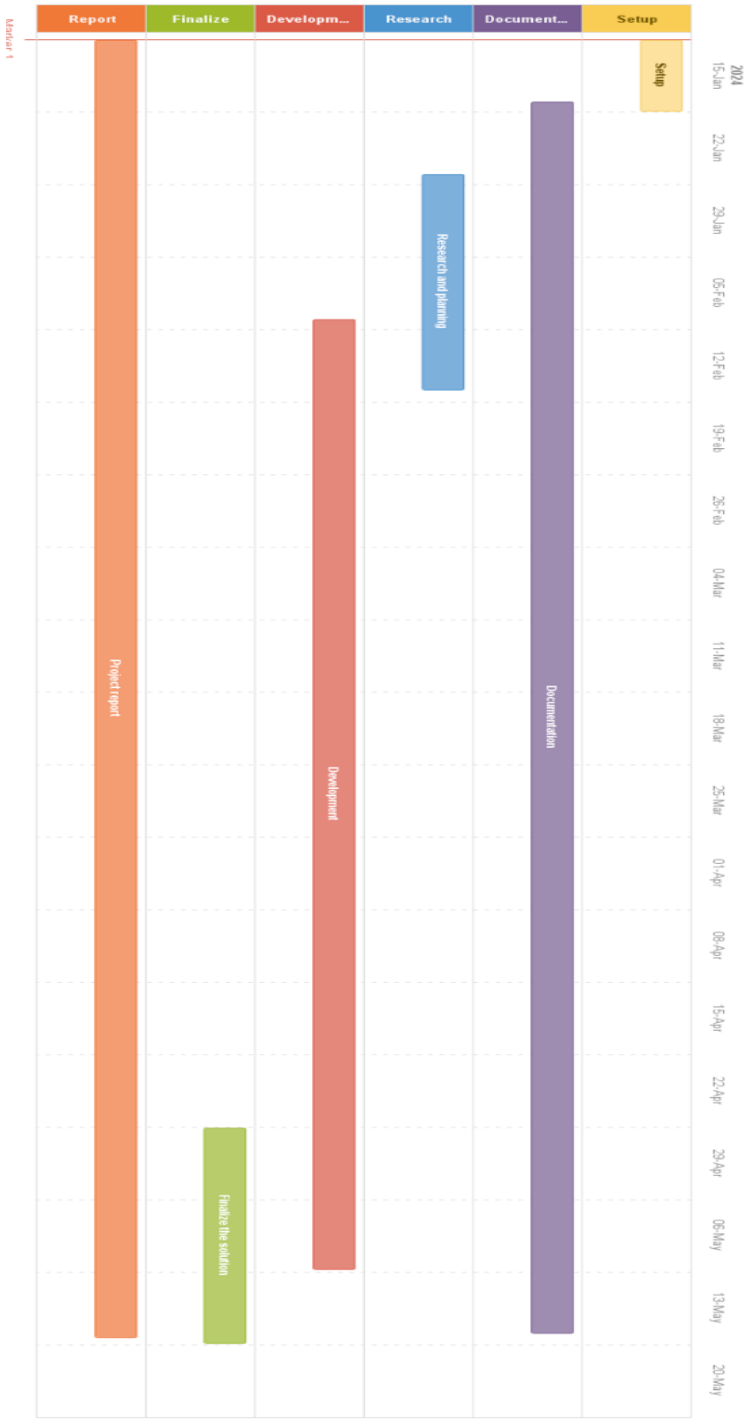
Risks will be continuously assessed throughout the project, considering factors such as data quality, model accuracy, group communication, and project timelines. Mitigation strategies will be developed for identified risks, and contingency plans will be in place.

Vulnerability	Probability *(1-5)*	Consequence(s)	Preventive measure(s)
Insufficient team coordination and communication.	2	Reduced efficiency, Reduced quality, Team conflicts, Bad use of resources	Conduct daily stand-up meetings following Scrum, Regular meetings with supervisor and client, Peer reviews, Long-term planning, Thorough planning, Sprint retrospectives
Resource bottle-necks and constraints.	3	Delayed progress, Reduced quality	Regular communication with supervisor and client, Thorough resource assessment
Unsuspected group member incapacity. (e.g. illness or injury)	1	Uneven distribution of work, Work overload, Reduced efficiency	Back-up solutions, Planning with margins, Adjustment of tasks
Tunnel vision of pending activities.	2	Reduced quality, Bad use of resources	Sprint retrospectives, Role rotation, Sprint planning, Status reports
Missing/forgetting deadlines.	3	Reduced quality, Penalty from client or NTNU	Thorough planning, Reminders, Time scheduling
Insufficient or clustered data.	4	Reduced ML model accuracy, Delayed progress	Extensive data preparation, Regular communication with client, Statistical adjustments
Inaccurate or biased ML model.	5	Reduced quality, Delayed progress, Project objective failure	Thorough research, Model experimentation, Communication with supervisor, Assessment of algorithms, Ensure high quality data, Extensive testing, Feature engineering
Work overload	3	Reduced efficiency, Reduced quality, Delayed progress	Extensive planning with margins, Clarification of expectations, Regular communication, Adjustment of tasks

6. Appendix

6.1 Schedule

Roadmap from the project's designated wiki-page on Confluence is attached. Note that this roadmap is an initial estimate and may be subject to change after future revisions.



6.2 Contact list

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6.3 Contract documents

6.3.1 Cooperation contract for the bachelor group

Cooperation contract is attached.

6.3.2 Standard agreement

Standard agreement is attached.