

# Exploring the Opportunities of Generative Artificial Intelligence in Concept Ship Design

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## ABSTRACT

*Designing vessels is a complex process requiring the consideration of numerous aspects to develop a successful design. Ship and submarine design often requires the designer to approximate, make assumptions, consider scenarios and imagine how the vessel may be used in operation. Having the ability to consult for feedback or request additional information may be a welcome aid.*

*The onset of Generative AI (GENAI) presents a new opportunity to integrate this resource into the workflows of the concept ship design process. Augmenting the design process could have a positive impact on the outcome of the design, further improving various qualities such as performance, sustainability, equality, diversity and inclusion. Aspects associated with weight groups, payload catalogues, technical analysis and layout set out will be explored to investigate whether GENAI could add value to the design process. A case study will be used to facilitate this investigation, taking note of GENAI's content throughout the process.*

## KEY WORDS

Generative Artificial Intelligence, concept ship design, text to text, text to image, Chat GPT, Gemini, Dal E

## BACKGROUND

### Generative Artificial Intelligence (GENAI)

Generative AI (GENAI) refers to a class of artificial intelligence systems that can generate new content, such as images, text, video, voice, or even music, often indistinguishable from content generated by humans. These systems are based on generative models, which are trained on large datasets to learn patterns and relationships within the data. GENAI has made significant strides in recent years, leading to advancements in creative content generation, data augmentation, and problem-solving across various domains (Fui-Hoon Nah et al., 2023).

In contrast to internet search engines, GENAI is designed to create novel content by learning patterns from datasets. It generates completely new and possibly realistic images, text, or other forms of media as opposed to finding existing media like in traditional search. Jason Allen famously won an art competition in 2022 by submitting a digital art piece to the Colorado State Fair's annual art competition, won an award, and only then did the submitters announce that it was created using GENAI (Kevin Roose, 2022).

Search engines such as Google, are focused on retrieving and presenting existing content from the web in response to user queries. They index and rank pre-existing information rather than generating new content, making their functionality distinct from that of GENAI. From a practical perspective, AI query data sources and generate answers based on the prompt, whilst with search engines, the user is expected to manually go through the results, assess applicability and apply the results.

The models produce these outputs based on a prompt or a series of prompts. This is a specific input or instruction given to the model to generate output. The prompt serves as a guide for the model to produce content based on the provided input, and if it's a follow-up prompt, previous prompts, and answers will be taken into consideration as context. The format and content of the prompt depend on the type of generative AI model and the desired output. Different types of models exist, mostly

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specialising in one format such as text to text or text to image. The specificity and clarity of the prompt play a crucial role in influencing the quality and relevance of the generated content however it is important to note that the same prompt will not necessarily generate the same exact results.

A new field of specialisation is emerging that is not limited to computer engineering called “prompt engineering”. The term prompt engineering can refer to the process of crafting effective prompts or inputs for generative AI models, to receive optimal outputs (MsKinsey&Company, 2023). Prompt engineering involves understanding the capabilities and limitations of the model and designing prompts that elicit the desired responses or outputs. Individuals may specialize in prompt engineering as part of their broader roles in machine learning engineering, data science, or AI research, however we speculate that in the near future most jobs aided by AI will require a basic understanding of prompt engineering.

Generative AI has applications in various fields, including:

1. **Image Generation:** Creating images that may resemble photographs, sketches, drawings, etc.
2. **Text Generation:** Writing coherent and contextually relevant text, which has applications in natural language processing, content creation and technical writing.
3. **Code Generation:** Writing computer code in a specified language to fulfill a design brief.
4. **Video Generation:** Creating video, including accompanying audio, based on user input prompts (OpenAI, 2024).

There is a large selection of commercially available GENAI tools available. Chat Generative Pre-Trained Transformer (ChatGPT) by OpenAI has arguably brought GENAI to the public limelight. The current GENAI tools are built on fields of research that pre-exist the current technology. Fields such as Machine Learning, genetic algorithms, sentiment analysis, data mining, etc. have been around for years. However, it was only fairly recently that the interest in GENAI has boomed. Competition is heating up with Google quickly attempting to catch-up by hastily launching Bard, only to rebrand to Gemini within a few months (Ortiz, 2024). It is well-accepted that OpenAI is the leading model with Chat-GPT, a text-text algorithm and Dall-E, a text-image algorithm, and now having demoed Sora, a text-to-video generating algorithm.

### ***Challenges with AI***

When new technologies and processes are introduced to an established industry, new challenges, risks and uncertainties become apparent. GENAI is no different, with several industries becoming increasingly concerned about how this technology can be improperly utilised in applications that may not be suitable for it yet. For example, the education industry is concerned of generative AI’s negative influence on learning (Michel-Villarreal et al., 2023) and the creative industry is aware of the impact it will have as algorithms are improved (Amankwah-Amoah et al., 2024).

While the potential of GENAI is undisputable, there are inherent risks associated with using such a platform. Some of the more noteworthy points for technical industries include:

1. Hallucinations (Alkaissi et al., 2023):
  - AI models, including generative ones, can sometimes produce erroneous or factually incorrect responses, but are presented by the model in a convincing manner. These “hallucinations” occur due to their reliance, and possible limitations, on training data and algorithms used to build the model.
  - Users may encounter misleading or blatantly wrong answers, especially when relying on AI chatbots for information. It is always recommended to check the response, which means the human using GENAI ultimately requires some field-knowledge to be able to check the response.
  - Detecting these biases or inaccuracies can be challenging as AI solutions become increasingly believable, especially to novice or inexperienced users.
2. Cybersecurity Risks (Gupta et al., 2023):
  - GENAI can inadvertently expose sensitive and proprietary enterprise data.
  - Interactions with AI chatbots may inadvertently leak confidential information, posing cybersecurity threats.
  - GENAI could be used by malicious actors (e.g. cyber criminals) to try and circumvent current security protocols or practices (Stanham, 2023)
3. Copyright Issues (Ren et al., 2024):
  - As GENAI is built on existing content to learn and train the model, there are ethical and legal copyright considerations on permission of using this data to generate new content (Appel et al., 2023)
  - As GENAI produces content, questions arise about intellectual property rights and copyright infringement.
  - Ensuring that AI-generated works respect existing copyrights is crucial to avoiding legal disputes.
4. Computational Power (Crawford, 2024):

- GENAI uses large amounts of computational power to train the model, keep it running, and to produce results to prompts. In a world where we are seeking to reduce our power consumption, there is an argument that the increased use of GENAI will increase the need of using more power.

### Industry Specific GENAI platforms

As stated earlier, the performance of an AI model is heavily influenced by the data used to train and develop it. Platforms like Chat-GPT have been trained on a myriad of data, and is able to provide answers about most generic questions. However, if there is a lack of specific information in its training model, it wouldn't be able to provide a specific answer to the prompt. One way of mitigating such risks is to develop and implement customized models for specific industries. These models are tailored to address the unique challenges and requirements of specific industries, domains, or applications, offering specialized capabilities and domain-specific knowledge. Some examples of how different industries can benefit from GENAI are:

1. **Engineering** (Kar et al., 2023)
  - GENAI models can aid in product design, optimization, and simulation across various manufacturing processes, such as additive manufacturing, CNC machining, and supply chain management.
  - Natural language processing models can generate technical documentation, automate parts cataloging, assist in troubleshooting and maintenance tasks as well as support project management tasks.
2. **Architecture**(Liao et al., 2024; van Hooijdonk, 2023)
  - GENAI can be used to streamline design processes, explore innovative solutions, and optimize complex systems and support technical designs.
  - Conduct parametric design, urban planning, spatial analysis and facilitate brainstorming sessions.
  - Natural language processing models can generate technical documentation, automating construction sequences and assist in project management.
3. **Healthcare** (Lan et al., 2023)
  - Generative models trained on medical imaging data can assist in tasks such as image reconstruction, disease detection, and medical image synthesis.
  - Natural language processing models can generate clinical notes, summarize medical records, or assist in medical literature review.
4. **Finance** (Cao, 2022)
  - GENAI can generate synthetic financial data that mimics real-world patterns without compromising privacy or security to help train models. It could also process large volumes of financial data, generate reports, and perform analyses and learn from historical fraud cases and identify suspicious patterns.
  - Natural language processing models can generate financial reports, summarize market trends, and analyze financial news articles

### Ship Design Procedure

Ship design is a complex iterative process used to design vessels needing to fulfill a role. Figure 1 illustrates a summary of the design method, showing the multitude of relationships between the different aspects needed to design a vessel. The aspects illustrated are technical and administrative that vary based on the scenarios being considered (UCL, 2024).

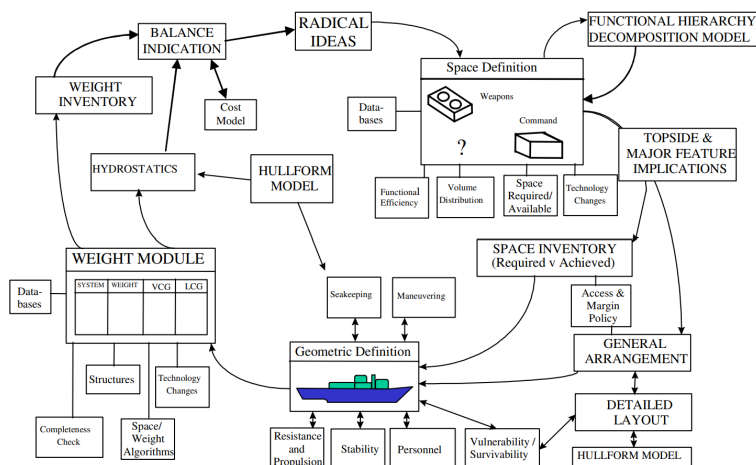


Figure 1 – Illustration of the Design Building Block Methodology applied to Surface Ships (Andrews et al., 2008)

The major milestones in the ship design process are setting the requirements, the initial sizing, conducting a cost capability trade off, payload selection, parametric survey and finally the design refinement (UCL, 2024). Each of these milestones require different skills and resources to complete however they all entail diligent project management to ensure the project is successful. The naval architect must also carry out supplementary analysis to determine what capabilities are essential and where compromises can be incorporated to create a vessel that is able to fulfill its role.

New maritime regulations, conflicting requirements and tight budgets are some of the reasons why ship designers must constantly keep up-to-date with the latest technologies and procedures to identify the best compromise for the design to be successful. As Figure 1 shows, radical ideas may also be required to satisfy some requirements however the consideration and/or implementation of such ideas typically requires the knowledge of a team of naval architects and marine engineers having experiences. While there isn't a standard procedure to follow when considering and implementing radical ideas, typical approaches include brainstorming, research and consultations with third parties who may have had to consider such options for other projects.

## **GENAI and Ship Design**

The ship design process presents a number of opportunities to explore the use of GENAI. While limited literature is available to show examples of how this has been done so far, models such as Chat GPT suggest that they would be able to conduct:

- Conceptual design exploration
- Feasibility analysis
- Performance Optimisation
- Material selection and Sustainability
- Risk assessment and Safety Analysis
- Integration of advanced technologies
- Documentation and Reporting.

No publicly available resource was found saying that GENAI was used in full or in part to design a vessel, but there is no doubt that it is being explored. Although such algorithms have been in existence for some time, their integration in company processes is limited. This new technology is pushing boundaries in a similar way to how the introduction of the internet in 1993 led to radical change to facilitate communication, knowledge transfer, collaboration and much more. In this instance, ship designers were not immediately drawn to this service. However, as technology evolved, the marine industry recognized the potential benefits of integrating the internet into ship design and operations. They now recognize its potential to create smarter, more connected vessels that benefit shipowners, crew, and passengers alike.

Direct evidence to demonstrate how each of these points were determined was not found however Khan S et al (Khan et al., 2023) conducted an analysis showing a Hullform parametric study using a customised genetic algorithm called ShipHullGAN, that was trained using 52,591 validated designs differing in features. The algorithm successfully generated valid designs that were deemed feasible however future work will involve integrating CFD solvers to continue building on the tool's capabilities (Khan et al., 2023).

## **SCOPE OF WORK**

The literature review highlights the need to explore how GENAI, particularly commercially available software, can help facilitate the ship design procedure. Different aspects of the concept design were investigated using commercially available text to text and text to image GENAI tools. The research aims to identify whether some examples of commercially available tools can add value to the ship design process by supporting, conducting or improving it.

## **METHOD**

A range of commercially available text-to-text and text-to image GENAI platforms were queried with questions relating to ship design. In addition to general questions that aim to establish the GENAI's confidence in conducting such analysis, the prompts were used to explore the early concept design aspects of potential designs. The latter was focused on two vessel types, a regular fishing boat for text-to-text and a cruise liner that pushes boundaries of the status quo for text-to-image. A summary of the requirements of each vessel can be found in Table 1.

**Table 1 – Requirements for the 2 vessels being considered in this study**

	<b>Fishing Boat</b>	<b>Cruise Liner</b>
Role	Utilitarian fishing vessel to operate in Indonesian waters to catch tuna	Extravagant Cruise Liner for young families to operate in the Mediterranean Sea having a floating zoo and entertainment.
Primary Tasks	Making new technology accessible to Indonesian communities	Embrace green technology
		Full of activities
Area of Operation	Indonesian Coast	Mediterranean Sea
Duration of Mission	4 days	10 days
Passengers	20	600
Accommodation	basic	luxury
Environmental	Net Zero	Net Zero
In Service Date	2030	2040

Each text-to-text GENAI model was provided with the same initial data associated with the requirement of each respective vessel. The current study was linear in its approach where only one GENAI model was considered at a time. Further studies exploring how responses one model could be linked to another GENAI model for increased utility and analysis.

The GENAI model was then asked a range of questions becoming more specific based on the responses received. The text-to-image models on the other hand were utilized to generate visualisations of the vessel or particular features. The outcomes of each respective query were recorded, and additional refinement was requested when needed.

## RESULTS

A selection of the results recorded in the study will be presented below showing the prompt and response. In those cases where the responses consisted of a series of bullet point outputs, up to 3 list levels are published..

### Text-to-Text

#### *Chat GPT 3.5*

*How does an AI machine such as Chat GPT think it can support the Ship design process?*

As an AI language model, I can indeed provide assistance in the ship design process by offering guidance, generating ideas, and answering questions related to various aspects of ship design. Here's how I can support the ship design, knowledge base, idea generation, problem solving, simulation and modelling, regulatory compliance, collaboration and communication and continuous learning and adaptation

While I cannot replace the expertise and experience of human naval architects, engineers, and designers, I can complement their skills and knowledge by offering valuable insights, information, and support throughout the ship design process. Ultimately, the combination of human creativity, expertise, and AI assistance can lead to innovative and successful ship designs that meet the needs of the maritime industry

*You are a naval architect tasked to design the fishing vessel in Table 1, what are your thoughts?*

Designing a fishing boat for Indonesian waters with a focus on catching tuna and incorporating new technology while ensuring environmental sustainability presents both challenges and opportunities. Here are some initial thoughts:

Size and Stability, Efficient Tuna Fishing Equipment, Accessibility of Technology, Environmental sustainability, accommodation and amenities, Safety features, local regulations, durability and maintenance. By integrating these considerations into the design process, the fishing boat can effectively fulfill its role while contributing to sustainable fishing practices and technology accessibility in Indonesian communities.

*How should this vessel be sized?*

The size of the fishing boat for tuna fishing in Indonesian waters should be determined by several factors including the number of passengers, the duration of the mission, the type of fishing equipment onboard, and the intended area of operation. Here are some considerations for determining the size of the vessel passenger capacity, cargo capacity, deck space, stability and seaworthiness, maneuverability and fuel efficiency. Considering these factors, the fishing boat should be sized to strike a balance between accommodating passengers and crew, providing adequate storage and deck space for fishing operations, ensuring stability and seaworthiness, and optimizing fuel efficiency. The specific size and dimensions will depend on the

detailed requirements of the mission and the preferences of the operators. Working closely with naval architects and marine engineers can help determine the optimal size of the vessel based on these considerations.

#### *How should the calculations be carried out*

Calculating the dimensions and specifications of a fishing boat involves several technical considerations and calculations. Here's an overview of the key aspects to be taken into account: hydrostatics and stability analysis, weight estimation, hull design, propulsion system sizing, structural design, systems engineering, regulatory compliance and cost estimation. These calculations and analyses are typically carried out by naval architects, marine engineers, and other specialized professionals using advanced software tools, mathematical models, and engineering principles. Collaboration between various disciplines is essential to ensure that the vessel meets its performance, safety, environmental, and operational objectives.

#### *What are the big ticket payload items that should be considered?*

In the context of designing a fishing boat, "big ticket payload items" refer to significant components or equipment that directly contribute to the vessel's functionality, operational capabilities, and mission objectives. These items are crucial for the vessel's primary task of catching tuna and ensuring operational efficiency. Here are some of the big ticket payload items that should be considered: fishing gear and equipment, fish storage and holding facilities, navigation and communication systems, safety and survival equipment, fuel and propulsion systems and deck machinery and handling equipment. These big ticket payload items constitute essential components of a fishing boat designed for tuna fishing in Indonesian waters. Each item plays a crucial role in the vessel's operational effectiveness, safety, and ability to fulfill its mission objectives. Integrating these payload items into the vessel's design requires careful consideration of space, weight distribution, operational requirements, and regulatory compliance.

#### *Can you give me a weight estimate in kg for Longline fishing equipment for a vessel like this?*

Estimating the weight of longline fishing equipment for a vessel depends on several factors, including the vessel's size, the fishing method employed, the target species (in this case, tuna), and the operational requirements. While it's challenging to provide an exact weight without specific details, I can offer a rough estimate based on common components and considerations. Here's a breakdown of the typical longline fishing equipment and their approximate weights:

- **Mainline:** The mainline is the primary line that extends from the vessel and supports the branch lines and hooks. Depending on the length and diameter, a mainline can weigh anywhere from 1 kg to 5 kg per 100 meters.
- **Branch Lines:** Branch lines are attached to the mainline and hold the baited hooks. The weight of branch lines varies depending on their length, diameter, and the number of hooks per line. On average, branch lines can weigh between 0.5 kg to 2 kg per 100 meters.
- **Hooks:** Hooks are essential components of the longline setup. The weight of hooks depends on their size, material, and design. On average, a hook can weigh between 20 grams to 100 grams, depending on the type and size of the target species.
- **Buoys and Floats:** Buoys and floats are used to mark the position of the mainline and provide buoyancy. The weight of buoys and floats varies depending on their size and material. A typical buoy or float can weigh between 0.5 kg to 5 kg each.
- **Weights and sinkers:** Weights or sinkers are used to keep the mainline and branch lines submerged at the desired depth. The weight of weights and sinkers depends on their size and material. They can range from 50 grams to 500 grams each.

#### *What propulsion system should be considered for this design?*

Selecting the appropriate propulsion system for a fishing boat designed to operate in Indonesian waters and catch tuna involves considering factors such as efficiency, reliability, maneuverability, environmental impact, and operational requirements. Here are several propulsion options to consider: Diesel propulsions, Hybrid propulsion, outboard motors, pod propulsions, stern drives and waterjet propulsion. The choice of propulsion system should be based on a comprehensive evaluation of the vessel's size, intended use, operating conditions, budget constraints, and environmental considerations. Collaborating with marine engineers, naval architects, and propulsion system manufacturers can help identify the most suitable propulsion solution for the fishing boat design, ensuring optimal performance, efficiency, and sustainability throughout its service life.

#### *Are these options appropriate for Net Zero?*

Achieving a "Net Zero" designation for a fishing boat involves minimizing or offsetting the vessel's greenhouse gas emissions and environmental impact over its operational lifecycle. While some propulsion options inherently produce fewer emissions or can be optimized for reduced environmental impact, others may require additional measures to achieve Net Zero status. Here's how each propulsion option mentioned previously aligns with Net Zero goals and considerations. Diesel propulsion, hybrid propulsion, outboard motor, pod propulsions, stern drives and waterjets

*Should alternative options like wind propulsion or electric drive be considered*

Yes, alternative propulsion options such as wind propulsion and electric drive should definitely be considered, especially in the context of designing a fishing boat with a Net Zero objective. Here's a closer look at these alternative options and their potential benefits:

- Wind propulsion,
  - Wind propulsion systems, such as sails or wind-assist technologies like Flettner rotors or kite sails, harness the power of the wind to supplement or replace traditional propulsion methods
  - Benefits include reduced fuel consumption, lower emissions, and increased energy efficiency, particularly during favorable wind conditions
  - Wind propulsion can be especially effective for vessels engaged in long-range voyages or coastal navigation where wind patterns are favorable
  - Integrating wind propulsion systems requires careful consideration of vessel design, stability, and operational requirements, but they can significantly contribute to reducing the vessel's carbon footprint and achieving Net Zero goals
- Electric drive
  - Electric propulsion systems, powered by batteries or fuel cells, offer a clean and efficient alternative to traditional diesel engines
  - Benefits include zero emissions at the point of use, reduced noise and vibration, and potential cost savings over the vessel's lifecycle
  - Electric drive systems are well-suited for short-range operations, harbor maneuvering, and low-speed cruising, making them ideal for fishing boats operating in coastal waters or protected areas
  - Charging infrastructure, battery capacity, and range limitations are important considerations when integrating electric drive systems, but advancements in battery technology and charging infrastructure are making electric propulsion increasingly viable for marine applications

*How achievable would it be to integrate wind propulsion on this fishing vessel being designed?*

Integrating wind propulsion on a fishing vessel designed for tuna fishing in Indonesian waters can be achievable, but it requires careful consideration of various factors including vessel design, operational requirements, cost-effectiveness, and regulatory compliance. Here are some key points to consider when evaluating the feasibility of wind propulsion integration:

1. Vessel Design and Compatibility
  - The fishing vessel's hull design, size, and stability characteristics must be compatible with the installation of wind propulsion systems such as sails, Flettner rotors, or kite sails.
  - Modifications to the vessel's superstructure and deck layout may be necessary to accommodate the additional equipment and rigging associated with wind propulsion.
2. Operational Profile
  - The vessel's operational profile, including typical routes, wind patterns, and sailing conditions, will influence the effectiveness of wind propulsion systems.
  - Wind propulsion may be more suitable for vessels engaged in coastal navigation or longer voyages where favorable wind conditions are more prevalent.
3. Performance and Efficiency
  - Wind propulsion systems can enhance the vessel's overall performance and fuel efficiency by harnessing wind power to supplement or replace traditional propulsion methods.
  - Computational fluid dynamics (CFD) simulations and performance modeling can help assess the potential impact of wind propulsion on the vessel's speed, maneuverability, and fuel consumption.
4. Costs and Return on Investment (ROI)
  - a. The initial investment and ongoing maintenance costs associated with integrating wind propulsion systems must be carefully evaluated against potential fuel savings and operational benefits.
  - b. Factors such as equipment costs, installation expenses, and crew training should be considered when assessing the economic viability of wind propulsion.
5. Regulatory Considerations
  - Compliance with maritime regulations and classification society standards is essential when integrating wind propulsion systems into the vessel's design.
  - Safety, stability, and seaworthiness requirements must be met to ensure the safe operation of the vessel and its crew.
6. Technology Readiness and Support
  - Availability of reliable and proven wind propulsion technologies, as well as access to technical expertise and support, are critical considerations during the integration process.
  - Collaborating with experienced wind propulsion providers and naval architects can help mitigate risks and ensure successful implementation.

*What design features do Indonesian fishers desire on their vessels?*

Indonesian fishers typically desire fishing vessels that are well-suited to the local maritime environment, meet their operational needs, and enhance their productivity and safety at sea. Here are some design features that are commonly sought after by Indonesian fishers for their vessels: seaworthiness, maneuverability, deck space and layout and storage and seaworthiness, maneuverability, deck space and layout and storage and fish handling facilities, safety equipment and features, comfort and accommodation, fuel

*What budget would an Indonesian fisher have to purchase a vessel like this?*

The budget required for an Indonesian fisher to purchase a fishing vessel can vary widely depending on several factors, including the vessel's size, age, condition, equipment, and specifications. Additionally, market conditions, availability of financing, and regional differences in pricing can also influence the cost of acquiring a fishing vessel in Indonesia. Generally, fishing vessels range in price from tens of thousands to several million dollars, with smaller vessels typically being more affordable than larger ones.

## **Gemini**

*How does an AI machine such as Gemini think it can support the Ship design process?*

My approach to supporting the ship design process differs slightly from other large language models like ChatGPT due to my specific capabilities and the ongoing advancements in the field of GENAI. Here's how I envision contributing:

1. Enhanced Information Access and Deeper Analysis:
  - Similar to other language models, I can access and process vast amounts of ship design data, including regulations, technical specifications, and case studies.
  - However, leveraging my advanced natural language processing (NLP) capabilities, I can go beyond simple information retrieval. I can analyze this data to identify trends, correlations, and potential design implications not readily apparent through basic summaries.
2. Collaborative Design Exploration and Iteration:
  - I can assist with design exploration by generating variations based on your initial specifications, similar to other models.
  - However, my ability to understand and respond to natural language prompts and feedback allows for collaborative design iteration. You can provide feedback on my generated concepts, and I can then refine them based on your input, iteratively leading towards the optimal design solution.
3. Advanced Optimization and Generative Design:
  - Beyond basic calculations, I am capable of utilizing machine learning algorithms to perform more complex optimization tasks. This could involve optimizing hull shapes for fuel efficiency or analyzing various configurations to maximize stability and payload capacity.
  - Additionally, I can leverage generative design techniques to explore entirely new design solutions by learning from existing successful models and identifying innovative layouts and structures.
4. Integration with Design Tools and Automation:
  - My ability to understand and generate code allows for potential integration with existing ship design software. This could involve automating repetitive tasks, extracting data from various sources into the design software, or even generating code to perform specific design calculations.
5. Evolving Capabilities and Adaptation:
  - As the field of generative AI continues to evolve, my capabilities will continue to improve and expand. This includes ongoing advancements in NLP, knowledge representation, and reasoning, allowing me to better understand the intricacies of ship design and provide even more comprehensive support.

Limitations:

Similar to other AI models, I cannot replace the expertise of human ship designers or engineers. My role is to augment their capabilities by providing efficient information access, facilitating design exploration, performing advanced optimization, and potentially supporting automation. Ultimately, the responsibility for creating a safe, functional, and compliant vessel lies with qualified professionals.

In conclusion, while other language models can offer valuable support in the ship design process, I believe my unique capabilities in information analysis, collaborative design exploration, advanced optimization, and potential integration with design tools offer a more comprehensive and evolving approach for the future of AI-assisted ship design.



*You are a naval architect tasked to design the fishing vessel in Table 1, what are your thoughts?*

I think this initial design concept for a tuna fishing vessel in Indonesia has great potential! As a large language model, I can't fully design the vessel myself, but I can offer some key considerations and suggestions based on the information you provided:

Strengths and Objectives:

- **Utilitarian:** Focusing on functionality for tuna fishing is a good starting point.
- **Technology Accessibility:** Integrating new technologies to benefit Indonesian communities aligns with a noble goal.
- **Net Zero:** Aiming for zero emissions is commendable and aligns with future sustainability goals.

Considerations and Suggestions:

- **Vessel Size and Type:** Based on the 4-day mission duration, 20 passengers, and basic accommodation, a medium-sized vessel (around 20 meters) could be suitable. Depending on the chosen technology, explore options like purse seiners, longliners, or even innovative designs like electric or hybrid fishing vessels.
- **New Technologies:** Identify specific technologies that address local needs. This could include:
  - Fuel-efficient engines or alternative fuel sources (e.g., biofuels) for net-zero emissions.
  - Advanced fish detection and tracking systems for sustainable fishing practices.
  - On-board pre-processing facilities to improve catch quality and value.
- **Local Context:**
  - **Regulations:** Ensure the vessel design complies with Indonesian maritime regulations.
  - **Infrastructure:** Consider local infrastructure like available ports and fuel supplies for the chosen technology.
  - **Community Needs:** Engage with local fishing communities to understand their specific needs and challenges to incorporate them into the design.
- **Cost and Feasibility:**
  - Net-zero technology is still under development and might be expensive.
  - Analyze the cost-effectiveness and long-term sustainability of implementing such technology.

Next Steps:

1. Conduct further research on specific technologies and their feasibility in this context.
2. Consult with naval architects, marine engineers, and local stakeholders to refine the design based on technical expertise and community needs.
3. Create detailed plans and cost estimates for building and operating the vessel.

With proper research, design, and collaboration, this project has the potential to be an innovative and impactful contribution to the Indonesian fishing industry.

*How should this vessel be sized?*

Determining the optimal size for your fishing vessel involves several factors, but based on the information provided, here are some considerations to guide you:

Key factors influencing size:

1. **Mission duration (4 days):** This suggests the need for sufficient fuel storage and provisions for the crew, but doesn't necessarily require a massive vessel.
2. **Number of passengers (20):** This translates to basic accommodation needs. Bunk beds and shared spaces can be employed efficiently on smaller vessels.
3. **Catch target (tuna):** Tuna fishing techniques like longlining or purse seining require varying degrees of space for equipment and catch handling.
4. **Net-zero goal:** Depending on the chosen technology (e.g., batteries for electric propulsion), you might need space for additional equipment, potentially impacting size.

Considering these factors:

- A medium-sized vessel (around 20 meters) could be a good starting point. This size offers a balance between accommodating basic needs, maneuverability, and potentially adhering to net-zero goals with advancements in technology.
- However, it's important not to solely rely on estimations.

Next steps for determining size:

1. **Refine your understanding of the chosen technology:** Different net-zero technologies like electric or biofuel engines might have varying space requirements.
2. **Consult with a naval architect:** They can provide expertise in calculating the necessary space for crew, equipment, fuel, and catch based on specific chosen technologies and fishing practices.
3. **Consider regulations and local context:** Indonesian maritime regulations might define minimum or maximum size limitations for specific fishing vessel types.

Additional points:

- Smaller vessels generally offer increased maneuverability and might be more fuel-efficient (excluding the potential impact of net-zero technology).
- Larger vessels can offer more space for catch processing, which might be relevant depending on your goals and chosen technology.

Ultimately, the optimal size will be a result of careful consideration of all these factors and collaboration with professionals like naval architects and local stakeholders.

#### *How should the calculations be carried out?*

While I cannot perform the specific calculations myself, I can guide you through the general process of determining the optimal size for your fishing vessel. Here's how it might unfold:

1. Gather detailed information:
  - Specific net-zero technology: Finalize the type of technology you plan to implement (e.g., battery capacity for electric propulsion, biofuel storage tanks). Each technology has specific space requirements.
  - Fishing practices: Determine the exact fishing technique you'll utilize (e.g., longlining, purse seining) as it dictates the space needed for equipment and catch handling.
  - Regulations: Research any size limitations or regulations set by Indonesian maritime authorities for your chosen fishing vessel type and technology.
2. Consult a naval architect:
 

With the gathered information, collaborate with a professional naval architect. They can perform the following:

  - Space estimation: Based on your chosen technology, fishing practices, crew size, and basic accommodation needs, the architect can estimate the required space for various onboard elements.
  - Weight and stability calculations: They can perform crucial calculations to ensure the vessel maintains proper stability and buoyancy while accommodating the planned weight of passengers, equipment, fuel, and catch.
  - Regulations compliance: The architect can verify if the proposed size adheres to Indonesian maritime regulations for the chosen vessel type and technology.

3. Software tools for visualization and optimization:

Naval architects often utilize specialized software to:

- Create 3D models: These models help visualize the vessel layout, ensuring efficient use of space and optimal placement of equipment.
- Perform simulations: Software can simulate the vessel's performance with different sizes and equipment configurations, providing valuable insights into fuel efficiency, stability, and maneuverability.

4. Iteration and refinement:

The initial size estimate from the architect might not be the final solution. Based on the calculations, simulations, and potential regulatory limitations, you might need to:

- Adjust the chosen technology: If space constraints arise due to the initial net-zero technology choice, explore alternative options that might offer a smaller footprint.
- Optimize the layout: The architect can work with you to refine the internal layout to maximize space utilization and ensure efficient workflow.
- Remember, this is a collaborative process. By providing detailed information, working closely with a naval architect, and utilizing specialized software, you can arrive at the optimal size for your fishing vessel, ensuring it meets your operational needs, adheres to regulations, and adheres to your net-zero goal.

#### *What are the big ticket payload items that should be considered?*

For your utilitarian tuna fishing vessel aiming for net-zero operation, several "big ticket" payload items need careful consideration:

1. Net-Zero Propulsion System:
  - This is likely the most significant investment and will depend on the chosen technology:
    - Electric: High-capacity batteries will be needed for extended operation. Their size and weight significantly impact available space and overall vessel size.
    - Biofuels: Requires storage tanks for the chosen biofuel, with capacity considerations based on mission duration and fuel efficiency of the engine.
    - Hybrid: Combines elements of both, requiring space for both traditional fuel tanks and the chosen net-zero technology (e.g., batteries).
2. Fishing Gear:
  - The specific equipment varies based on the chosen fishing technique:
    - Longlining: Requires longlines, reels, hooks, and bait storage.
    - Purse seining: Needs purse seines, winches, and potentially fish sorting and processing equipment.
3. Catch Handling and Processing (Optional):

- Depending on your goals, you might consider:
  - Refrigeration units: To preserve catch quality, especially for longer missions.
  - Processing equipment: If you plan to pre-process the catch onboard for increased value.
- 4. Navigation and Communication Equipment:
  - Essential for safety and efficient operation:
    - GPS and navigation systems: For accurate positioning and course plotting.
    - Communication equipment: Radios and satellite communication devices for emergency situations and staying connected.
- 5. Safety Equipment:

Mandatory and crucial for crew safety:

- Life rafts and life jackets: For emergency situations.
- Firefighting equipment: To address potential onboard fires.
- First-aid kits: To provide basic medical care for crew members.

Additional Considerations:

- Spare parts: Carrying essential spare parts for critical equipment minimizes downtime and ensures operational continuity.
- Freshwater and provisions: Enough freshwater and food supplies are essential for the crew's well-being during the 4-day mission.

Remember, the final selection and cost of these big-ticket items will depend on the chosen net-zero technology, fishing technique, and specific functionalities you prioritize. Carefully analyzing your needs and conducting thorough research on each item is crucial for making informed decisions within budgetary constraints.

*Can you give me a weight estimate in kg for Longline fishing equipment for a vessel like this?*

Providing a precise weight estimate for longline fishing equipment for a vessel intended for your project is challenging due to several factors:

- Specificity of equipment: The weight can vary significantly depending on the specific longline configuration chosen. Factors like:
  - Mainline length: Longer mainlines require more weight.
  - Number of hooks: More hooks contribute to increased weight.
  - Hook size and material: Larger and heavier-duty hooks weigh more.
  - Buoy type and number: The type and quantity of buoys used to mark the mainline can impact weight.
- Fishing vessel size: While your project outlines a medium-sized vessel (around 20 meters), slight size variations can still influence the amount of equipment typically carried.
- However, to provide a rough estimate, a vessel of this size engaged in longline fishing in Indonesia might typically carry longline equipment weighing between 1,000 and 3,000 kg. This includes:
  - Mainline: 5,000 to 10,000 meters, typically made of synthetic materials like nylon or Dyneema, weighing around 0.2-0.3 kg per 100 meters.
  - Hooks: 1,000 to 3,000 depending on the target species and spacing, with individual hook weights varying based on size and material (typically 50-200 grams each).
  - Swivels and clips: Used to connect the mainline to leaders and hooks, contributing a relatively small overall weight.
  - Buoys: Several dozen buoys might be used, with varying weights depending on size and material (typically 1-5 kg each).

Important Note:

This is just a general estimate, and the actual weight of your longline equipment will depend on the specific choices you make regarding the factors mentioned above. It's crucial to consult with experienced longline fishermen and fishing gear suppliers in Indonesia to get a more accurate estimate based on your specific needs and local practices.

*What propulsion system should be considered for this design?*

Choosing the most suitable propulsion system for your net-zero fishing vessel in Indonesia involves careful consideration of several factors:

1. Net-Zero Goal:
  - Electric:
    - Pros: Zero emissions, quiet operation, potential for efficiency improvements.
    - Cons: High initial cost of batteries, limited range based on current battery technology, requires access to charging infrastructure.

- Biofuels:
    - Pros: Reduced emissions compared to traditional fuels, potentially aligns with local sustainability initiatives if using regionally produced biofuels.
    - Cons: Emissions still present, engine modifications might be needed, availability and cost of suitable biofuels in Indonesia need evaluation.
  - Hybrid:
    - Pros: Combines the benefits of electric and traditional fuel sources, offering extended range and flexibility.
    - Cons: Increased complexity, potentially higher maintenance costs.
2. Operational Needs:
- Mission duration (4 days): This suggests needing sufficient range or the ability to recharge/refuel efficiently.
  - Area of operation (Indonesian Coast): Accessibility of charging infrastructure (for electric) or biofuel availability needs evaluation.
3. Local Context:
- Regulations: Indonesian regulations on net-zero technologies and emissions might influence your choice.
  - Infrastructure: Availability of charging stations (electric) or biofuel suppliers is crucial for operational feasibility.

Considering these factors:

- Hybrid systems might be a good initial option. They offer the flexibility of using a combination of electric and traditional fuels, providing extended range while reducing emissions compared to solely relying on traditional fuels. This might be suitable until battery technology and charging infrastructure in Indonesia advance significantly.
- Biofuels could be a future alternative. If sustainable and cost-effective biofuel production and distribution become established in Indonesia, biofuels could become a viable option for achieving net-zero goals.

Additional Considerations:

- Emerging technologies: Explore advancements in hydrogen fuel cells or other promising net-zero options, keeping in mind their current feasibility and long-term potential.
- Consult with experts: Collaborate with naval architects, marine engineers, and local stakeholders to understand the best fit for your project based on technical expertise and the evolving landscape of net-zero technologies in Indonesia.

Remember, there is no single "perfect" solution at this stage. Carefully evaluating the factors mentioned above and staying updated on technological advancements will guide you towards choosing the most suitable and sustainable propulsion system for your innovative fishing vessel.

*Are these options appropriate for Net Zero?*

The appropriateness of the proposed propulsion systems (electric, biofuels, and hybrid) for achieving net-zero emissions for your fishing vessel project depends on a nuanced understanding of the concept of "net-zero" and the specific context of your project:

Understanding Net-Zero:

- Net-zero emissions: This doesn't necessarily mean zero emissions during operation. It signifies that any emitted greenhouse gasses are balanced by removing equivalent amounts from the atmosphere elsewhere in the lifecycle of the vessel and its operation.

Evaluating the Options:

- Electric:
  - Pros: During operation, electric propulsion produces zero emissions directly.
  - Cons: Emissions are potentially generated during electricity generation if the source isn't renewable. Additionally, battery production and disposal might have environmental impacts.
- Biofuels:
  - Pros: Some biofuels, like sustainably produced biodiesels or advanced biofuels, can offer significant emissions reduction compared to traditional fossil fuels.
  - Cons: Even "cleaner" biofuels still generate emissions during operation. Additionally, sustainability concerns exist regarding potential land-use change and potential indirect emissions associated with biofuel production.
- Hybrid:
  - Net-zero potential: Hybrid systems can be considered partially net-zero if they combine electric propulsion with renewable energy sources (e.g., solar panels for battery charging) and biofuels with extremely low lifecycle emissions.

Contextual Considerations:

- Indonesian energy mix: If Indonesia's electricity grid relies heavily on fossil fuels, electric propulsion might not be truly net-zero due to indirect emissions during electricity generation.

- Biofuel sustainability: If the chosen biofuel isn't demonstrably sustainable, it might not contribute meaningfully to net-zero goals.

Therefore:

- None of the options might be fully "net-zero" in the strictest sense, considering the current limitations and potential upstream emissions. However, they represent steps towards achieving net-zero by reducing direct emissions compared to traditional fossil fuels.

Recommendations:

Focus on maximizing the use of renewable energy sources whenever possible, regardless of the chosen propulsion system.

This could involve:

- Onboard solar panels for partially charging batteries in an electric or hybrid system.
- Investing in renewable energy sources for charging infrastructure if opting for electric propulsion.
- Prioritize biofuels with demonstrably low lifecycle emissions if biofuels are considered.
- Continuously monitor and refine your approach as technology advances and the understanding of "net-zero" becomes more comprehensive.

Ultimately, achieving true net-zero requires a holistic approach that extends beyond the vessel itself, encompassing the entire lifecycle, energy sources, and potential environmental impacts of all involved elements.

*Should alternative options like wind propulsion or electric drive be considered?*

- While your initial options (electric, biofuels, and hybrid) offer promising paths towards reduced emissions, including alternative options like wind propulsion and electric drives in your evaluation is definitely worthwhile. Here's a breakdown of their potential:

Wind Propulsion:

- Pros:
  - Harnessing natural wind power can significantly reduce reliance on fossil fuels and associated emissions.
  - Simple and low-maintenance technology compared to some other options.
  - Environmentally friendly and aligns with net-zero goals.
- Cons:
  - Highly dependent on wind conditions, making them unreliable for consistent operation and requiring a backup propulsion system like a diesel engine.
  - Limited effectiveness in calm winds and might not be suitable for all fishing activities.
  - Potentially lower maneuverability compared to traditional engines.
- Electric Drive (assuming you meant electric motors powered by on-board batteries or other renewable sources):
- Pros:
  - Zero emissions during operation if the electricity source is renewable (e.g., solar panels on board).
  - Quiet operation compared to traditional engines, potentially reducing underwater noise pollution.
  - High potential for efficiency improvements as battery technology advances.
- Cons:
  - Limited range due to current battery limitations, potentially requiring frequent recharging.
  - High initial cost of batteries and charging infrastructure.
  - Weight and space constraints associated with batteries might require careful design considerations.

Considering your project's specific context:

- Indonesian Coast: While wind patterns might be favorable in some regions, relying solely on wind propulsion might not be feasible due to potential calm periods.
- Mission duration (4 days): Current battery technology might limit the range of an electric drive system for a 4-day mission without recharging options.

Therefore:

- Wind propulsion can be considered as a supplementary option. In conjunction with another propulsion system (e.g., hybrid with a diesel engine), it could be used in favorable wind conditions to reduce fuel consumption and emissions.
- Electric drive has potential but requires further investigation. Evaluating advancements in battery technology, potential for onboard solar charging, and exploring hybrid configurations with a smaller battery pack for limited electric operation are recommended.

Additionally:

- Emerging technologies like hydrogen fuel cells might offer future possibilities for net-zero operation, but their current stage of development needs to be factored in.
- Seek expert advice from naval architects, marine engineers, and wind propulsion specialists to understand the feasibility and practical applications of these alternative options in your specific context.

- By exploring various options and conducting thorough research, you can choose the most suitable and sustainable propulsion system for your innovative fishing vessel, contributing to advancements in net-zero fishing practices in Indonesia.

*How achievable would it be to integrate wind propulsion on this fishing vessel being designed?*

Integrating wind propulsion into your fishing vessel design has potential but comes with challenges and considerations for achieving practical and operational success. Here's an assessment of its feasibility:

Feasibility factors:

- **Technical feasibility:** Integrating wind propulsion systems onto vessels is technically possible. Different configurations exist, such as rigid sails, soft kites, or Flettner rotors.
- **Partial emissions reduction:** Wind power can significantly reduce reliance on fossil fuels and associated emissions when conditions are favorable.

Challenges and limitations:

- **Dependence on wind:** Wind is unreliable and unpredictable. Calm periods or unfavorable wind directions would require a backup propulsion system like a diesel engine, negating some environmental benefits during those times.
- **Limited effectiveness:** Wind propulsion is less effective in calm conditions and might not be suitable for all fishing activities requiring precise maneuvering or maintaining specific speeds.
- **Maneuverability concerns:** Depending on the chosen wind propulsion system, vessel maneuverability might be impacted, potentially affecting fishing operations and safety.
- **Design considerations:** Integrating wind propulsion requires careful design integration with the existing vessel structure and other equipment, potentially impacting layout and functionality.
- **Safety and operational training:** Crew members need training on operating and maintaining the wind propulsion system and adapting fishing practices to variable wind conditions.

Considering your project's specific context:

- **Indonesian Coast:** While wind patterns are generally favorable in some regions, relying solely on wind propulsion might not be feasible due to potential calm periods.
- **Mission duration (4 days):** A backup propulsion system is highly recommended for completing the mission in case of unfavorable wind conditions.

Therefore, integrating wind propulsion on this vessel is achievable but with limitations. Here are some recommendations:

- **Treat wind propulsion as a supplementary system.** Combine it with another, more reliable propulsion system (e.g., hybrid) to provide flexibility and ensure operational continuity when wind is insufficient.
- **Carefully evaluate the chosen wind propulsion system's impact on maneuverability** and ensure it aligns with the intended fishing practices.
- **Consult with naval architects and wind propulsion specialists** to design the system effectively and integrate it seamlessly into the vessel's design.
- **Remember, achieving true net-zero requires a multifaceted approach.** While wind propulsion offers potential, it's crucial to consider its limitations and combine it with other sustainable solutions for a comprehensive and practical net-zero fishing vessel design.

*What design features do Indonesian fishers desire on their vessels?*

Understanding the specific needs and desires of Indonesian fishers is crucial for designing a truly useful and sustainable fishing vessel. While specific preferences might vary based on factors like location, fishing techniques, and target species, here are some general design features often desired by Indonesian fishers:

Efficiency and Functionality:

- **Fuel efficiency:** Reducing fuel costs is a significant concern, so features like efficient hull design, optimized engine selection, and potential for alternative fuels (e.g., biofuels) are often desired.
- **Ease of operation:** Simple and intuitive controls, user-friendly layouts, and minimal maintenance requirements are valued, especially for smaller-scale or less experienced operators.
- **Durability and reliability:** Vessels operating in potentially harsh marine environments need robust construction materials and reliable equipment to minimize downtime and ensure safety.

Safety and Comfort:

- **Safety features:** Adequate life-saving equipment, proper navigation and communication systems, and adherence to safety regulations are essential for ensuring crew well-being at sea.
- **Basic comfort:** While space might be limited on smaller vessels, providing comfortable sleeping quarters, designated cooking areas, and basic sanitation facilities is crucial for longer missions.

Storage and Processing:

- Adequate storage space: Sufficient space for fishing gear, catch, provisions, and other equipment is essential for efficient operation.
- Basic processing capabilities: Depending on the target catch and market demands, on-board processing facilities like sorting, icing, or refrigeration might be desired to improve catch quality and value.

Additional Considerations:

- Cultural and religious considerations: Incorporating design elements that respect the cultural and religious beliefs of Indonesian fishers can foster a sense of ownership and comfort onboard.
- Environmental sustainability: While the project aims for net-zero emissions, features that minimize waste generation, promote fuel efficiency, and encourage responsible fishing practices are generally appreciated by environmentally conscious fishers.

It's crucial to emphasize that these are general considerations. To gain a deeper understanding of the specific needs and preferences of Indonesian fishers in your target region and fishing practices, it's highly recommended to:

- Conduct interviews and focus groups with local fishers and fishing communities.
- Engage with local boat builders and maritime experts familiar with the regional context.
- Research existing literature and studies on the needs and challenges faced by Indonesian fishers.

By involving the intended users in the design process and understanding their specific needs, you can create a fishing vessel that is not only technologically innovative and environmentally friendly but also practically useful and well-received by the Indonesian fishing community.

*What budget would an Indonesian fisher have to purchase a vessel like this?*

Unfortunately, it's impossible to provide a definitive budget for a vessel like the one you're conceptualizing without more specific details. Several factors significantly influence the cost:

- Net-zero technology: The chosen net-zero propulsion system (electric, biofuels, hybrid) has a substantial impact on the overall cost. Currently, electric propulsion systems with sufficiently powerful batteries are still expensive, while the cost of biofuels and their infrastructure can vary significantly.
- Final design and size: The finalized size and complexity of the vessel design directly impact the cost of construction materials, equipment, and labor.
- Local market and regulations: Costs of materials, labor, and permits can vary depending on the specific location in Indonesia where the vessel is built.

However, considering the features and target functionalities mentioned, here's a general range to provide context:

- A medium-sized (around 20 meters) fishing vessel with basic accommodation, designed for longlining in Indonesian waters, and utilizing traditional fuel sources might cost between US\$200,000 and US\$500,000.
- Integrating net-zero technologies like electric propulsion or biofuels can significantly increase the cost, potentially doubling or tripling the base price depending on the chosen technology and its current market state.

It's important to remember:

- This is just a rough estimate based on general market trends and might not accurately reflect the actual cost.
- Obtaining accurate pricing requires consulting professional naval architects and shipbuilding companies in Indonesia. They can provide cost estimates based on your specific design, chosen technologies, and local market factors.

Additionally:

- Consider exploring available government subsidies or financing options for sustainable fishing vessels in Indonesia. Some initiatives might offer financial support to encourage the adoption of net-zero technologies in the fishing industry.
- Collaborate with local communities: Partnering with fishing communities and organizations might offer opportunities for collective investment or innovative financing models to make these types of vessels more accessible to Indonesian fishers.

Remember, the primary goal is to design a sustainable and affordable solution for Indonesian fishers. By carefully considering their needs, exploring cost-effective options, and seeking potential financial support mechanisms, your project can contribute to a positive transformation in the Indonesian fishing industry.

## **Text to Image**

A sample of the images created using the requirements for the cruise liner will be presented below.

### ***Microsoft Copilot with Dal-E (OpenAI tech)***

Microsoft Copilot generates 4 images for each prompt submitted. The GENAI's initial response to the requirements set can be seen in Figure 2 to Figure 5.





**Figure 2 – AI Generated cruiser liner 1**



**Figure 3 - AI Generated cruiser liner 2**



**Figure 4 - AI Generated cruiser liner 3**



**Figure 5 - AI Generated cruiser liner 4**

Additional prompts were then implemented to coerce the GENAI model to add different features. Similarly, four images per updated prompt were generated however only the best outcome each of the updates is being reproduced here in Figure 6 to Figure 9.



**Figure 6 – Add wind propulsion**

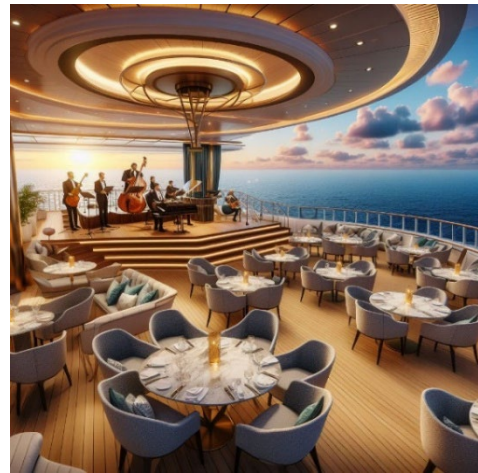


**Figure 7 – Add Flettner Rotors**





**Figure 8- Add solar panels**



**Figure 9 – Interior shot of dining lounge**

Additional results recorded from this explorative study can be found in Figure 10 and Figure 11.



**Figure 10 - AI Generated energy efficient Cruise liner 1**



**Figure 11 – AI Generated energy efficient Cruise liner 2**

### *Deep AI*

The fantasy Deep AI model was prompted to create images of cruise liners meeting the design requirements. A sample of the results can be seen in Figure 12 and Figure 13.



**Figure 12 – AI generated fantasy cruiseliner**



**Figure 13 - Interior of fantasy cruise liner**

## DISCUSSION

The results presented showcase the outcomes of the investigative study into using text to text and text to image GENAI models for concept ship design. A total of four models were used independently from each other utilizing similar prompts depending on the type of GENAI model throughout the process. The study yielded some interesting results that will be expanded upon to ultimately determine whether ship designers should consider using such tools and who stands to benefit the most from them.

When using either of the text to text GENAI models, plausible results were recorded that would be suitable to consider at an early stage of the design. When reflecting on whether the responses were elevating the ship design process or returning elementary aspects that should already be known by the designer, it was concluded that this is highly dependent on the experience of the designer and on the past portfolio of the studio. This means that design studios that have designed a particular vessel type for many years stand to gain far less than those exploring new business and design opportunities in the particular sector.

Naturally, when one lacks experience, there is a greater chance of acting on incorrect, incomplete or false knowledge. While the same argument could be put forward when utilizing open source non peer reviewed material, the GENAI algorithms are able to frame responses in a convincing and well framed manner. To counter this risk, studios should consider carrying out a risk assessment on the utilization of such algorithms for each respective project and confining the scope of the GENAI exploration. Such an approach would enable safer use of while acknowledging the embedded risk is the design process.

Both text to text GENAI algorithms recognized their limitations and suggested contacting naval architects and marine engineers despite having told the algorithm that they are that capacity. This outcome is reassuring as it sobers the user to acknowledge the uncertainty in response and provides them with good direction with what to do next.

This study also showed the importance of generating prompts well to try and tap in to useful information that be included in the design process. Users must be aware of the language used to generate responses and make use of action words to empower the algorithm to divulge data that would be otherwise time consuming to determine. As with any numerical or analytical model, verification and validation should be conducted to try and quantify the error and uncertainty in the predicted results. Since ship design is a heavily iterative process, it is commonly known that the initial parameters considered for a design don't need to have high accuracy or confidence as they are sure to change as the design evolves. The GENAI models can add value by accelerating this process and empowering the designer to continue advancing. A GENAI register should be created to complement the assumptions register to help trace and troubleshoot any parameters formally established by a GENAI machine.

The responses from the current study didn't suggest or recommend novel technologies despite having set the algorithm design requirements to do that. When emphasizing this and even suggesting some possible options such as wind or electrical propulsion, the algorithm didn't dispute them but it is clear that they weren't the first option of choice for it to recommend. A potential reason for this is that the data used to form these models is heavily biased by technologies that claim to be reach net zero but isn't able to verify that using technical knowhow. In light of this, it is unlikely for the algorithm to produce something new in way of technology.

The legal aspects of acting on the advice of such models that could later be traced to misinformation generated by GENAI are interesting and valid to be aware of. The maritime industry is heavily regulated and already has rigorous regulations, procedures and protocols to safeguard all parties, irrespective of how the vessel was designed. Prescriptive regulations may limit the use of such models but goal based regulations are already heavily scrutinized, irrespective of whether the proposals were generated by AI. It would be interesting to investigate whether GENAI models could be used to assist in scrutinizing designs or narratives before they are submitted for assessment. Similarly, regulating bodies could consider developing dedicated models to aid them in processing requests. Such an approach would leave more resources to instances or cases in the regulating body that require more attention.

An interesting outcome of this study was becoming aware of the potential information overload produced by the GENAI models. The study presented in this paper took longer than expected due to the volume of information and data returned by the models. Although this was not initially expected, design studios should be conscious of this and introduce measures to limit the breadth of direction and time sunk into a project through AI. The barrier to access knowledge and data is so minimal that it encourages further prompting in areas that may not necessarily add value to the project.

The results from the study conducted with text to image GENAI models produced a range of images that were refined with further prompts through the same GENAI algorithms. The ship design process rarely uses images to facilitate design but they can be helpful to start conversations and get ideas of layout and payload integration on similar vessels.

The images created by the GENAI models have minimal value from a technical perspective but do present the opportunity of visualizing radical ideas. Although none of the images are suitable for construction, they could be useful to demonstrate to clients requiring bespoke aesthetic statement features on a particular vessel. Figure 12 is a good example of this where despite the vessel not being practical to construct in that format does have a visual appeal that may be appropriate for the target end user it was trying to attract. The fantasy elements of the vessels produced did offer the opportunity to have some interesting discussions with no effort needed to create them in the first place. In particular, the visualization of a zoo on a cruise ship could be seen as a useful output to the client requesting it to understand the extent the zoo would dominate the vessel. This could have been used to help facilitate a conversation with the client to reel back the design requirement to something more manageable or determine a constructive way of how the radical idea may be implemented.

Similar to text-text models, text to image models also generated incorrect responses that are not even physically possible to create. Interestingly, Gemini took more of an initiative with the design process. In some instances, the output was unquestionable, even to a non-technical person such as in Figure 10. Other AI generated images with irregular proposals may not necessarily be as clear to non-technical people such as Figure 11 where water jets were fitted to the proposed cruise liner.

Nonetheless, there is no doubt that these GENAI models are powerful and increasingly becoming more capable. Should a dedicated GENAI tool be developed specifically for ship design that is coupled with physics models to introduce technical rigor, it is fair to assume that more sensible outputs would be created. Although not available yet, new GENAI models that would do text to CAD or IMAGE to CAD would enable quicker transitions between formats. Software such as Autodesk Fusion already makes use of generative design as part of its offering where products being designed are modified according to different constraints and criteria. Similar approaches can be found in literature for different hull form analysis models but they require substantial training and expertise to use.

## **CONCLUSIONS**

The study undertaken successfully explored the utilisation of text to text and text to image GENAI models for concept ship design. Two differing case studies were considered to explore the type of content that the GENAI models could generate to determine whether they would be an added asset to the ship design process.

GenAI is very easy to engage with, breaking the barrier between thoughts and actions. The experience is similar to talking with a colleague when asking questions. This differs to search engines what require selecting key words for the speech. The models are also able to remember the previous responses and use this to understand the context of the questions and influence the next prompts.

The results and analysis recorded suggest that overall, GENAI would help the ship design process but should only be used in an assistive role. Until the design studio is confident with how to use it and gain confidence in the results, greater care should be implemented to minimise risk of acting on invalid recommendations. It is evident that not having the relevant technical background and understanding in both ship design and AI could result in poor decision making.

The GENAI models used for this study were trained and modelled against an existing catalogue of items that are not topic specific. A ship design studio could build their own version of an AI tool by inputting appropriate research papers, past designs and relevant content that could be a useful source of information to influence future designs. Such models could be tailored for initial sizing, parametric modelling or other ship design milestones.

Based on the study conducted, GENAI models can be a useful addition to the ship design process but their use should be limited to an assistive role. The text-text GENAI models were able to produce more useful results than the text-image models however the benefits of being able to cycle through new images to facilitate brainstorming did not go unnoticed. The models utilized were unable to propose new ideas, methods or technologies for the ship design process. Coupling such models with a physics model or numerical analysis may yield more complex but plausible results. Other possibilities to explore include the linking of different GENAI models to determine whether there exists a benefit of having them work together.

A genuine opportunity exists to develop tailored GENAI models for the ship design process. Future work should explore this option further and work closer with ship designers to record their feedback when using this technology.

## **DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN WRITING**

Statement: During the preparation of this work the author(s) used [CHAT GPT 3.5, Microsoft CoPilot, Dal E and Deep AI] in order to conduct the research and support the report writing process. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

## CONTRIBUTION STATEMENT

**Author 1:** Conceptualization; data curation, methodology; writing – original draft.

**Author 2:** Conceptualization; supervision; writing – review and editing.

**Author 3:** Conceptualization; – review and editing.

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