Drone Technology in the maritime industry - a company proposal and solution report to Rohde Nielsen

ROHDE NIELSEN

Group 50

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Date of submission

December 17, 2023

Executive summary - Nadia

The following paper examines the strategic initiative at optimizing and enhancing the efficiency of Rohde Nielsen's inspection processes through the integration of drone technology. Human accidents on vessels are a prevalent issue each year, often stemming from manual inspections. This study addresses and explores this problem, presenting a solution in the form of a partnership with UPTEKO. The collaboration involves the provision of an automated drone with an integrated AI system, modular and specifically designed for vessel inspection and navigation during docking. Various methodologies were employed to arrive at this solution, including the use of the 5 Whys, Brainstorming, Question Tree, Interviews, Dot Voting, Harris Profile, and desk research. The study begins by stating Sustainable Development Goals (SDG) followed by utilizing a Value Proposition Canvas to assess customer needs. A Lean Business model canvas is then employed to evaluate the strategy for the business plan, and a risk analysis is conducted to anticipate potential challenges during solution implementation. Finally, an economic perspective on the investment is presented, along with a comparison to provide an estimated cost.

Moreover, the study addresses the following problem statement:
"How can we develop a solution capable of detecting and tracking damages on marine vessels, improve navigation safety during docking and reduce associated risks in the maritime industry, in order to improve efficiency in maintenance workflows?"

The study's findings suggest that a more digitized solution, which enhances operational processes in the maritime industry for Rohde Nielsen, believes to be a more profitable investment compared to traditional manual inspection methods. This approach is not only cost-effective but also time-efficient, ensuring a more streamlined work approach and better safety for workers. Additionally, the implementation of a more sustainable approach contributes to achieving the SDG goals.

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1. Problem background

The maritime industry faces a series of evolving challenges in today's era. At the forefront of these challenges is the issue of vessel maintenance and sustainability - a crucial matter for companies like Rohde Nielsen. In the pursuit of maritime excellence, these challenges are viewed as opportunities to enhance safety, efficiency, and eco-friendliness within the sector. (Sichun, 2023b)

Rohde Nielsen confronts the intricate challenges of vessel maintenance, which are critical to ensuring safety, efficiency, and environmental compliance in maritime operations. One of the most pervasive issues is hull fouling, where marine organisms colonize the hull, which could lead to increased drag, elevated fuel consumption, and higher emissions. This not only affects the operational costs and environmental impact of the fleet, but it also damages the structural integrity and efficiency of the vessels. (Mutual, n.d.-b)

Additional concerns include the potential for structural damage such as fatigue cracks and corrosion. These can develop under the constant stresses of marine operation and the corrosive saltwater environment. Thermal stresses on vessel structures can create hot spots, posing significant fire risks if not identify and managed promptly. Moreover, the impact of such stresses is compounded by the dynamic nature of the maritime environment, where varying temperatures, salinity, and water movement contribute to the deterioration of materials. (Princeokporu, 2023d)

Furthermore, damage to protective coatings and paint systems not only exposes the hull to accelerated degradation, but also leads to harmful substances into the marine ecosystem. The imposition of regulations by the IMO on the types of antifouling paints is a response to the environmental threat posed by traditional toxic compounds used in hull paints . (*How Biofouling Impacts Vessel Efficiency — and How to Fix It*, n.d.-b)

On the superstructure and deck, mechanical damage from operational stress and environmental exposure can impair the ship's functionality and raise safety risks for the crew. The complex system of machines and equipment on board is vulnerable to various issues, including electrical issues and hydraulic breakdowns, which require careful and frequent maintenance and checks. (Princeokporu, 2023e)

Navigation and docking present their own sets of risks, requiring precise operations to avoid accidents that could have severe environmental repercussions. Collisions during berthing are among the most frequent maritime accidents and represent a significant safety concern that must be addressed through improved operational practices and safety policies. (Hsu, 2014d)

1.1 Research

Given the complexities detailed in the problem background, research into maritime vessel maintenance and sustainability has focused on critical areas to tackle industry's evolving demands:

The International Maritime Organization's (IMO) has established aggressive targets for emission reductions by 2030 and 2050, the maritime industry is focusing on enhancing vessel performance from the design phase all the way through to daily operations. (*Sustainable Shipping and Future of Marine Industry in 2030*, n.d.-b)

Digitalization is highlighted as a critical strategy for enhancing ship efficiency in pursuit of these environmental goals. Concurrently, advancements in hull maintenance, particularly early-stage for fouling and gentle cleaning methods, are extending the life of vessel coatings and reducing environmental harm. (Oliveira & Granhag, 2020b)

Moreover, Research has also emphasized adopting corrosion control strategies through protective coatings, cathodic protection, and the selection of corrosion-resistant materials is essential for maintaining the structural integrity and operational efficiency of vessels. (Princeokporu, 2023f)

In terms of safety, particularly during the critical phases of docking and berthing, research has identified essential factors, including the concentration of workers, condition of mooring lines, and emergency response. By refining safety protocols and policies, the industry aims to mitigate the inherent risks of maritime navigation. (Hsu, 2014e)

Collectively, this research indicates a clear shift towards technology-enhanced, sustainable maritime practices, and underscoring the importance of collective effort and innovation to achieve the IMO's sustainability objectives and maintain high safety standards.

2. Methods

This section outlines the research methodology employed in our study, focusing on drone technology's application in the maritime industry for Rohde Nielsen. We have adopted a multi-faceted approach, integrating both qualitative and quantitative research methods alongside primary and secondary data collection. Our methodology is designed to ensure a robust, data-driven foundation for our proposal, enabling us to address the specific needs and challenges faced by Rohde Nielsen.

Qualitative & quantitative research: We conducted interviews with maritime industry experts and personnel to gather insights into the current challenges of damages and maintenance of vessels. Focus groups with technical staff and experience were also held to understand the practicalities of integrating drone technology into existing workflows. This qualitative approach allowed us to capture the nuanced opinions and experiences of industry stakeholders, providing a rich context for our quantitative findings.

Quantitative data were collected through statistical analysis. This helped establish a clear picture of the current market landscape, an overview and the potential for cost savings and efficiency gains through drone technology.

Primary data & secondary data collection: Our primary data were gathered through the interviews. Additionally, we conducted in-depth interviews with Upteko, the drone technology provider. These interviews granted us direct insight into the capabilities, performance, and application scope of drones in maritime settings. Furthermore, observations of hull inspection processes were conducted to gain firsthand knowledge of the challenges and potential areas for improvement.

Secondary data: A thorough review of existing literature was undertaken, including academic journals, industry reports, and case studies on drone usage in maritime and other related industries. We analyzed data from maritime safety boards and insurance claim reports to identify common themes in hull integrity issues and the role of maintenance practices in mitigating these risks.

Comparative Analysis: To benchmark the potential of our proposed solution, we conducted a comparative analysis of existing technologies and methods used in inspections. This comparison extended to evaluating the cost-effectiveness, safety, and regulatory compliance of traditional practices versus drone-assisted inspections.

Risk Assessment: We conducted a risk assessment to identify and evaluate the potential risks associated with deploying drone technology for inspections. This involved scenario planning and developing risk mitigation strategies to ensure the safety and reliability of our solution.

Methodological Approach:

In utilizing these methods, our approach was systematic and iterative:

- **Data Triangulation**: We cross-referenced findings from different data sources to validate the information and ensure a high degree of reliability in our conclusions.
- **Iterative Review:** Our methodologies were not static; we revisited and revised our approaches in response to emerging data and stakeholder feedback.
- **Stakeholder Engagement:** Throughout the research process, we engaged with various stakeholders to ensure our methods and interpretations remained aligned with industry realities and expectations.

The combination of these methods provides a comprehensive understanding of the potential impact of drone technology in the maritime industry. This methodology offers a detailed assessment and insights required to make informed decisions on integrating drone technology into Rhode Nilsen's operations. (*How Drone Technology Is Improving Safety in the Maritime Industry - Martek Marine*, 2023b) (M_Admin, 2022b)

3. Company description

Rohde Nielsen, established in 1968 by Captain Jens Rohde Nielsen, is a prominent company in the marine dredging and construction industry. It operates primarily as a marine dredging contractor, providing a wide range of services including beach nourishment, land reclamation, port development, offshore trenching, backfilling, and both capital and maintenance dredging of ports and fairways. The company's expertise in these areas has been a driving force behind its development and growth.

Headquartered in Copenhagen, Denmark, Rohde Nielsen maintains a strong global presence, operating worldwide both as a general contractor and as a subcontractor. The company's focus is not only on maintaining its position as the largest independent dredging contractor in Scandinavia but also on being a preferred partner for dredging projects globally.

Financially, Rohde Nielsen has demonstrated significant performance. In the fiscal year 2020, the company reported an annual revenue of approximately 893.33 million Danish kroner. This financial strength underlines the company's solid position in the industry. Rohde Nielsen employs a workforce of between 101 and 500 employees, indicating a substantial operational scale. The company's diverse and broad-ranged fleet is central to its ability to meet and exceed client expectations in various marine construction activities. (Rohde Nielsen, 2021b)

Rohde Nielsen's commitment to its core competencies in marine technology, ports, and harbors has been fundamental to its success and growth over the years. It continues to specialize in key areas such as capital and maintenance dredging, land reclamation, and coastal defense, including beach nourishment. These specializations not only highlight the company's technical capabilities but also its dedication to contributing to coastal and marine infrastructure development. (Language, n.d.-b) (*Rohde Nielsen a/S - Owner | Dredging Database*, n.d.-b)

3.1 Stakeholder Analysis

A stakeholder matrix is a tool used to identify and analyze stakeholders in a given situation, project, or organization. The typical matrix has two axes: one axis shows the stakeholders' influence or power concerning the project, while the other axis demonstrates their interest or engagement in the project. This creates a visual representation that helps identify, prioritize, and understand stakeholders' needs, attitudes, and influence on the project or decision-making process. (Zanchetta, n.d.)

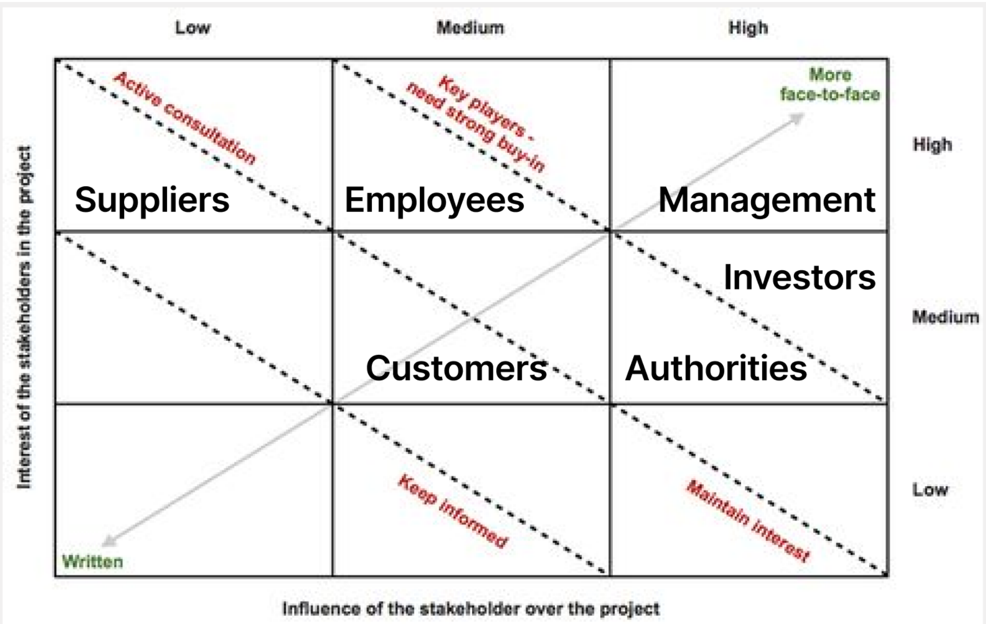

Figure 1. Stakeholder Analysis

Investors: These are individuals or entities who own shares in the company. Since they've invested a substantial amount of money in the project, they have a significant interest in its success. However, their influence can vary based on the extent of their ownership in the company.

Management: They hold high influence as they determine the direction of the company. Additionally, the project's success directly impacts the company's outcomes, so the management has a substantial interest in it.

Employees: While they may not make the decisive decisions, they still wield considerable influence on the project's success and quality. Hence, they hold a moderate level of influence. They have a high interest as the project's outcomes can affect their work environment, jobs, and the company's future.

Customers: Rohde Nielsen, including captains and crew, exert influence through their demands and expectations. Hence, they have a moderate level of influence. Since they rely on our service, they naturally hope for a successful project, indicating a moderate level of interest.

Suppliers: Despite having a high interest in the project's success for their business, they typically have limited direct control over the project's direction, resulting in low influence. However, the project's success is crucial for their ongoing business as suppliers, hence their high interest.

Authorities: Authorities possess the power to impose requirements or regulations and approve certain aspects of a project. Therefore, they hold high influence. Their primary focus is ensuring compliance with laws and regulations, resulting in a moderate level of interest.

4. Market description

The global commercial drone market attained a market size of USD 8.77 billion in 2022 and is projected to reach USD 10.98 billion in 2023, with an anticipated escalation to USD 54.81 billion by 2030, demonstrating a Compound Annual Growth Rate (CAGR) of 25.82% during the forecast period (2023-2030) (Fortune Business Insights, n.d). The commercial drone market is also the fastest growing drone technology segment estimated to represent 60% of the overall drone industry's revenue (this includes commercial drones and military drones). (Castellano, n.d)

The evolving applications of drones in the maritime industry showcase their versatility and effectiveness in addressing a wide range of challenges. As technology continues to advance the integration of drones into maritime operations is to become even more widespread and necessary. Drones are used for missions that are too “dull, dirty, or dangerous” for humans; this include 3d mapping, delivery, inspections, data transmissions, and video collection and much more (Naukowe, 2021).

Competition in the drone industry within the maritime sector is intense, driven by the increasing need for efficient and cost effective solutions for different tasks with some of the biggest companies being based in the USA (Insitu) and China (DJI Enterprise) but also seeing Scandinavian newcomers gaining more market share (Upteko, DK). (*Commercial Drone Market Size, Share | Global Forecast [2030]*, n.d.-b) (Castellano, 2017b)

5. Identification of the hard nut

To identify the challenging aspect, we employed the Double Diamond model, an innovation and design process consisting of four stages: Discover, Define, Develop, and Deliver. These stages incorporate both divergent and convergent thinking to foster creativity in generating ideas and finding concrete solutions to the problems. In defining the problem for addressing Rodhe Nielsen's challenges, we utilized various methods such as mind mapping, question trees, interviews, desk research, and the 5 Whys technique.

Through the methods used in the Discover phase, we identified that the most significant issues to address were delays in detecting damages on vessels and damages caused during vessel docking. Considering the frequent docking and rigorous use of vessels in challenging projects like dredging, addressing this issue is paramount. Resolving it could lead to substantial financial savings for the company.

In the Define phase, we precisely outlined the problem we aimed to solve by refining and filtering the information gathered during the Discovery phase. Through extensive data analysis, desk research, and consultations with the company, we gained insights and knowledge that facilitated the refinement of ideas for the subsequent stages of the project.

5.1 The hard nut definition

“How can we develop a solution capable of detecting and tracking damages on marine vessels, improve navigation safety during docking and reduce associated risks in the maritime industry, in order to improve efficiency in maintenance workflows?”

6. Proposals

It is imperative to explore innovative solutions that not only address the immediate challenges, but also pave the way for future advancements regarding the complexities of maritime vessel maintenance. The following section introduces a comprehensive solution proposal, crafted to meet a set of selected criteria that are important for enhancing the operational, environmental, and economic aspects of vessel maintenance.

6.1 Dot voting

To fairly decide on the criteria for our solution proposal, we employ dot voting, a participatory decision-making technique. Each person involved gets a set of "dots" to vote for the criteria they consider most important, in our case, four dots. The criteria with the most votes will form the foundation of our solution assessment.

Figure 3. Dot Voting

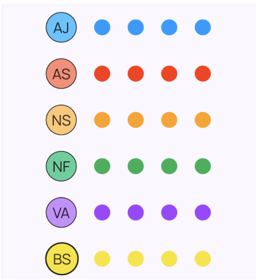

Figure 2. Dot Voting

After conducting the dot voting exercise among group members, the distribution of votes has highlighted the priority of each criterion as follows:

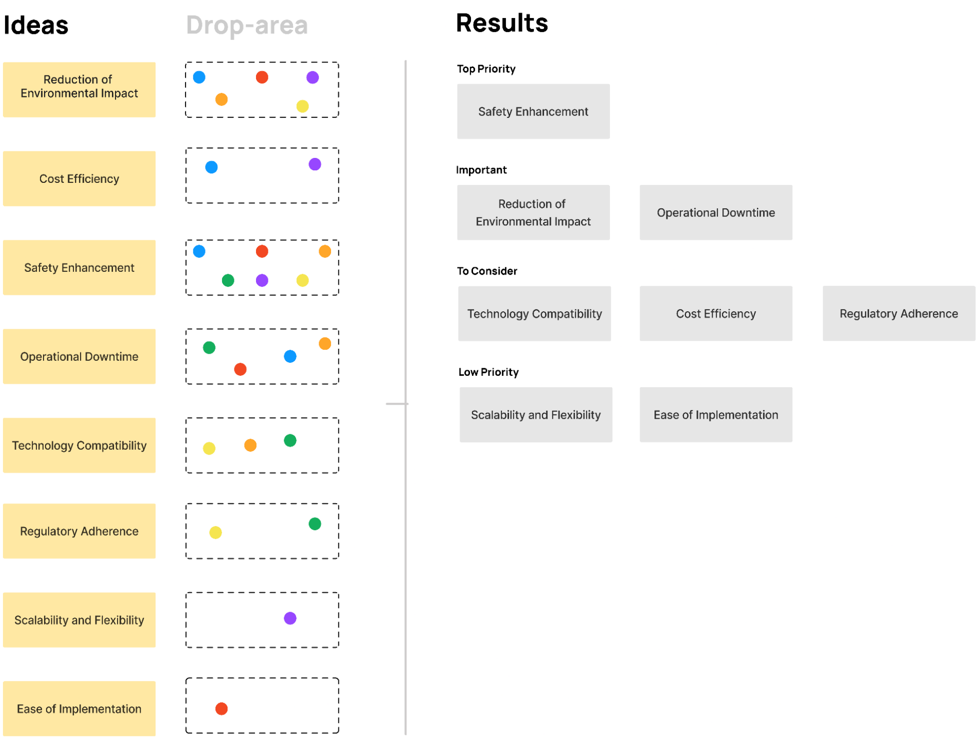

Figure 4. Dot Voting

Criterias explained:

- **Reduction of Environmental Impact:** Solutions should contribute to lowering emissions and pollution.
- **Cost Efficiency:** The approach must offer cost savings over the vessel's lifecycle.
- **Safety Enhancement:** Any proposed solution must improve personnel safety
- **Operational Downtime:** Solutions should minimize the downtime of vessels during maintenance.
- **Technology Compatibility:** Integration with existing vessel systems and infrastructure should be seamless.
- **Regulatory Adherence:** Compliance with international maritime laws and regulations is non-negotiable.
- **Scalability and Flexibility:** The solution should be adaptable to various ship sizes and operational scopes.
- **Ease of Implementation:** Solutions should be practically deployable with minimal disruption to current operations.

The results indicate a preference for a solution that enhances safety, reduces environmental impact, and minimizes operational downtime.

6.2 Harris profile

We are now utilizing the Harris Profile method to systematically evaluate the proposed solutions, which are described below, against the criteria's above. This tool will enable us to quantitatively assess each concept's strengths and weaknesses, ensuring a comprehensive comparison. We are aiming to identify the most suitable solution to address the complex challenges of maritime vessel maintenance and sustainability, aligning with our strategic goals and industry standards.

Solution Proposal 1 - Silicone-Based Coatings:

Research has highlighted silicone-based foul-release coatings (FRCs) as a sustainable alternative to traditional toxic antifouling methods. A study in the Baltic Sea tested the environmental suitability and efficacy of silicone-based coatings, showing promising results in reducing marine pollution and the risk of invasive species. These silicone solutions have been shown to rival or surpass the protective qualities of traditional coatings, with much less toxicity, which aligns with environmental sustainability goals. See appendix 1 for an illustration of the solution. (*Ship Hull Anti-fouling - Are Silicone-based Coatings a Viable, Sustainable Alternative to Toxic, Copper-based Coatings in the Baltic Sea?*, 2023b)

Solution Proposal 2 - Robots:
The maritime industry is assessing the feasibility of using robots, such as magnetic crawlers, to automate the task of vessel hull maintenance. These robots could automate the labor-intensive cleaning process, minimizing the risk to human workers, and potentially lower maintenance costs. Different types of robots might be required for various maintenance duties. These robots could operate in coordination and communicate among them to effectively perform a wide array of tasks. See appendix 2 for an illustration of the solution.

Solution Proposal 3 - Drone inspections:
The maritime sector is increasingly adopting drones for vessel inspections, offering a safer and more cost-effective approach compared to traditional methods. Classification societies such as Lloyd's Register and the American Bureau of Shipping have been developing regulations and guidance to integrate drone technology into maritime operations. The usage of drones are specially praised for their ability to achieve greater inspection accuracy as it allows for accurate data collection with less operational interruption - by reducing the preparation and execution time required for traditional inspection programs. See appendix 3 for an illustration of the solution. (Staff, 2020b)

Harris profile below:

CRITERIA	PROPOSAL 1				PROPOSAL 2				PROPOSAL 3			
	-2	-1	1	2	-2	-1	1	2	-2	-1	1	2
Reduction of Environmental Impact												
Cost Efficiency												
Safety Enhancement												
Operational Downtime												
Technology Compatibility												
Regulatory Adherence												
Scalability and Flexibility												
Ease of Implementation												
CALCULATED POINTS	-3				-3				10			

Figure 5. Harris Profile

From the comprehensive analysis and discussions, and through the methodical application of the Harris Profile, it has become clear that drone technology stands out as the optimal solution for the maritime maintenance challenges faced by Rohde Nielsen.
The drones' performance across multiple key criteria — including safety enhancement, reduction of environmental impact, and operational downtime — underscores their potential to revolutionize vessel inspections and maintenance, aligning it with both the company's needs and industry-wide sustainability goals.

7. Collaboration with Upteko

We propose a collaboration with the Danish technology firm, Upteko. Established in 2018 by Mads, Benjamin, and Sebastian, Upteko is a company specializing in the development of drone applications for the Offshore and maritime sector. As an end-to-end company, Upteko provides a full and integrated solution tailored to Rohde Nielsen's requirements. This includes services ranging from the initial development and design of the drone, based on Rohde Nielsen's needs, to the implementation, maintenance, and ongoing support, covering all phases of the collaboration.

8. Solution

We are proposing a partnership with UPTEKO, focusing on their automated LARK drone equipped with an integrated AI system. This drone is modular and specifically designed for vessel inspection and navigation during docking, yet it is versatile enough to cater to various maritime operations based on customer requirements. Its adaptability allows for convenient packing and transportation to any vessel when needed for inspection or navigation.
The automated nature of the drone makes it user-friendly. The captain can simply select the desired task on the screen connected to the drone, and it will autonomously perform the inspection or navigate the vessel during docking. The inspection occurs during dry docking, and upon completion, the drone generates a PDF file containing relevant information, streamlining, and digitizing the process for greater efficiency. This innovative solution enhances the overall operational capabilities and effectiveness of maritime activities.
We created our own drone sketches with the dimensions 70x70x55 (Length, width, height). (see appendix 4)

Sensors and camera

The drone is equipped with a suite of sensors that work together to ensure efficient and effective operation. GPS and navigation sensors provide precise location data for accurate path following and stability, while optical cameras on the underside capture high-resolution imagery for tasks like inspection. Thermal and infrared cameras detect heat signatures, essential for night operations. LIDAR sensors create detailed 3D maps of the surroundings, aiding in terrain analysis and obstacle avoidance. Ultrasonic sensors, located on the underside, help in altitude maintenance and safe landings. Proximity sensors around the drone enable automatic collision avoidance, especially in complex environments. Environmental sensors gather crucial data like humidity and temperature, and communication antennas ensure strong connectivity for control and data transfer. This integration of sensors allows the drone to navigate precisely, perform a variety of tasks, and operate safely in diverse conditions. (Flynt, 2020b) (*Drones and Optical Sensors: No Longer a Remote Possibility*, n.d.-b) (*Zenmuse L1 - UAV Load Gimbal Camera - DJI Enterprise*, n.d.-b) (Security, n.d.-b)

Figure 6. LARK Drone

Vessel adaptation

The drone learns to adapt to different vessels through a series of simulations. First, it's programmed with information about various types of vessels, helping it understand how to navigate around them. Then, the drone practices flying in different simulated environmental conditions like wind and waves, adjusting its flight accordingly. Its sensors are fine-tuned to detect and react to the vessel and its surroundings accurately. The drone also practices specific tasks it might need to perform, like inspections. Safety is a big focus too, with the drone being tested in emergency scenarios to ensure it can handle unexpected situations. Throughout these simulations, its performance is constantly analyzed and improved using AI and machine learning. This process of testing, feedback, and refinement continues until the drone can safely and effectively adapt to a variety of vessels in different conditions. This also means that the drone is fully automated. (Zhang et al., 2021b) (*Researchers Develop Drone-*

based System to Detect Marine Debris, Expedite Clean up (Video) - NCCOS Coastal Science Website, 2022b) (Sivertsen, 2023b)

Functionality

Rhode Nielsen's drone is engineered for versatility and efficiency in maritime operations. It's easily adaptable to different areas of the vessel and suitable for various vessel types. A key feature is its damage detection capability. Using high-resolution cameras and specialized sensors, the drone can quickly identify vessel damages like hull abrasions and structural issues. This function enhances regular maintenance and is crucial for safety checks, making our drone an essential tool for safe and efficient maritime activities.

9. SDG Goals

9.1 Industry, innovation, and infrastructure

We contribute to the SDG goal 9 "Industry, innovation and infrastructure" by integrating drones into the maritime industry, more precisely used for inception when dry docking and navigating the vessel. This enhances efficiency and reliability within the industry, optimizing resources and improving productivity. They contribute to the sustainability of infrastructure development, aligning with the goal to build resilient and sustainable cities. In this goal, there is also focus on the innovation aspect. Drones are a technological approach to making manual work faster and easier. This also opens to innovation in an industry traditionally reliant on conventional approaches. Furthermore, the solution is beneficial to the company image being more explorative to technologies and innovation overall. Drones, as a technological innovation, expedite manual work, fostering innovation in a traditionally conventional industry. Beyond operational benefits, our initiative positions the company as explorative and innovative, positively impacting its image. They play a pivotal role in fostering the sustainability of infrastructure development, in line with the objective to construct resilient and sustainable cities. In terms of the innovation aspect, drones serve as a technological means to expedite and simplify manual tasks. The adoption of drones signifies a proactive stance toward technology and innovation, further solidifying the company's reputation as forward-thinking and explorative. (*Goal 9 | Department of Economic and Social Affairs*, n.d.-b)

9.1.2 Climate action

This objective revolves around proactive efforts to improve the climate. Through the adoption of our solution, Rohde Nielsen takes immediate and impactful action to address climate concerns. The implementation contributes to efficient energy consumption, as drones operate with efficiency, consuming less energy than conventional and manual methods. (*Goal 13 | Department of Economic and Social Affairs*, n.d.-b)

9.1.3 Life below water

The solution actively aligns with the SDG goal, aiming to preserve and sustainably utilize oceans and marine resources. Through the implementation of drone technology and the enhancement of vessel inspection, our initiative significantly contributes to the improvement of marine biodiversity. Early detection of issues facilitates proactive measures, preventing harm to species and habitats, and fostering a more sustainable and balanced marine ecosystem. (*Goal 14 | Department of Economic and Social Affairs*, n.d.-b)

10. Business models

10.1 Value proposition canvas

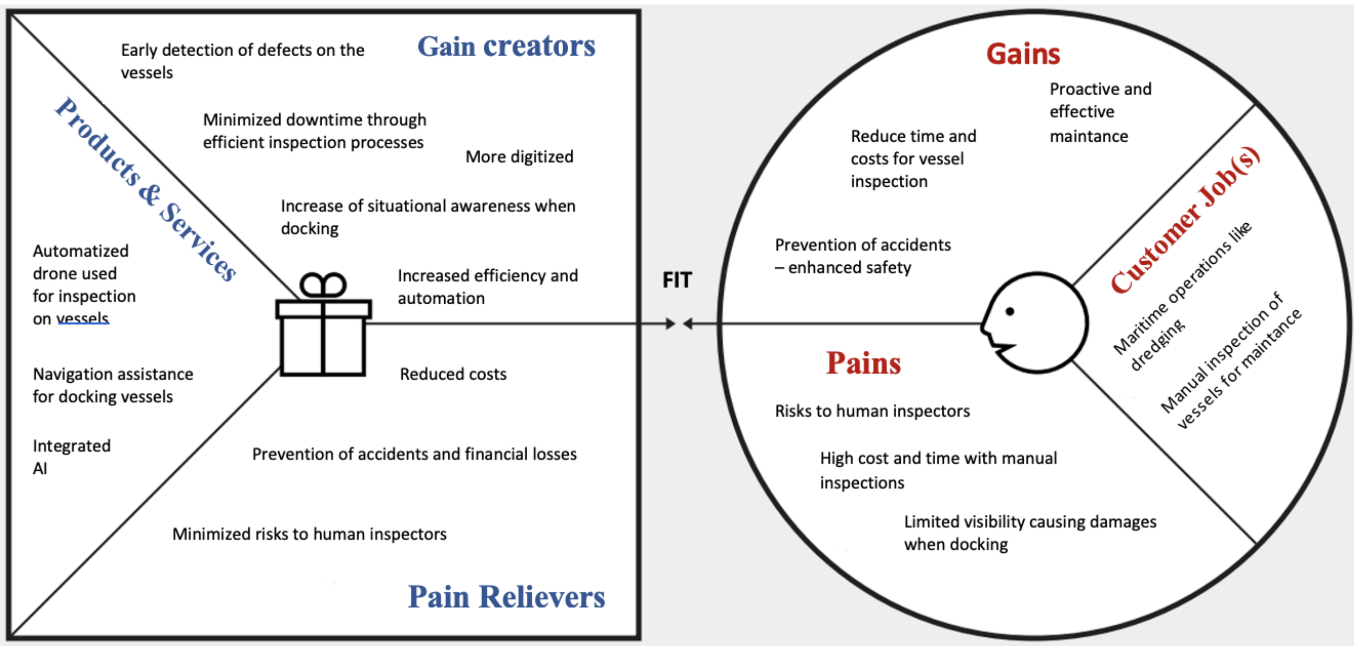

Figure 7. Value Proposition Canvas

The Value Proposition Canvas serves as a model that aims to help clarify how a product or service effectively can meet the needs of the customer, thereby assessing product-market fit and aligning with customer preferences. Practically, this involves initially examining the customer profile, represented by the filled-out circle on the right-hand side. Subsequently, the value map, located on the-left-hand side, is completed to determine if a product market fit exists. Within the customer profile, elements such as customer jobs, representing the tasks customers aim to accomplish, gains, denoting desired outcomes and specific benefits sought, and pains, encompassing adverse results, obstacles, and potential risks associated with current work related to customer jobs, are considered. The value map enumerates all the products or services intended for the customer based on their profile, forming the foundation of the canvas. Gain creators are elements that fulfill customer desires, especially in gains, while pain relievers indicate how a product can mitigate issues or pains experienced by the customer. Further details on these aspects are elaborated in the subsequent section. (B2B International, 2022b)

The Value Proposition Canvas above has been crafted to pinpoint the advantages that the drone technology can provide to the customer Rodhe Nielsen. This value proposition aims to strengthen their existing position in the market.

10.1.1 Customer Profile

Customer jobs: The customer is engaged in maritime operations, including dredging and construction, as well as manual inspection of vessels for maintenance purposes such as hull fouling removal and defect identification.

Gains: There is a need for more efficient and proactive maintenance to reduce the time and cost associated with inspections. Improved safety is also a priority, specifically in preventing accidents to ensure employee well-being.

Pains: In the maritime industry, there is an inherent risk with human inspections, leading to challenges in terms of time and cost efficiency. Manual inspections are time-consuming and costly, and limited accessibility hinders the timely detection of faults. Additionally, limited visibility poses a threat, potentially causing damages to vessels during docking procedures.

10.1.2 Value map

Products and services: Upteko offers both a product and a service. The product is an automated drone equipped with an integrated AI system, utilized for vessel inspection and navigation during docking. The service involves Upteko providing assistance for software updates, product/system failures, and other related needs.

Gain creators: Implementing this technology results in a more digitized system, streamlining the processes of vessel inspection and docking. The AI system in the drones efficiently detects defects compared to manual methods, enhancing situational awareness during docking operations.

Pain Relievers: The adoption of drones leads to cost reduction by minimizing workers' time and manual efforts. For instance, after an inspection, the drone automatically generates a PDF document, eliminating the need for manual documentation. The use of drones also mitigates risks to human inspectors, reducing accidents and associated financial losses for both the company and workers. Additionally, during vessel docking, limited visibility concerns are addressed, minimizing the risk of accidents.

Rohde Nielsen has the opportunity to transition from traditional methods of inspection and docking to a modern, digitized solution. This shift holds the potential to optimize their operational processes. The value proposition canvas presents all the gains that can be achieved if Rohde Nielsen wants to implement the technology and accept the value proposition.

10.2 Lean Business Model Canvas

In this segment of our report, we introduce the Lean Business Model Canvas for our proposal to Rohde Nielsen, offering a concise yet comprehensive overview of our proposed drone technology solution in the maritime industry. This canvas serves as a strategic guide for the proposed integration of drone technology within Rohde Nielsen's operations, emphasizing the practical and economic advantages of our solution.

Our innovative approach, featuring AI-powered drones, promises a significant leap forward in inspection precision and efficiency. We outline how this technology will not only enhance vessel maintenance but also ensure compliance with maritime regulations, delivering tangible benefits to Rohde Nielsen.

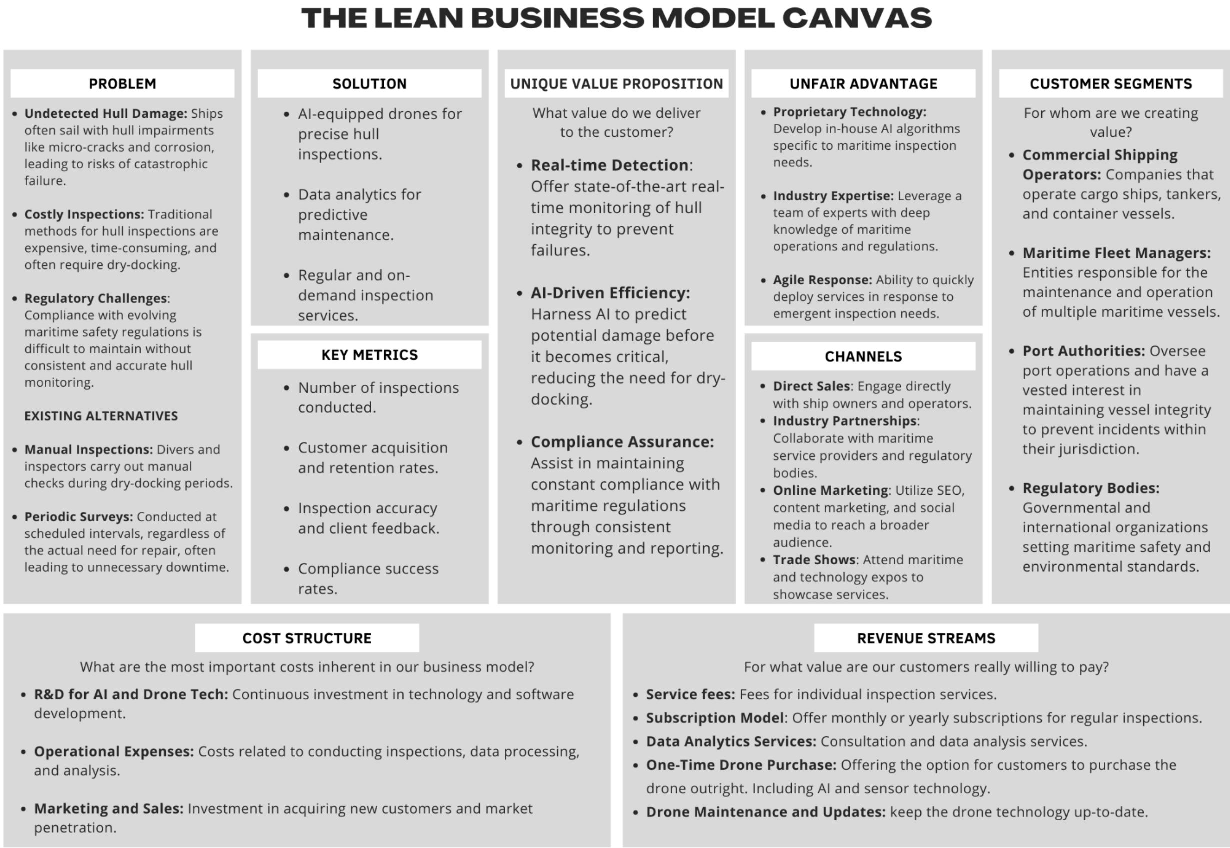

Figure 8. Lean Business Model Canvas

The cost structures associated with implementing this solution are also presented in a clear, accessible manner. (Alam, 2023)

10.3 Risk analysis

With the introduction of drone technology in Rohde Nielsen operations, it is vital to explore the possible challenges they might bring. A risk analysis helps understand and manage potential issues, ensuring a safe and effective integration of drone technology.

The figure below shows risks based on their probability and potential consequences. The following section outlines the 3 key risks identified. (Hayes, 2023)

1. Regulatory Compliance
2. Safety Concerns
3. Data Security and Privacy
4. Weather and Environmental Conditions
5. Integration challenges
6. Costs and return of investment

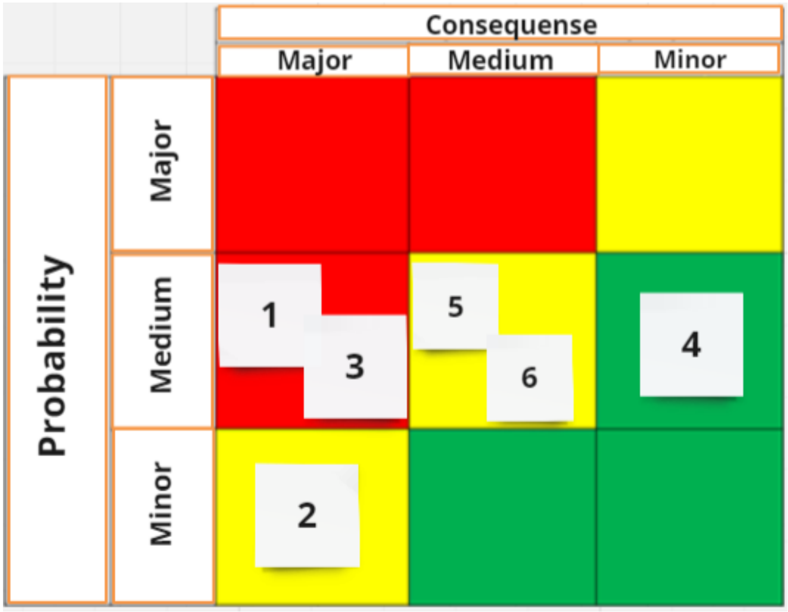

Figure 9. Risk Analysis

1. Regulatory Compliance

- ***Risk:*** Changes in regulatory and legal restrictions in drone usage could impact the companies ability to deploy drones legally, resulting in operational delays. This is particularly precarious for Rohde Nielsen when undertaking governmental projects, as project delays incur significant costs daily.
- ***Mitigation:*** Stay informed about local and international regulations, obtain necessary permits, and ensure that the drone technology complies with all relevant laws. Conduct regular internal inspections of drone operations to guarantee quality and efficiency use.

2. Safety Concerns

- ***Risk:*** Accidents or collisions involving drones, either with other drones, vessels, or infrastructure, could pose safety risks.
- ***Mitigation:*** Implement strict safety protocols, conduct thorough training for drone operators, and incorporate collision avoidance systems into the drone technology.

3. Data Security and Privacy

- ***Risk:*** Unauthorized access to sensitive data collected by drones or concerns about privacy violations.

- ***Mitigation:*** Implement robust data encryption, secure communication channels, and establish clear guidelines on data handling and privacy protection. Obtain necessary permissions for data collection in compliance with privacy laws.

11. Economic view

11.1 Investment

We aimed to provide a comprehensive overview of the costs associated with implementing the drone in Rohde Nielsen's inspection process. Unfortunately, this task proved unfeasible due to a lack of available data. The absence of information extends not only to the investment estimates in year 0 but also to the variable and fixed costs for subsequent years. Regrettably, Rohde Nielsen was unable to furnish the required data, and our internet research yielded no additional insights. UPTEKO, too, could not offer further details beyond the price of the LARK drone, which stands at 130,000 DKK. Consequently, the absence of this critical information constrains us from presenting concrete data. Instead, we provide an estimation and evaluation to offer perspective on the potential implementation of the drone.

In addition to the cost of the drone itself, the following expenses are anticipated to be necessary in year 0:

- LARK drone: 130,000 DKK
- Payload (camera)
- Sensors
- Software and data storage
- Training and certification (for drone operation)
- Regulatory compliance
- Insurance

Variable costs, such as insurance and maintenance, will continue in subsequent years (i.e., year 1, 2, etc.). While year 0 constitutes the most substantial investment in the drone, the evaluation suggests that the significant cost reduction from year one onwards makes it a more profitable venture for Rohde Nielsen. The estimation and evaluation account for these factors, offering valuable insights despite the absence of precise data on costs and investment over the specified time frame.

11.2 Comparison

Examining the cost comparison between current inspection methods and the incorporation of drone technology reveals a substantial difference. The value proposition canvas earlier clearly indicates that adopting drone technology with an automated and digitized system will lead to cost and time reductions for Rohde Nielsen and suit their needs. Specifically, operational time will be diminished as the drone requires minimal time to fly around and inspect the vessel, in contrast to manual inspections where workers must thoroughly investigate the entire ship, potentially overlooking information or details about damages. Furthermore, studies indicate that incidents frequently occur during manual ship inspections, a risk mitigated by using drones. Tasks such as data analysis and report preparation, integral to traditional inspection processes, consume time. However, when a drone is deployed for inspection, it efficiently collects data and sends information via a PDF file to stakeholders, streamlining the process.

In situations where captains encounter difficulties while docking the vessel, drones can provide a better view and guidance. Despite drones primarily being used for inspections, this is advantageous for Rohde Nielsen, as their modular and versatile nature allows the company to invest in one single drone that can be operational to multiple vessels.
When integrating a drone into the workflow, obtaining a permit to fly it in the area is necessary. While this process can be intricate, it is crucial and mandatory.

Overall, significant disparities exist between traditional inspection methods and the digitized approach using drones. Traditional methods are often less efficient, requiring more time due to extensive manual labor and sometimes resulting in vessel downtime. Time efficiency is paramount, considering that time equates to money. The automated nature of drone inspections eliminates the need for extensive manual paperwork, contributing to cost savings. Drones also overcome the challenges of hazardous areas on vessels, reducing the economic impact of worker illnesses and delays.

In terms of operational costs, the use of drones during inspections is economically advantageous compared to the wages of workers conducting prolonged manual inspections. The precision of drone sensors in capturing vessel details translates to substantial cost savings compared to potential oversights by human inspectors. Despite the need for regulations and permits when using drones, their integration into inspections enhances cost-effectiveness, making them a valuable and efficient tool for Rohde Nielsen.

12. Conclusion

Our analysis in the integration of drone technology within Rohde Nielsen's maritime operations highlights a promising opportunity for transformative change. The proposal centers on leveraging advanced AI-powered drones provided by Upteko to revolutionize vessel inspection, navigation during docking, and overall maintenance workflows.
The new LARK drone with its built-in AI system is a symbol of innovation and effectiveness. Its ability to work with different types of ships, detect damage, and use very detailed sensors shows how it could change how we take care of boats in the sea. Teaming up with Upteko means they'll work together smoothly, from planning to making it happen, to making sure it keeps working well and gets the support it needs.

Our proposal aligns with various Sustainable Development Goals (SDGs), notably Goal 9: Industry, Innovation, and Infrastructure; Goal 13: Climate Action; and Goal 14: Life Below Water. By embracing drone technology, Rohde Nielsen not only enhances operational efficiency but also helps innovation and sustainability in the maritime sector, contributing to environmental care and industry advancement.

The Value Proposition Canvas and Lean Business Model showcase the concrete benefits for Rohde Nielsen. The value proposition highlights the advantages and solutions achieved by integrating drones, focusing on lower operating expenses, enhanced safety, and more efficient workflows. The Lean Business Model focuses on expenses, income sources, and approaches to involvement, confirming the financial sustainability and strategic benefits of our suggestion.

In conclusion, the integration of drone technology within Rohde Nielsen's operations presents a transformative pathway towards efficiency, safety, and sustainability in the maritime industry. Embracing this technological evolution positions Rohde Nielsen to lead the sector into a new era of streamlined operations, cost reduction, and fortified safety protocols.

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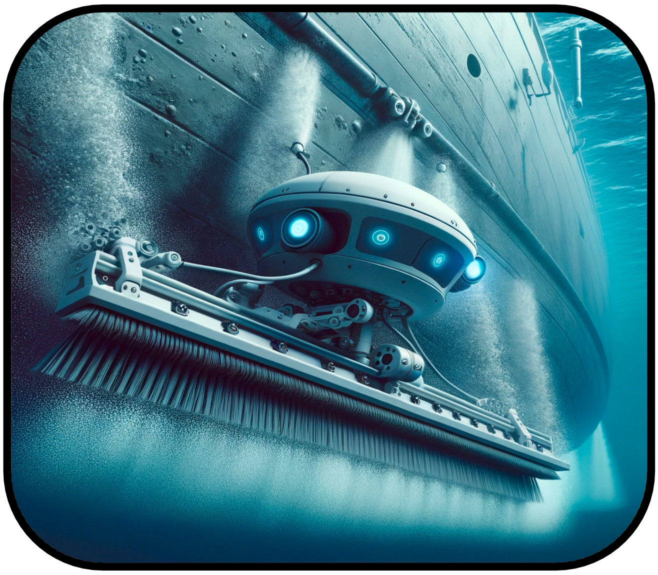
14. Appendix

1. Silicone-Based Coatings solution: (ChatGPT, DALL-E generated)

2. Robots-solution: (ChatGPT, DALL-E generated)



3. Drone-solution: (ChatGPT, DALL-E generated)

4. Sketch of drone