Proceedings of 15th International Marine Design Conference (IMDC-2024)
June 2-6, 2024
Amsterdam, the Netherlands

Early Marine Systems' Design – Cracking the wicked problem - The case of a novel biomass harvesting vessel.

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ABSTRACT

Several IMDC contributions have argued for a better approach to capture stakeholders' expectations in vessel newbuilding projects' execution. The appropriate processes of requirements elucidation are, however, often forgotten or insufficiently handled in traditional ship design and customer-designer settings. Such situations most often reveal a situation in which both "tamed" and "wicked" problems are addressed and must be dealt with properly and effectively at the earliest stage of the process. This paper shows how such problems can be addressed by using the existing multidisciplinary methodology. A practical approach consisting of a set of methods, tools, and work processes integrated into the Accelerated Business Development (ABD) approach is applied to a specific use case, a next-generation factory stern trawler development.

A detailed step-by-step story of the early vessel design process – requirements elucidation in parallel with concept design solution development – is outlined following a narrative approach. The process being described covers how necessary support information, stakeholders' expectations identification, business-related analyses, specific design layout, onboard comfort, and fish process handling and storage are dealt with effectively and efficiently. This case study exemplifies specific solutions to better handle particularly wicked problem situations, but also tamed problems are addressed systemically.

The paper concludes by showing how a final ship design solution can look like and consequently be prepared for and to be built. The handover process and documentation from requirements capture and concept design solution development to further basic design activities are highlighted. The case vessel at hand won the prestigious "ship-of-the-year" award in Norway in 2023. The paper critically discusses what are likely to be the most important factors leading to this outcome.

KEY WORDS
Ship Concept Design; Vessels Design Solutions; Stakeholder Requirement Elucidation; Accelerated Business Development; Novel Stern Trawler Design

INTRODUCTION

Loopholes still exist in early ship design processes…

Over the years, several previous IMDC papers (Ebrahimi et al., 2018; Ulstein & Brett, 2009, 2012, 2015) have discussed the topic of how to improve the customer-ship designer requirements elucidation process and project realization dialogue. Improved understanding of the issue, methodology, theory, and practical approaches have been developed, introduced, and partly applied in what we can call piloting initiatives, but few discuss their full-scale application. Many of the useful

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Submitted: 15 February 2024, Revised: 16 April 2024, Accepted: 1 May 2024, Published: 20 May 2024

Conference paper, DOI: https://doi.org/10.59490/imdc.2024.850 e-ISSN: 3050-4864

contributions still treat this early phase of ship design very superficially and new methods to improve the situation have proven to be very "toyish" in the sense that they are mere conceptual ideas, initial and very generic and generalized examples of applications, at best, providing relative indication values because of simplistic analyses or simulations with "dummy" variables applied. Some of them are, however, well documented in open sources and available for experience capture and repeat studies, but their real-life applications are scarce (Curry et al., 2017; Garcia et al., 2019; Pettersen et al., 2018; Rehn et al., 2016).

Introducing a novel work process in a conservative business environment represented by the mainstream naval architecture and marine engineering fraternity can be a long and bumpy road to pave. Thus, it should be of no surprise to anybody that progress in the refinement of the current naval architecture and marine engineering discipline, is a gradual and step-by-step process, much influenced by different cultural and regional practices, and specific shipping sector and industry segment preferences. Frequently, it has been indicated that a proper customer–ship designer interaction process is partly neglected, or simply missing altogether (Ulstein & Brett, 2009, 2012, 2015). It is argued by some, that this discrepancy is due because such interaction is being considered too complex or too intrusive to effectively capture the vital and critical information elements of a new building project. Consequently, the outcome of such vital processes, so far, has proven to be meagre, and the following concept and basic design work correspondingly uncertain, risky, and costly. Despite these pledges to the ship design community to pay more attention to this early part of the ship design process, recent industry experiences have not shown significant improvements, according to the authors' observations. There are exceptions though. One of these exceptions is the story being told in this article – explaining in more detail and chronological order how novel systemic-based requirement elucidation and new building project information solicitation can be carried out successfully. The reason for addressing this topic one more time is the belief that practical applications of novel approaches in ship design, like the accelerated business development approach of Ulstein, might bring more understanding to the benefits of approaching tame and wicked problem-solving holistically and as early as possible in the concept vessel design process. The paper shows what is going on in practice, who are the actors, what is the program, what are the interphases and interrelations in the process, what are critical inputs, control functions, resources, transformations, outputs and finally, outcomes of the communication and information sharing efforts. How can this comprehensive and collaborative setup enhance and progress future early concept ship design, and thus the quality of the basic design and detailed engineering downstream initiatives, finally leading to better ships are elaborated upon in this article and specific results documented and discussed.

Furthermore, this article shares reflections on commercial, operational, and technical aspects relating to early conceptual ship design and the requirement elucidation process between the customer and the ship designer. It contrasts how theory and practice can go "hand in hand" with significant real-life process achievements as a result. When following a new building project initiative over a longer period and trying to describe in more detail what is happening along the way, it is hopefully obvious to the reader that such a longitudinal study (Huber & Van de Ven, 1995) presented in a 20-page article cannot go into all details about the events and happenings. The authors of the article have, therefore, taken the liberty to condense the actual process that took place in the early phase of the project, trying to focus on what turned out to be the most important events, discussions and under way conclusions, and leaving out minor details.

This article addresses the challenge of the naval architecture and marine engineering community about the fact that, although many authors and scholars on the subject promise early-stage ship design improvements, most of them end up starting their storytelling with the "pre-defined" box of design requirements. That is, presumably all relevant and critical requirements have already been identified and documented, ready for the designer to work on, without any further checks and balances. This can be seen as a quick way to avoid or escape wicked problem aspects. Nevertheless, the authors of this paper experience that not going through these early extra rounds of clarifications has in some cases led to catastrophic or at least substantial project development failures. We try to show how such ineffective ship design processes can be avoided and original expectations be met.

This story begins - customer inquiry…

The telephone is ringing: "Hello, Brett speaking." – "…Mr. Brett, I have been asking around already, talking to three ship designers and they have not been interested in exploring my ideas about a novel next-generation factory stern trawler. They want to sell me their existing designs, which are the best on the market, they say and are not interested in spending time and money on exploring our new ideas. - That's not what we want, I told them, Mr. Brett. My customers want a novel vessel solution that can secure high-quality catch and make sure the fish products are being presented at the counter of the fish mongers on the Continent, such that I can achieve extra profits compared to the other trawler fishermen out there. Honestly speaking, I don't think they understand our ideas and expectations in the first place, but we have some ideas worked out already based on our best knowledge and experience from many years of trawling. … Are you guys willing to help us explore these ideas and develop a new vessel concept that can meet our overall expectations?" – "…Yes, we are. When can we get together and start the development process? We think we have the right apparatus, skills, and experience to assist you... You are more than welcome to see us quickly."

Project milestones – how did it go…

Seven years later, the novel factory stern trawler is just about to be launched and put into service. After six months of structured, facilitated, and continual documentation of business concept development, market, and business performance yield evaluations, onboard studies, idea exploration workshops, functional modelling and simulation, and vessel concept development, the stakeholders' expectations and requirements' elucidation were considered fully captured and a feasibility study concluded. Hence, a vessel concept design documentation package could be delivered to the naval architects and marine engineers to start their basic design process and later a detailed engineering process.

One more year was spent developing the basic design of the vessel together with the exploration of the novel fish catching and handling system at the stern, combined with the new fish processing factory solutions. Another year was used to engineer the whole vessel system in detail and be ready for contracting and construction at the yard. Yet another year was, however, consumed to identify, negotiate, and placing the new building order at agreed upon price, finalise financing, and secure the right suppliers for the extensive equipment systems development and delivery.

This article concentrates on the very early phases of a marine systems design process and particularly outlines how well-documented facilitation techniques can be used to master tamed and wicked problems, which almost always are present in various ways in vessel new building projects to be carried out. The rest is history and not part of this article's story. Figure 1 shows the macro activity of the use case study indicating the timing and resources consumption of the key events of the process.

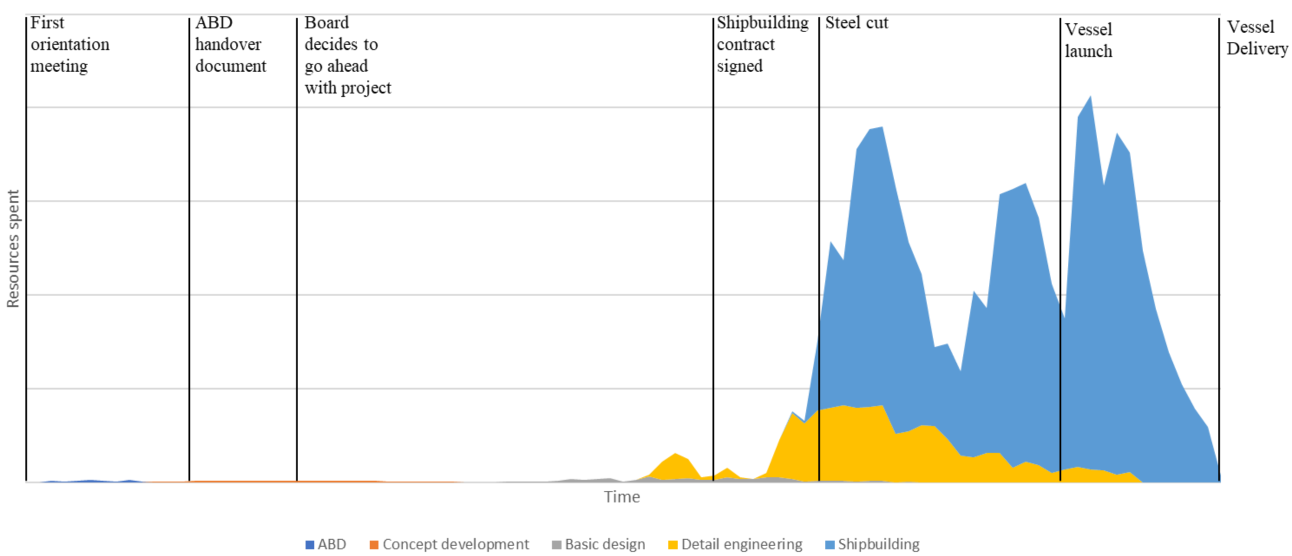


Figure 1: Key events in the project development and equivalent resource consumption.

The "tame" and "wicked" problems – how do we go about them…

Solving "tame" problems in early marine systems design is typically handled traditionally by addressing the problem at hand with one part of the problem that can be isolated and fixed by simply eliminating the problem, treating or mitigating the problem, transferring the problem (to a collaborating partner or insuring the latent risk involved), and or finally tolerating that the problem exists, but might not after all mean a lot of risk to the project realization process (Head, 2022). Typically, the process starts with a given, not necessarily verified requirement list and specific input as to the gross size of the vessel, its functionality, and special features desires. Relevant and preferred suppliers are identified and listed for later contact and project dealings. Then a traditional "circular" or iterative basic design approach in line with the design spiral (Garcia, 2020; Ebrahimi, 2021) is carried out producing one or more comparative vessel design solutions, within a set of pre-defined target specifications. A final decision about the preferable design solution is taken and the project is ready for launch.

Typically, our traditional and well-proven approaches to naval architecture and marine engineering's role are proven to be efficient in solving such linear and analogue problems. Many articles over the years have confirmed this observation (Andrews, 2018).

"Wicked" problems, however, represent issues that are different - emergent and systemic - and thus require changes in multiple systems or development logic constituting the problem at hand. Systemic, in the sense that you can't fix them by fixing the parts, you can only try to change the system of systems to dissolve them (Rittel & Webber, 1973; Head, 2022). You must change your approach from fixing parts to trying to re-organize the system(s) functionally, utility, capacities and space allocation, technologically – new equipment and their integration, commercially – a new business setting and performance yield offering, and or operationally – for example, higher operability, because no amount of increasing or improving the parts makes an integrated whole, which results in the emergence of new levels of improvement. It is only by improving the organization of the parts or sub-systems that you can increase and grow the integrity of the whole ship as a system and get the emergence of the system's overall performance, i.e. regeneration of the vessel solution as an integrated system.

One way to effectively map and handle the wicked problem situation is, therefore, to begin with a process of discovery or elucidation (Adi & Stoeckle, 2022). Begin with the current, observable facts and ask "why" – going backwards in time to create a chain of causality – causal maps exploration – what is related to what and how. Remember, each cause also has an effect in such circumstances. The next step is to predict what will happen going forward in time and ask, "what if" and "what next". By asking what next and if and continuing the chain of events, we can get sets of ongoing future consequences – causal maps of the situation at hand including, but not limited to the already known domino effect of our present decisions and actions (Sarkar & Kotler, 2018).

"Are these challenges one problem or several problems to handle, and is it at all possible to expect a rational and elucidated handling of the nature of such a wicked problem situation?" (Andrews, 2003). Andrews continues: "Identifying what is the nature of the problem is the main problem, and that attempting to do so without recourse to potential material solutions verges on making a difficult operation impossible". The wicked problem is, therefore, much more than identifying all the expectations, requirements, and needs of the ship owner and or close by stakeholders – it is truly about identifying what is the nature of the greater problem, what is the main problem. The nature of the greater problem is an all-encompassing feature including the life-cycle aspects of the vessel concept design solution, and we are, therefore, of the opinion that also such features as the market situation, the economic situation in general and the involved firms' condition – desires, qualities, capacities, capabilities, experience, and robustness, play a significant part in the overall nature and dynamics of the "wicked problem" identification and description challenge.

It is still a limiting consideration and an interpretation of the original "wicked problem" concept (Rittel & Webber, 1973), which prevails in the ship design world among naval architects and the like (Brett, Carneiro, et al., 2006; Ulstein & Brett, 2009, 2012, 2015). This is demonstrated by the repeated rationalization of the solution space: Setting strict and limiting boundaries to the solution space, taking for granted that the functional expectations and requirement description of the customer are properly documented, and validated, and that the parametric set of ship dimensions are well balanced and verified, thereby, partly avoiding the complexity and uncertainty aspects of the new building project at hand. It is also seldom understood and practised that the solution space will change over time because of good and bad times (Epoch-Era) and other unforeseen events (Gaspar et al., 2012; Keane et al., 2015) influencing the life cycle performance of the vessel designed. Thus, future projects require an identification and mapping of the likely life cycle use of the vessel design solution and its utility functionality. Only in a few use cases known to the authors, have the overall medium to long-term market situation, commercial use, and corresponding built-in utility functions of the vessel design solution been explicitly handled as a decisive factor defining the final life-long solution space. More recently, the decarbonization of the shipping fleet has emerged as yet another extremely difficult problem to solve and entails a life cycle dilemma for the actors involved in the project development discussions and decision-making.

The paper is structured as follows: First, the premisses for the article are outlined - is it possible to handle tamed and wicked problems after all, arising in concept ship design contexts and if so, by which method(s) and approach(es)? Second, the story of a real design project is told. We conclude and discuss why the applied process is a preferable way of performing ship design solution work in the future.

One approach doesn't fit all situations…

Yet, it is the opinion and experience of the authors that effective early-stage ship design process approaches must be aligned with the nature of the customer inquiry to the naval architect and marine engineer, and tuned to the specific context or business situation the inquiry is generated from.

The StO, CtO, and EtO terms are archetype design and production approaches being described in complementary design literature (Semini et.al, 2014). Their interpretations are StO or MtS – Standardize to Order or Make to Stock, CtO or AtO – Customize to Order or Assemble to Order, and finally, EtO – Engineer to Order, with StO being the most downstream position and EtO the most upstream position in the ship design value chain. The basic idea behind these terms is to understand the characteristics and attributes of the final ship products being produced and offered. These terms are used in te next paragraphs to categorized and describe different customer-designer (C-D) relationships.

The more specialized the product, the more flexibility is needed, and the more the customer or the relevant stakeholders must be involved in the development process. The more standard the ship design solution, the more downstream and little involvement of the customer is necessary, yet existing and in-depth market and product knowledge and expertise is very high – you get what we offer you. Typically, the downstream-oriented processes lead to shorter lead times, higher delivery reliability, and lower costs; in contrast, the upstream-oriented approaches allow a higher degree of customization, increased reliance on customer participation and continual decision-making, longer lead time, higher costs – the solution is developed as you go.

Over the years, the authors have experienced many different customer-designer relationships and types of inquiries, which probably can be categorized into five different archetypes (Lageman, et.al, 2024):

- C-Ds1: "I want this particular vessel; can you design it for me?" – triggers normally an EtO vessel design solution process…
- C-Ds2: "Do you have a solution that can do..." – this triggers normally a CtO vessel design solution process…
- C-Ds3: "Can you help us respond to this tender" – this triggers normally a StO vessel design solution process…
- C-Ds4: "I have a promising idea about a new vessel design we would like to order; can you develop it for us" – triggers normally an EtO vessel design solution process… and finally,
- C-Ds5: "We have an interesting business proposition to offer you – do you want to be part of the project-making initiative" – triggers normally an StO (CtO) vessel design solution process…

These five C-D archetypes of inquiries, typically, require or dictate a different dialogue with the customer and the follow-up process of the project initiated by the inquiry. Since the dialogue and the follow-up process of the project are different, we are of the opinion that also the overall approach of the dealings of the projects must follow different approaches concerning – what information to identify, collect, collate, and store, who are the most important stakeholders involved and what decision-making processes will most likely take place or should take place, how far is the customer willing to stretch when it comes to costs and price, what are the premises for the project realization, involved presumptions and assumptions – the project boundaries for defining the ship design solution space. Unconventional situations require alternative responses. Hence, the naval architect and marine engineer must develop sufficiently flexible and adaptive behaviours to master such a variety of customer-designer settings. Fast adoption of new work processes and use of novel design tools, including generative artificial intelligence, become a must. So is also real-time handling of big data and statistics – multi-variate regression analysis (MVRA), analytical hierarchical process (AHP), neural network (NN) techniques, and the like.

The use case to follow aims to show how such flexibility, adaptability, and adaptation capabilities are used to make successful early concept ship design projects come to fruition.

But some approaches for improvement are better than others…

Knowledge about the project requirements and or expectations is normally spread over many actors being involved in realizing the ship design initiative. The actors in such processes are ship owners, operators, charterers, brokers, investors, designers, consultants, ship equipment suppliers, classification societies, flag states, and other more peripheral stakeholders in the value chain. None of these parties has alone or isolated the full picture and specific knowledge on assessing a ship's commercial, operational, and technical performance in a broader business concept realized. Culture, traditions, and specialization over many years among actors in the overall realization value chain are most likely to blame for not bringing these actors closer together and making them more effective in communicating with each other. Historically, separate documents like outlines, contracts and/or building specifications and drawings have constituted the communicational instrument and transactional document among the players in the overall decision-making process. Owners' specifications are typically formulated based mainly on their experience in ship operations. Ships are in operation all the time, but new building projects commonly take place only every 5 to 7 years period with that ship type and capability. Expanding on what is, or has been, the experience of the past is more typical than what it is that we need. Designers, on the other hand, typically optimize a vessel concerning preferred engineering criteria, such as installed engine power, speed, or lane meters, and not infrequently their production facilities. If more specific and complimentary project information is necessary, ad-hoc inquiry sessions are typically held with different information sources both firsthand and secondhand type. More often than is admitted, solutions developed along these lines are presented as best practice and state-of-the-art, without really meeting preferred requirements following a sound set of rationales and scientific reasoning. Too often it is forgotten to ask the wicked problem solver questions – why, what if, and what next? As such, they are not grounded on proper explanatory theory and methodology capturing the total complexity and broader context of a true business idea realization. Quite typically, the business development process, fleet and/or ship design integration and their respective decision-making processes are separate and fragmented with little interaction across the stakeholders' boundaries. Furthermore, existing embedded design processes with yards and ship design firms and logistics performance cannot normally be directly compared against operational performance parameters, which work against the pre-conditions for the achievement of effective design and marine systems' service solutions. Additionally, the nature of ad-hoc solutions is that they must be elaborated under the pressure of time, and therefore these solutions themselves very often contribute to deficient designs and extra costs.

All stakeholders' expectations must be integrated into the overall development and decision-making process. The required elements for effective decision-making are not always quantifiable and many of them are purely qualitative considerations, highly subjected to personal perception and appreciation of things and stories. This paper, again, suggests that an integrated and complementary analysis tools package should exist as part of an overall systemic approach to handle this complexity. This can support more effective decision-making in marine systems and concept ship design developments.

The way forward – the ABD-approach as mitigating methodology…

The ABD approach is both a communicational and a decision-making support methodology to be used among all the actors in the total decision-making process of a marine system realization. Its role is to record and guide the complex information-gathering and decision-making process when a new building project takes place, particularly in the early phases of such project execution. Expectations, requirements, assumptions, presuppositions, limitations, and project boundary restrictions are described and kept readily available for further and later interpretation of the results of the feasibility analyses being carried out, and finally benchmark what is a better vessel design solution (Ulstein & Brett, 2015). Various influences among system variables are identified and measured concerning their interrelationship strength or correlations. Sensitivities are also estimated and studied. The ABD approach is the structure (process guide) within which the various methods, analysis techniques, supporting default values, preliminary design tools and work procedures are found and elaborated upon. Over time, an experienced database is built up to be used as a benchmark, as well as a best practice repository for faster business development-oriented concept ship design solutions (Brett et al., 2018a).

The owner-designer interaction is often complicated by the owner's focus on previous solutions and gradual improvements thereof. Designers, on the other hand, tend to optimize the design towards specific technical Key Performance Indicators (KPIs) and their production facilities. The ABD approach counteracts these discrepancies and inefficiencies and secures holistic management of complex data in the form of analysis metrics, models, maps, film/video, statistics, sensor signals and the like. In short, the ABD approach is a methodology that is developed to structure the process of turning a business idea and vessel design concept into reality, which includes a concept ship design solution or a smaller portfolio of promising solutions, which can easily be turned into a comprehensive detailing of a ship description and specification. Thus, ABD provides a structure to the process of identifying promising ship solutions that fit into the commercial and operational context in which they shall operate.

The ABD approach is organized as a guideline consisting of 9 modules ensuring a comprehensive and structured approach for capturing the commercial, operational, and technical context of the ship design(s). Using the method contributes to reducing uncertainties in marine business development projects. Figure 2 shows the structure of the ABD approach as it is practised today and in this use case study, highlighting in blue the modules described in this paper. A more detailed description about the different modules can be found in previous IMDC papers (Brett et al., 2006 & 2018; Garcia, 2020; Pettersen et al., 2018). In this paper, the practical application of it about a specific concept ship design project is elaborated upon.

The approach advocates that a new or improved marine solution system, where the ship plays a significant role, shall fulfil the needs and expectations of all the involved stakeholders in the best possible way. We have carried out more than 20 such ABD processes over the last 15 years, on our development projects (C-Ds5) and together with customers (C-Ds4). Comprehensive data analytics processes, field studies, statistical regression studies, AIS observations and recordings of vessel types to understand their real-life operational patterns over time have been carried out as typical complementary fact-finding in such ABD approaches. In addition, it has been necessary to expand the ABD toolbox with a Fast Track Concept Design Approach (FTCDA) (Ebrahimi et al., 2018). This simulation tool combines multivariate statistics, network data resources ship design expertise and classic naval architecture and marine engineering methods from all disciplines to accelerate effective decision-making in vessel design. The FTDCA is an integration tool which gathers information elements from the ABD approach and uses these inputs to balance one or more ship design solutions applied in Module 5 of the ABD methodology. These concept design solutions are then benchmarked by a performance yield indexing matrix with relevant existing peer vessel alternatives. Hence, the concept design solution is validated, and vessel features verified such that the overall performance of the vessel can be rectified if inferior or undesirable performance yield is the result. Typically, final vessel design solutions are to be spotted and selected in the vicinity of relevant performance-based Pareto fronts' knuckle points (points of diminishing returns). A more detailed explanation of the FTDCA is to be found in other IMDC papers (Ulstein & Brett, 2012). All this work is done before any principal drawings are carried out for the vessel.

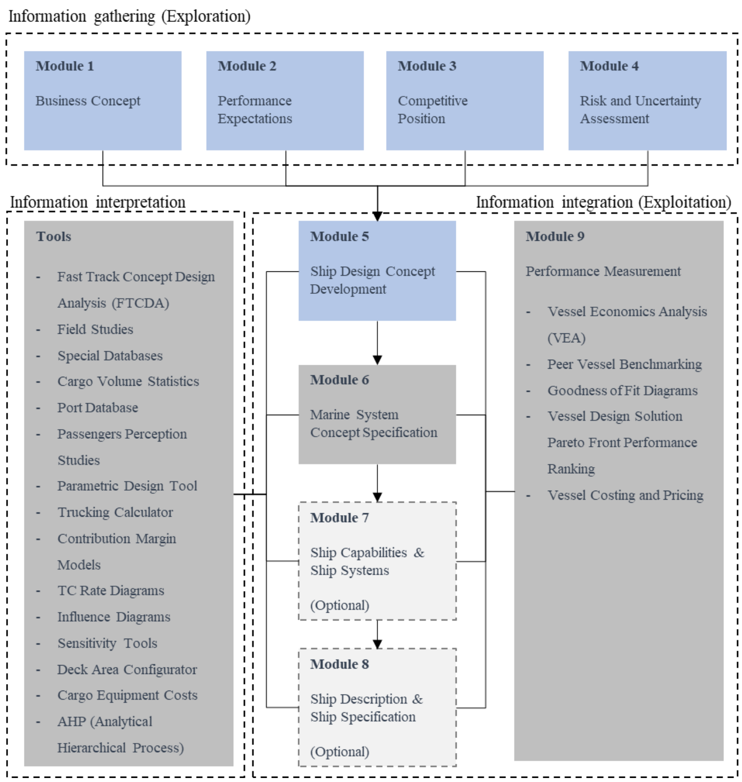


Figure 2: The ABD approach structure of activities.

The implementation of an ABD approach in early design phases has demonstrated three principal advantages: more robust decisions, and higher quality vessel design solutions - due to the availability of additional information at an early stage of the concept design process. Other achievements include a significant reduction in response time and committed resources and the capability of evaluating (visually and analytically) multiple design solutions. In addition, it brings the possibility of performing sensitivity analyses of cost, capacities, and capabilities towards specific design parameters. Complementary use of the FTCDA, ABD and other data-driven analytics tools allows us to validate and verify promising solutions very quickly. This again, has dramatically reduced the response time with customers at the concept design solution stage.

Apply structure and formats with care and pragmatism…

Yet, when an ABD approach is carried out in real life, adaptations and practical adjustments when applying the facilitated methodology are necessary. With more than 15 years of experience in performing such project-customized approaches, it is clear that a few very important principles and practices still apply for the methodology or approach to function the way it is developed. These principles and practices are:

i) Be loyal to the holistic or systemic principles of systems theory and management – the whole is more important than the details of the individual parts…

ii) Be sure you cover the intent of the 1 to 8 modules – a structured approach for information gathering and step-by-step decision-making with as little room for reconsidering previous decisions as possible – a red thread of decision-making logic should be visible as the overall process progresses. Module 9 is only a "toolbox" of different analysis tools and techniques to support the effective decision-making process feeding in and out of the other 1 to 8 Modules.

iii) Always apply the wicked problem solver: the why's-, the what ifs-, and the what-next questionnaire…

iv) Record and document everything that is said and decided…

v) Be sure there is progression in all workshops…even if important challenges must be left behind – you can always go back when your info box or repository is expanded to the extent necessary

vi) Be sure you perform the ABD process in an appropriate setting… - room for everyone to think, read, discuss, and write as well and electronic multi-display facilities are readily available.

vii) Relevant executive management of the customer firm must be present – In addition, support personnel and or specialists could be present.

viii) Educated pragmatism should be applied – when the development process takes a new direction be sure you let go about the structure but not intent, and only to the extent that serves the purpose of arriving at the goal of the project.
ix) Identify critical "white spots" – areas of interest where information is lacking partly or completely and search for improved knowledge in these areas that can have a vital effect on the final decision-making in the project.
x) Develop and expand causal maps of obvious and not-so-obvious causal relationships among project output and outcome-sensitive factors.
xi) All agreed-upon project activities and information sharing must be carried out on a "free will" basis when the direction and intent of development is agreed.
xii) Customers should be willing to share, normally considered proprietary and partly confidential commercial information.
xiii) Agree upon deliverables throughout the ABD process and be sure mutual project performance expectations are adjusted and balanced.
xiv) Make sure you can justify the project partnership and execution from a policy, strategic, expertise, experience, and economic sustainability perspective.

In addition to these principles, several practices have proven to work well and support the ABD approach. It is important that:

1. Sketches of ideas are made along the way.
2. A design protocol is established and kept up to date during the process to document all underway decisions.
3. A consistent presence in workshops of executive decision-makers and their invited specialists.
4. Preparation between workshops and regular exchange of preliminary project material developed.
5. Continual documentation of discussion of options, limitations, and reservations' - flipcharts and operative marker pens are crucial – tape-recording can be used for safeguarding information – and to avoid unnecessary repetition in consecutive workshops.
6. Workshops are held to the convenience of the customer, but preferably not more than two to a maximum of three weeks in between workshops – they can be half a day or a full day session.
7. Arrange as many workshops as found necessary to capture all important information and make customers/stakeholders comfortable about the information robustness and methodological rigour, but not more – once every month over a three to six-month period is feasible, sometimes more often when arriving faster at promising solutions.
8. Typically, it can be useful to discuss and agree upon various exit possibilities along the way of project execution, to be triggered if one of the parties becomes uncomfortable in the process or for other reasons the project has to be brought to a stop.
9. Bring along as much relevant background information and documented experiences as you can think of – electronically or on paper.
10. Identify, make available and test relevant data sources.
11. Look for opportunities to make pre-studies of known or identifiable information about typical issues, problems, and accidents – "learning" events relating to the vessel segment to be studied and critically scrutinized.
12. Investigate opportunities if it is possible to arrange for shorter or longer site field trips onboard similar or related vessels to better reveal facts about the vessel's operation and "life onboard".
13. Behave like a professional process consultant – be sure your attitude and behaviour vis-à-vis the customer are proper and will motivate the customer to continue the process. Provide useful information elements, critically analyse and diagnose the information shared, ensure effective support for ideas development and make the process a comfortable one. Recommend alternative solutions and discuss how they can be realized – a process consultation does not assume that the customer knows what is wrong what the challenges or problems are, what is needed to mend the situation, or what the consultant or customer should do to improve the situation. Let the common diagnosis and suggestions for improvement – the intent, help the project to plan how to achieve the goals of the project initiative and improve the situation (Schein, 1988).
14. Perform as many relevant pre-analyses of the data repository as found useful for the coming study at hand – too much is better than too little.
15. For new market segment entry make an extra effort to study the macro and micro commercial, operational and technical aspects of the segment and behaviours over at least 10 years and preferably 30 years overview can be quite useful.
16. Be sure you make a thorough update of the customers' existing fleet, operations, technical preferences, and commercial performance.

It is also important to adopt and adjust the use of analysis tools and simulations as necessary and useful. Minor to moderate changes also must be made to the process of documentation of process progress. Typically, more formal report formats of the MS-Word-type have been exchanged with the use of MS-PowerPoint as the prime communication tool. The whole process must be carried out with a high degree of pragmatism. In the use case story being presented in the following, these principles and practices are largely followed.

As previously mentioned, the ABD approach is not a universal tool for any ship design requirement capture or elucidation situation. It is particularly valuable, in customer-designer situations C-Ds4 and C-Ds5, described more in detail in paragraph "One approach doesn't fit all situations…" (page 6) of this article. Typically, the first category is generated by a customer project inquiry and not a customer design inquiry (C-Ds1, a broker inquiry (C-Ds2) or a vessel tender inquiry (C-Ds3). These latter three categories from experience do not require the full ABD approach to be handled properly. They can in most cases be carried out with an ABD-light methodology application – by specialised questionnaires and requirements checklists, for example. The C_Ds5 situation, on the other hand, is what in more recent times has been described as project making activity and will almost always require a full ABD process to be performed, documented, and used for the promotion of the initiative of a promising marine system business proposition and its corresponding ship design solution(s).

The use case reviewed and discussed in this article is typically, a C-D4 (EtO) situation. Before starting to elaborate on the C-D4 (EtO) use case, we review the broader ABD-based pre-analysed business environment for the Factory Stern Trawler market segment.

The context and subject – why a factory stern trawler focus and what are we up against…

It is expected that aquaculture and ocean fisheries will have to cover a major portion of the growth in seafood demand in the future, as it is said to have less effects on the reduction of fish stocks, but ocean fisheries are also expected to contribute. Firstly, by improvements in the exploitation of current fish biomass (using fish oil, fish meal and other products), and secondary by exploitation of biomass species (mesopelagic). Both factors could contribute to the growth of biomass food produced from the sea while maintaining the level of capture and reproduction of resources. (Garcia et.al, 2018)

The need for more effective vessels producing higher quality biomass motivates a renovation and renewal of the fleet – a fifth generation of factory trawlers. This new generation should be characterized by fishing efficiency, with a focus on fish product quality and better exploitation of fishing captures, flexibility from the number of products, species and waters or regions, and the best possible quota utilization.

Another factor spurring a fleet renovation is the poor energy efficiency and environmental footprint of the current trawler fleet, as compared to more modern pelagic trawlers or purse seiners (Ziegler et al., 2013). The replacement of environmentally harmless refrigerants, used by many of the vessels in the current fleet, could reduce the carbon footprint of factory trawlers by up to 30% (Ziegler et al., 2013).

History and introduction to factory trawlers – what to be prepared for…

The Food and Agriculture Organization in the United Nations (FAO) identifies 11 types of fishing vessels (Thermes et al., 2023). Of these, there are three that represent most of the fleet and represent the three principal fishing techniques: seiners, trawlers and liners. Figure 3 includes a short description of these three categories represented by the most popular vessel type under them. The type of fish or protein to catch, the area of operations, and the quota assigned are the main drivers in the selection of what vessel type to go for. Hence, seiners are used primarily for pelagic species, while trawlers and liners are used for mesopelagic and demersal species.

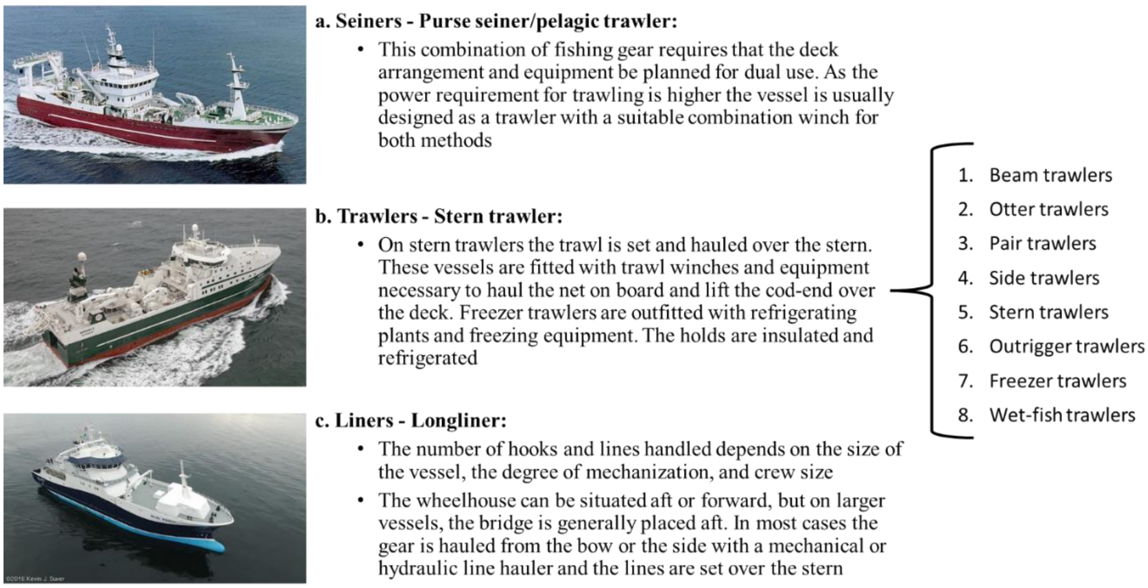


Figure 3: Main categories of fishing vessels and sub-categories of trawlers.

Due to their catching efficiency, stern trawlers are among the most populated vessel types. Ranging from smaller vessels focused on coastal operations and with cargo holding keeping fish on ice, to large units equipped with factories capable of processing the capture and freezing it. This fleet has evolved significantly since the first units were built in the 50's, characterized by the combination of a stern ramp and onboard processing. The vessels built after 2010 are considered the fourth generation of factory stern trawlers. With a focus on fuel efficiency, the vessels of the fourth generation have engines with up to 20% lower specific fuel oil consumption than those of the third generation (Fernandez et al., 2014), representing a major improvement in the vessel's economics and emission footprint. According to (CRISP, 2015), the newer tonnage is 50% more efficient in terms of unit fuel consumption used per kilo captured fish/biomass and resulting in a fishing business which is 5-15% more profitable. The same article highlights some of the improvements from this generation, such as hull shape design and factory processes, including robotized freezers and storage. However, methods for fish handling are still poor and little evolution has taken place over the past 60 years (CRISP, 2015), resulting in more than 15% dead fish before the fish can be processed.

We advocate, therefore, that the design of the next generation of factory stern trawlers, the fifth generation, should focus on fishing efficiency, looking for maximizing revenue and profit through improved quality of the end biomass product by flexibility dictated by the number of products, species, and waters (regions) to be explored and a best possible quota utilization. It requires therefore to integrate technical, operational, and commercial perspectives, and a better collaboration of the different stakeholders in the early stages of the ship design process. It is our proposition, that a shipowner will not invest in a new vessel if he or she cannot see an economic benefit from it. Hence, our approach must ensure that such an intent must be met.

USE CASE STUDY

The use case in this paper is a written description of how the customer-ship designer setting works in real life in a new building project context. It outlines, from the users' point of view, the realization of an ABD approach in developing a concept vessel design solution within a given business concept framework. This use case is represented as a sequence of simplistic steps, beginning with exploring the ABD module one to eight guidance and ending with a proper business concept description and the handover documentation of a fit-to-purpose ship design solution, ready for detailed design and finally a new building project realized at a yard.

Project initiative background…

Inquiry from customer: "Do you want to participate in a joint industry project to develop the next generation factory stern trawler with novel fish catching and process treatment equipment and ship factory arrangement?" - As previously stated, we quickly responded to the customer and accepted their invitation. There were three main reasons for this fast response. Firstly, we had for some time seen that the market demand for larger fishing boats was expanding – so the market potential looked promising, and we needed an additional new ship segment to be consolidated into our existing, but declining product and service portfolio of existing ships. Secondly, we love innovation challenges and could see a fine possibility to grab this chance to develop something novel and groundbreaking and demonstrate our vision – "turning visions into reality". Thirdly, re-vitalize and leverage our strong fishing vessel newbuilding project delivery history, totalling 63 vessels, including trawlers, longliners and purse seiners.

Our project involvement strategy was, however, accepted under one very important premise: The FST concept design solution had to represent something completely new – just making a copy of the most recent FST design solutions of our competitors was not an option. If we should go along with this customer inquiry and offer to run a full ABD process on a no-cure-no-pay basis, we should also retain the rights to the design solution for repeat sales, either on our own or together with the customer. Perhaps we could even use the customer to promote the eventual successful and attractive design.

The customer insisted that we listen carefully to their ideas and expand upon those ideas for the realization of the project. Then, whatever additional ideas we might have to enhance their ideas and conceptual thinking was much welcomed.

Both parties accepted the preliminary terms and mutual project exit possibilities were agreed upon. Consequently, a Memorandum of Understanding, a Cooperation Agreement, and a Concept Design Agreement were agreed upon and signed. When the Basic Design work started an additional Agreement for Front-End Engineering and Design contract was also signed.

The project initiative was started, and 6 consecutive ABD workshops were carried out within half a year, to identify, collect and collate relevant vessel concept design solution project data. Two field study trips were carried out – one visit to an FST in port alongside the quay and one three-day trip offshore at a fishing site to acquaint with the FST operations and test new ideas from people onboard FSTs.

Preparations for the kick-off meeting…

Less than a week after our two telephone discussions, a project kick-off meeting was agreed upon and held at the ABD facility room of the designer. Four executives from the customer and 6 representatives from the designer firm met to clarify the project terms, a presentation of the customer business idea and proposition was given, and a quick review of the ABD approach was performed.

Within the next 4 weeks, a first full-day ABD workshop at the designer premises was arranged to primarily find out: What is the project idea? What is the project background? Who will be the permanent participants (decision-makers)? Who will participate in what, when, and in what way? What relevant skills, expertise, and knowledge are available for problem-solving challenges? What is the project schedule? What could be the project milestone plan forward? How much time can be spent and the time availability of key decision-makers? What is the project funding capability of the project initiative? Who are the relevant and preferred suppliers to work with, when do we introduce them to the project initiative, and who will contact them? What do we know about the project challenge at hand? Where can we find relevant and useful problem-solving background material? How do we involve our people – experts, specialists, and facilitators (consultants)?

Agreed upon information exchange, collection, collation and storage of the various background documents, analyses reports, drawings, miscellaneous illustrations, and other materials were carried out and a common project development Sharepoint site was established.

ABD Module 1, 2, 3, and 4 work – a brief synopsis…

Module 1 sets out to develop a realistic and well-thought-through description of the business concept, a clear statement as to what is the business proposition that the customer wants to pursue. Critically assess the realism and feasibility of the business concept and proposition by answering key questions about the various aspects surrounding the business concept. In Module 2, the objective is to identify all important project stakeholders that are affected and/or involved in the overall project to be realized and assess their individual and collective expectations towards the concept vessel design solution to be developed. Also identifying the competitive position and context of the proposed project business concept is important and is handled by the guidelines of Module 3. Assess what the potential is for the business concept to be successful, given the competition it will face. Identify competitive issues and aspects that will influence the development of the vessel concept design solution. Module 4 assists the ship design process by identifying important aspects that represent a risk for the project to be realized. A risk aspect in this context is any element that poses a threat to the successful development and execution of the vessel concept design solution. Module 5 identifies and assesses different and promising vessel concept design solutions utilizing relevant specialized and proprietary ship design tools listed in Module 9 of the ABD methodology in addition to "standard" naval architecture and marine engineering methods (Papanikolaou, 2019).

Modules 1, 2, 3, and 4 are critical to the follow-up work to be carried out in Modules 5 to 8. In this use case, only project work related to Modules 1 to 5 is presented and reflected in the article discussion. Fragments of the overall approach relating to these 5 modules are primarily depicted to give association to the more detailed work taking place in the real-life set of ABD workshops carried out. Brief comments have been inserted where found necessary and useful to link the various tableaus and make a continuous use case story.

ABD Module 1, 2, 3, and 4 work – results…

Firstly, we had to define the scope of the project. The fishing company had experience, and quotes, for ownership and operation of factory stern trawlers targeting white fish (cod, pollock, haddock) and shrimp. In line with the ABD procedure, the customer presented their original business idea and project intent. Very clearly, they stated and documented, what the direction of the innovation should take: To develop a new factory stern trawler vessel concept different from a traditional stern trawler concept into a new biomass production platform/floating factory to secure a differentiated biomass product from a quality standpoint. Furthermore, to secure full biomass utilization of any catch and increased utilization of more sustainable species' catch including new technology and novel catch processing and handling equipment – restitution tanks for live fish catch, hydrolysis of enchilada, CO_2 freeze, filleting and separation, and a protected shrimp factory. Additionally, the vessel solution should be optimized from an energy consumption standpoint and alternative decarbonized fuel solutions should be considered. Maximum safe operational robustness should also be achieved.

The business proposition for the development of the 5th generation factory stern trawlers extracted from Module 1 was then framed as follows:

"Maximizing revenue and profit through improved quality of the end product by flexibility from nos. of products, species and waters and a best possible quota utilization."

The business proposition relies on three main opportunities identified in the wild fish market segment:

1. 100% resource utilization of the raw material currently being extracted from sustainable Norwegian marine resources.
2. Producing high-quality and differentiated products in the catch line.
3. Increase in the exploitation of sustainable stocks that are lower in the marine food chain (mesopelagic).

That, together with the market situation (rising fish prices, relaxation of fuel prices and political willingness) and the stagnation of the fleet and vessel design developments, had motivated a rising interest in a renewal of the factory stern trawler fleet in the coming years.

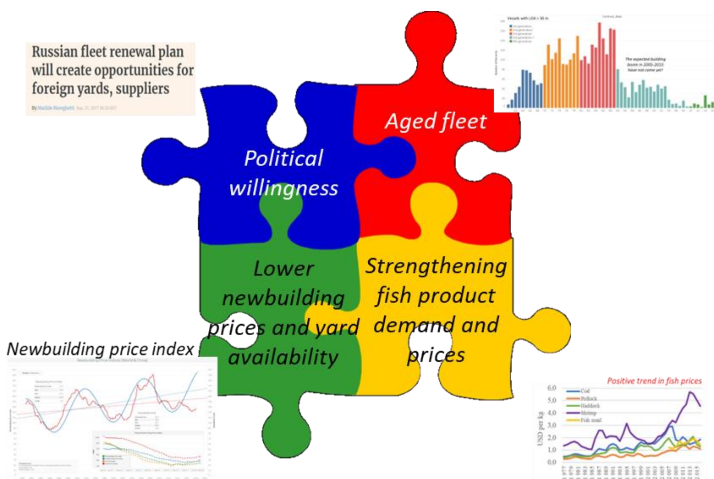
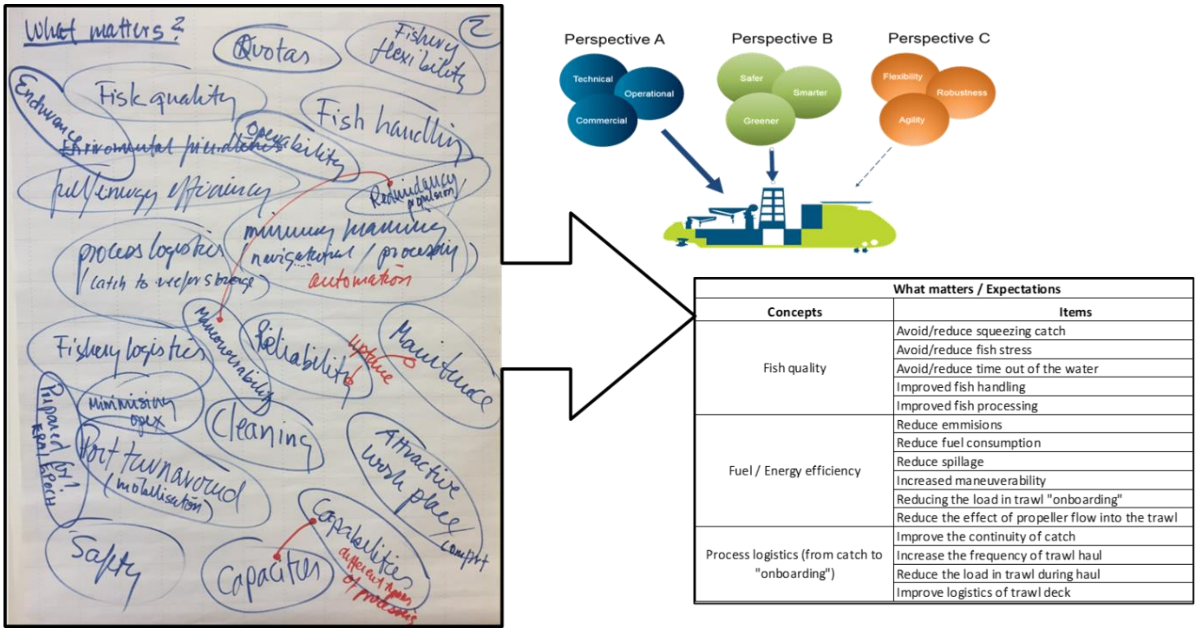


Figure 4. Contextual factors supporting the robustness of the business idea.

The business proposition came hand in hand with a set of expectations for the vessel design. The expectations were captured during the initial ABD workshops. Firstly, with an unstructured brainstorming to capture important expectations from the different stakeholders and actors involved (captain, chief, financial manager, end consumer of fish, etc). The different expectations were thereafter structured and further described by items that could related to the systems, functions, and performance elements of the vessel, as described in Figure 5.



What matters / Expectations	
Concepts	**Items**
Fish quality	Avoid/reduce squeezing catch
	Avoid/reduce fish stress
	Avoid/reduce time out of the water
	Improved fish handling
	Improved fish processing
Fuel / Energy efficiency	Reduce emmisions
	Reduce fuel consumption
	Reduce spillage
	Increased maneuverability
	Reducing the load in trawl "onboarding"
	Reduce the effect of propeller flow into the trawl
Process logistics (from catch to "onboarding")	Improve the continuity of catch
	Increase the frequency of trawl haul
	Reduce the load in trawl during haul
	Improve logistics of trawl deck

Figure 5: Identification of stakeholder expectations for a 5th generation type FST.

Ahead of initiating a design development process, the ABD process involves a familiarization with the existing vessel operations and the context in which they are carried out, including commercial, operational, and technical aspects. Figure 6 exemplifies some of the support documentation extracted for project challenge identification and broadening the elucidation of the project solution space and later important vessel concept design solution development decision-making. Some of the analyses included an analysis of vessel operations and the development of operational profiles, a study of the quota system and expectations on quota developments, and fish price developments. Furthermore, it was clarified what to fish and where to fish. Similarly, analysis work was performed to identify a complex fish quota (Norwegian) arrangement, which was found to have a major impact on the FST vessel design solution. Figure 6 is a collage of the module 5 analyses.

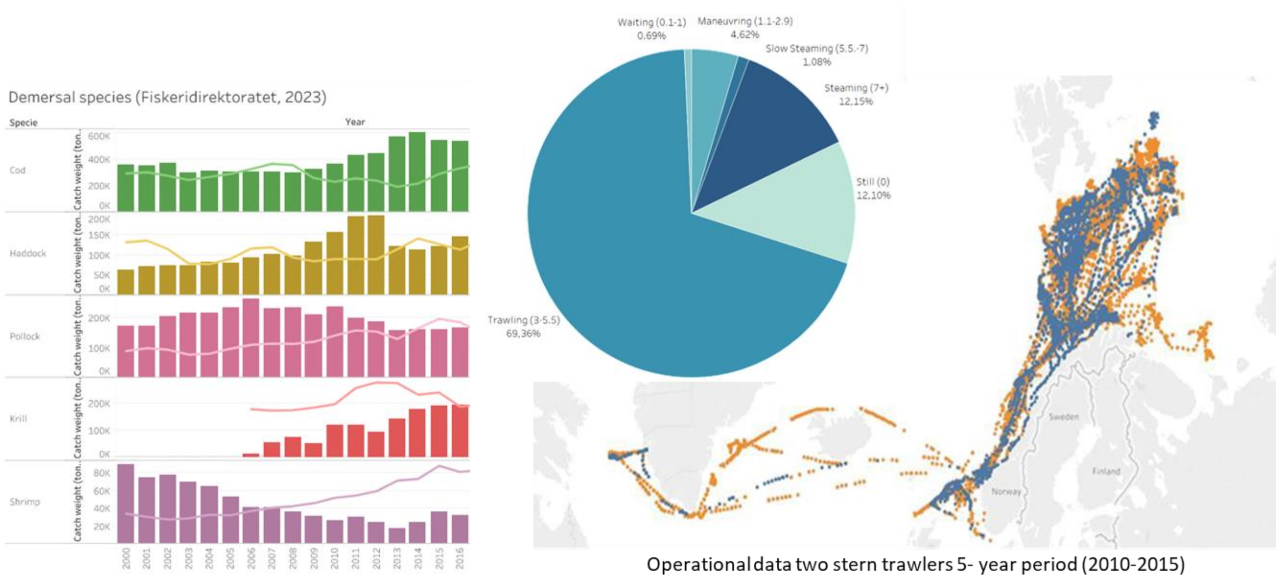


Figure 6: Collage of analyses performed during the ABD process.

The understanding of the market was strengthened by an analysis of the market competition performed as part of Module 3. For this purpose, the project performed a deep analysis of the existing fleet, including analysis of trends on main vessel parameters (length, beam, cargo hold capacity, etc), a clustering of the factory stern trawler fleet (Figure 7), and a review of competing designers and relevant building yards.

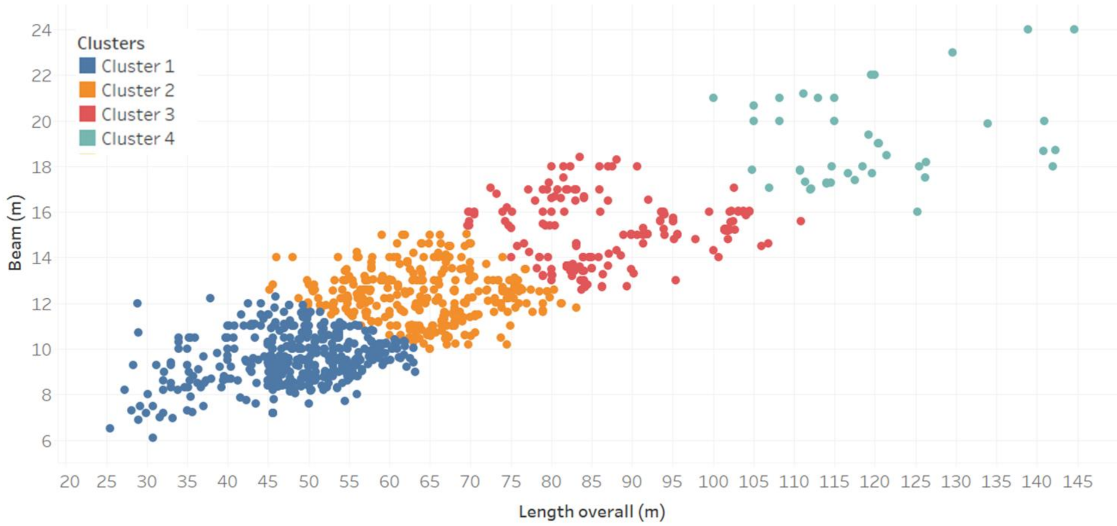


Figure 7: Overview of the stern trawler fleet categorized in clusters by length overall and beam.

A vital aspect of developing such a novel vessel design solution is to map the causal models of revenue and cost drivers and enablers. Figure 8 depicts the two causal maps for revenue-making and cost-driving factors of the FST model. The different factors contributing to revenue generation and vessel expenses are categorized by the degree to which the project can influence them – high (green), medium (orange), and low (red) influence.

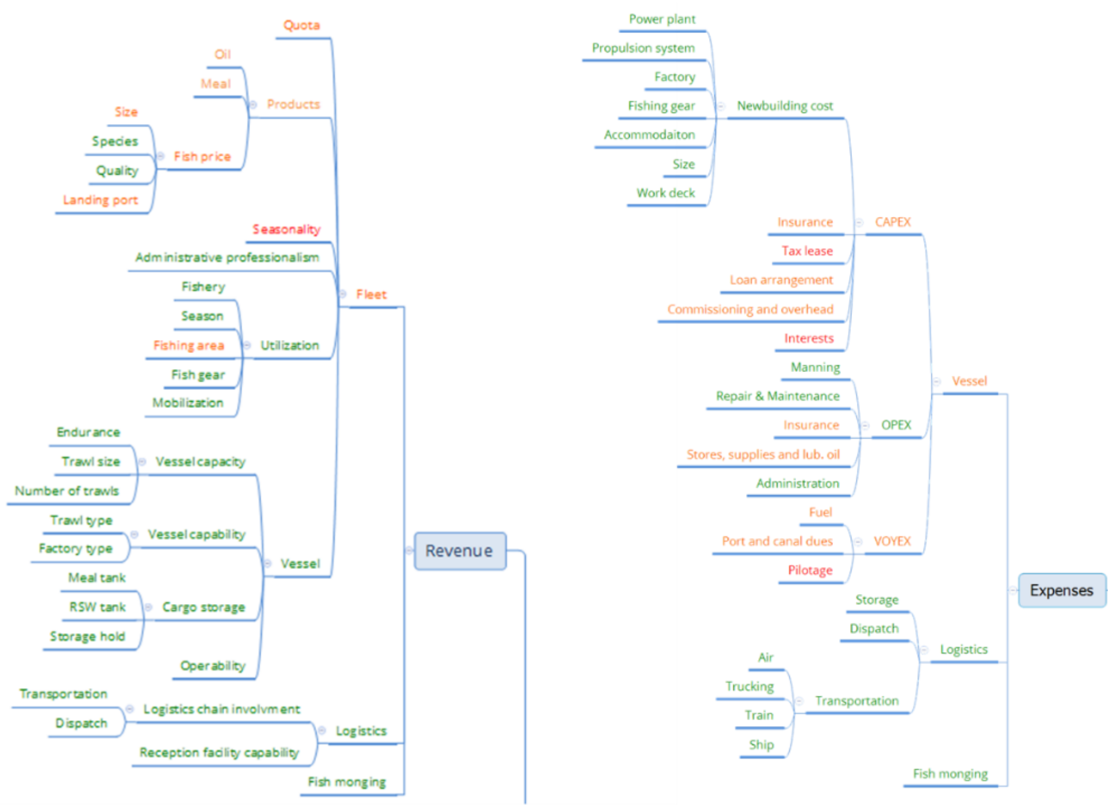


Figure 8: FST vessel revenue-making and cost-generation models.

The project carried out an onboard field study to establish a broad and deep understanding of the FST operation and feedback on vital operational vessel design features for improvement. Field studies are a structured process to capture "hands-on" information from vessel operations. The methodology is well documented in previous literature (Gernez et al., 2014; Lurås & Nordby, 2014) hence, it is not detailed described in this article. Figure 9 summarizes special aspects and design features relating to the bridge, accommodation, fish handling, fish factory, fish equipment deck, and finally, the trawl concept and reception facility, to be carefully looked at and improved as part of developing the novel 5th generation FST.

Figure 9: Main evaluation areas during the field trip.

The project also carried out an evaluation of risk and uncertainties (Module 4) related to the vessel business case. This process has been previously described in an IMDC publication (Garcia et al., 2018). The evaluation included the development of a simulation model to explore the impact of externalities on the cash flow of the vessel while in operation.

There is only one last element required before the traditional design work (naval architecture and marine engineering calculations) starts: defining a design strategy and tactics that cater for the achievement of the business proposition and guide the designers during the conceptualization and detailing of the vessel design solution. Figure 10 exemplifies the breakdown of our design strategy and tactics related to enhancing the quality of the fish product.

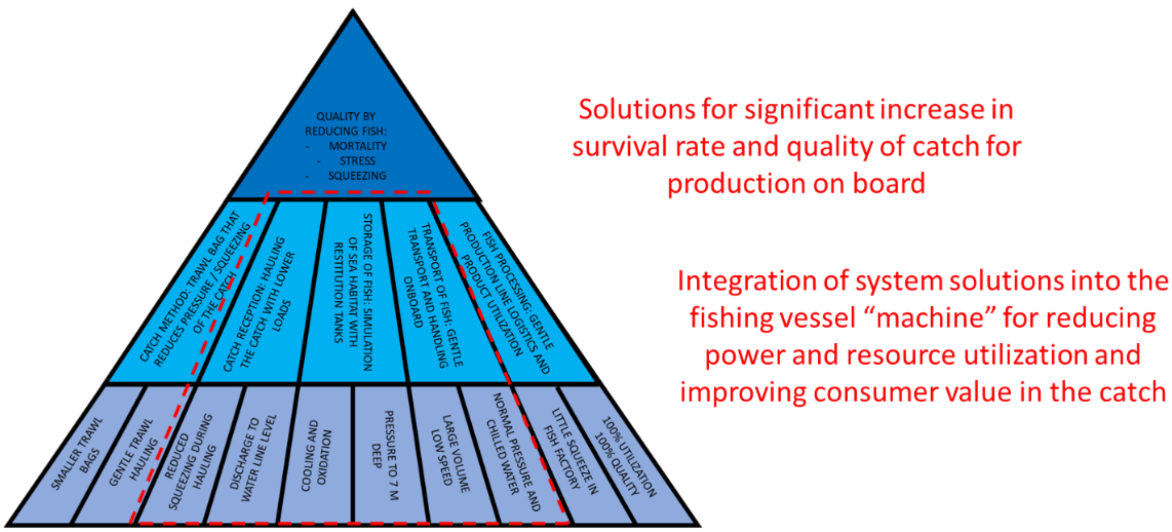


Figure 10: Design strategy and tastings for enhancing fish quality.

ABD Module 5 work – a promising vessel concept design solution is emerging…

The objective of Module 5 work of the ABD approach is to describe, supported by conceptual drawings and supporting analyses, different but promising solutions meeting the initial and underway stated expectations and requirements and assess these solutions by a set of specific, pre-defined criteria. These criteria are metric interpretations of all the expectations and requirements available and are relevant for proper and robust decision-making as to what is the better ship concept solution of the ones proposed. In this way, the main attributes, unique features, and performance yield can be compared and benchmarked in a micro and macro contextual way.

The design development (Module 5) started by framing the business proposition on tangible needs and expectations, that are thereafter elucidated in design parameters that define the boundaries of the design solution. Figure 11 exemplifies this process as a mind map leading from performance expectations (extracted in Module 2) into a vessel design definition. This process also requires identifying critical functions of the vessel platform. The project also depicted the early ship function diagram of the main and most critical functions of the novel vessel design to be explored (Figure 11 – right) and concluded as a part of the vessel concept design solution configuration.

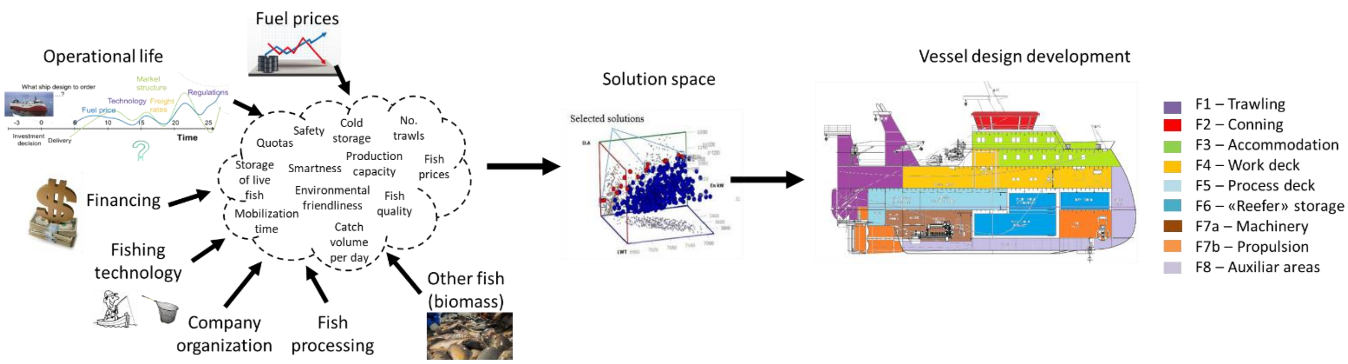


Figure 11: Mind map of the wicked problem leading towards a solution space and the vessel functional design development.

Here is where the identification and selection of technical solutions start. The project carried out a detailed evaluation and review of different technologies and technological solutions for the different functions of the vessel. Different alternatives were proposed and discussed during the workshops, involving expertise from the ship design company, shipyard, equipment suppliers and not least the vessel operators. Figure 12 briefly documents the process of testing new ideas in introducing new functional ideas to the FST and their configuration consequences and implications. It shows how various alternatives (A, B, C, D, etc) are considered, evaluated, and finally decided as to what seems to be the most promising solution and arrangement. From the illustrations, it is indicated by a big cross what solutions were disqualified in the workshop-based decision-making processes. The various functional areas (F1 to F8) are considered one by one with various solution options.

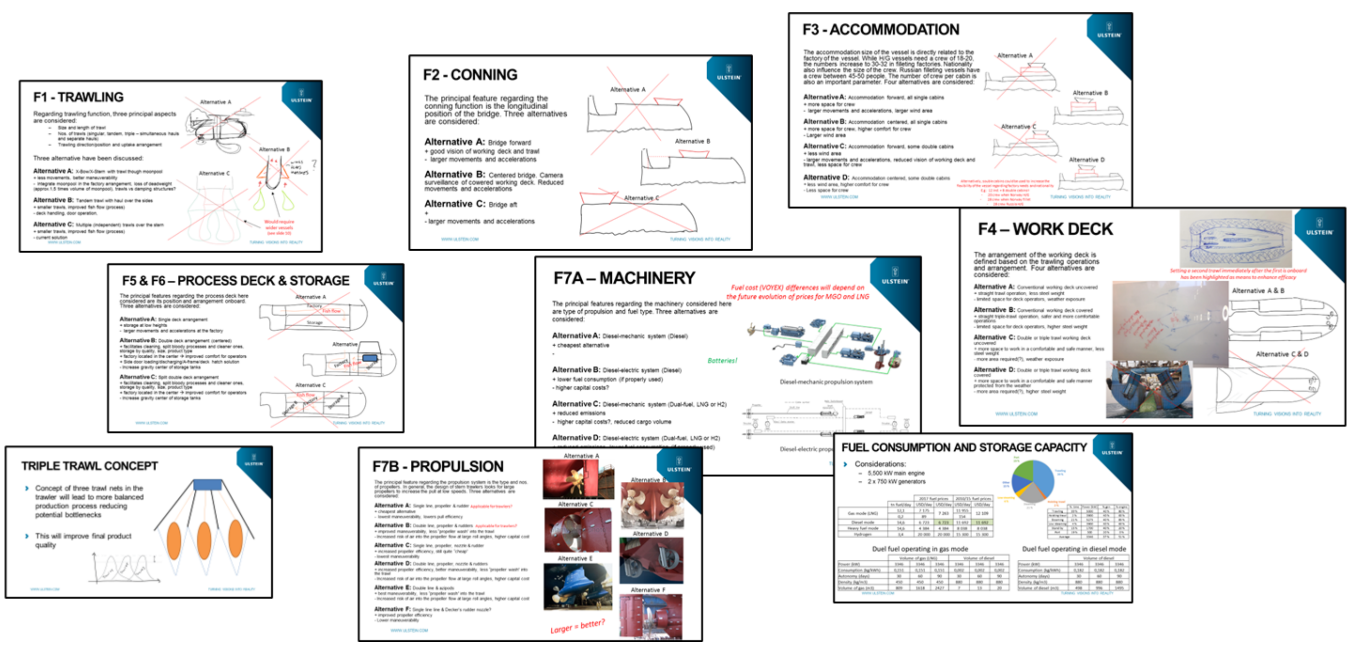


Figure 12: Examples of workshop configuration exercises summarized.

No ABD-scrutinized project can be finalized without a proper measure of merit benchmarking process. In Module 9, different performance yield indexed benchmarking methods are suggested and recommended for use. The project developed a set of key performance indicators (KPI) and a goodness-of-fit (GOF) matrix that were used in the ABD approach to distinguish what is a better FST vessel concept design solution among alternatives developed and existing trawlers in operation . The "-" sign in the KPI definitions represents the average value for the fleet, i.e., the KPIs are non-dimensional. Figure 13 presents the relative performance yield of different concept design solutions compared against each other and a full Goodness-of-Fit (GOF, with expectations and requirements') index satisfaction (Brett, Boulougouris, et al., 2006; Brett et al., 2018b; Ebrahimi et al., 2018).

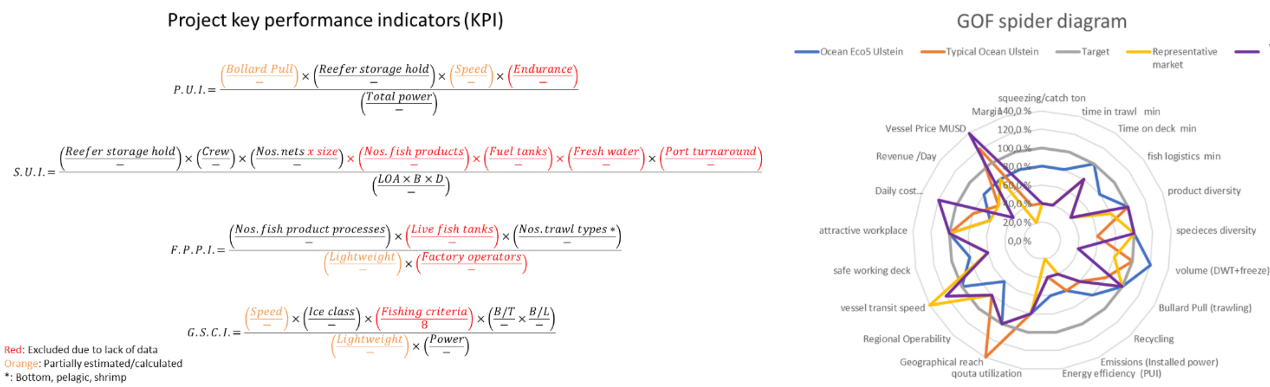


Figure 13: Evaluation of key performance indicators and goodness-of-fit.

Figure 14 represents an excerpt of ABD approach documentation, outlining and displaying the findings of the ABD process and effort.

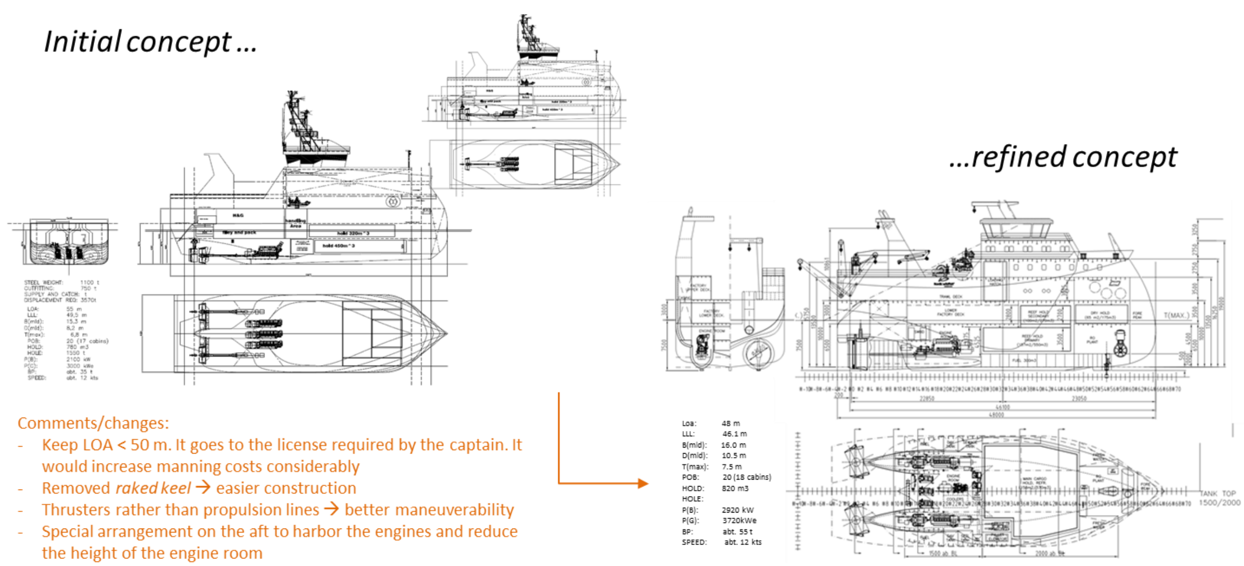
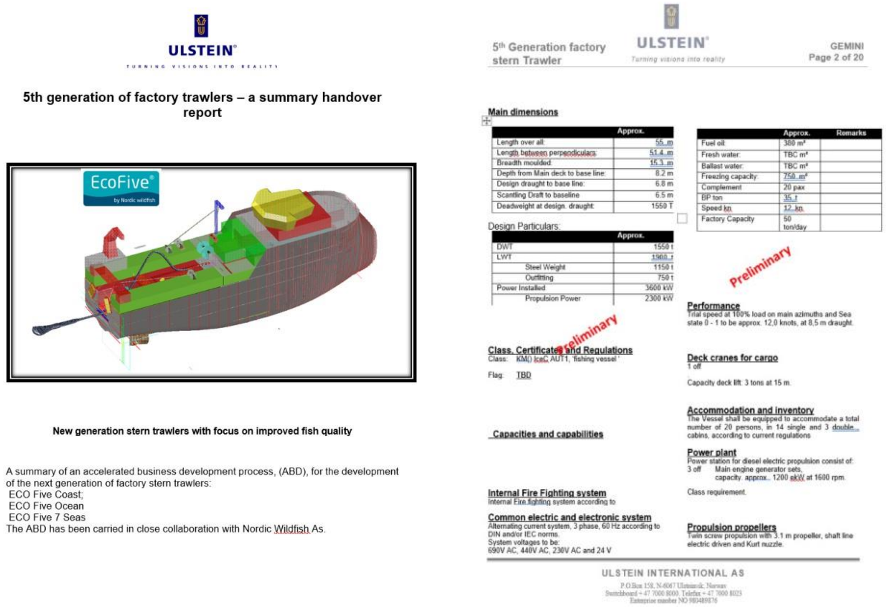


Figure 14: Stages of the vessel concept design solution development including the novel catch reception system.

Figure 15 presents the final 3D rendering of the FST vessel concept design solution in its natural environment – at sea. The project has been recognized with the "Innovation Award" at Nor-Fishing in 2022 and named "Ship of the Year" at Nor-Shipping in 2023.

Figure 15: a 3D rendering of the final FST vessel concept design solution.

Figure 16 displays the cover page of the vessel concept design handover document summing up the ABD approach undertaken and sent to our basic design naval architects and marine engineers for the final realization of the design project and preparing for contractual work and yard detailed engineering and production planning. The document was complemented by all the preliminary analysis reports and MS.ppt series of vessel concept design solution descriptions.


ULSTEIN

5th generation of factory trawlers – a summary handover report

EcoFive

New generation stern trawlers with focus on improved fish quality

A summary of an accelerated business development process, (ABD), for the development of the next generation of factory stern trawlers:
ECO Five Coast;
ECO Five Ocean
ECO Five 7 Seas
The ABD has been carried in close collaboration with Nordic Wildfish As.

5th Generation factory stern Trawler — ULSTEIN — Turning visions into reality — GEMINI Page 2 of 20

Main dimensions

	Approx.
Length over all:	55 m
Length between perpendiculars:	51.4 m
Breadth moulded:	15.3 m
Depth from Main deck to base line:	8.2 m
Design draught to base line:	6.8 m
Scantling Draft to baseline	6.5 m
Deadweight at design. draught:	1550 T

	Approx.	Remarks
Fuel oil:	380 m³	
Fresh water:	TBC m³	
Ballast water:	TBC m³	
Freezing capacity:	750 m³	
Complement	20 pax	
BP ton	35 t	
Speed kn	12 kn	
Factory Capacity	50 ton/day	

Design Particulars:

	Approx.
DWT	1550 t
LWT	1900 t
Steel Weight	1150 t
Outfitting	750 t
Power Installed	3600 kW
Propulsion Power	2300 kW

Preliminary

Performance
Trial speed at 100% load on main azimuths and Sea state 0 - 1 to be approx. 12,0 knots, at 8,5 m draught.

Class, Certificates and Regulations
Class: KM() IceC AUT1, 'fishing vessel'

Flag: TBD

Deck cranes for cargo
1 off

Capacity deck lift: 3 tons at 15 m.

Accommodation and inventory
The Vessel shall be equipped to accommodate a total number of 20 persons, in 14 single and 3 double cabins, according to current regulations

Capacities and capabilities

Power plant
Power station for diesel electric propulsion consist of:
3 off Main engine generator sets, capacity. approx. 1200 ekW at 1600 rpm.

Class requirement.

Internal Fire Fighting system
Internal Fire fighting system according to

Common electric and electronic system
Alternating current system, 3 phase, 60 Hz according to DIN and/or IEC norms.
System voltages to be:
690V AC, 440V AC, 230V AC and 24 V

Propulsion propellers
Twin screw propulsion with 3.1 m propeller, shaft line electric driven and Kurt nuzzle.

ULSTEIN INTERNATIONAL AS

Figure 16: an example of the information handover document and appendixes exchanged between concept and basic design development teams.

The ABD use case aftermath…

Seeing the opportunity to launch a new ship segment in the Ulstein portfolio of services and designs it was decided to immediately expand the ABD approach findings into a suite of FSTs based on the ABD work process findings. Three different sizes were explored and parametrically adapted – Coast, Ocean, and 7SEAS. In addition, three different branding concepts were introduced – high, medium, and low-standard outfitting solutions. The unique features of the novel 5th generation FST portfolio, including all three versions of the novel FST concept, were extracted and made into strong selling points. Figures 17 and 18 present these ideas in a pictorial format.

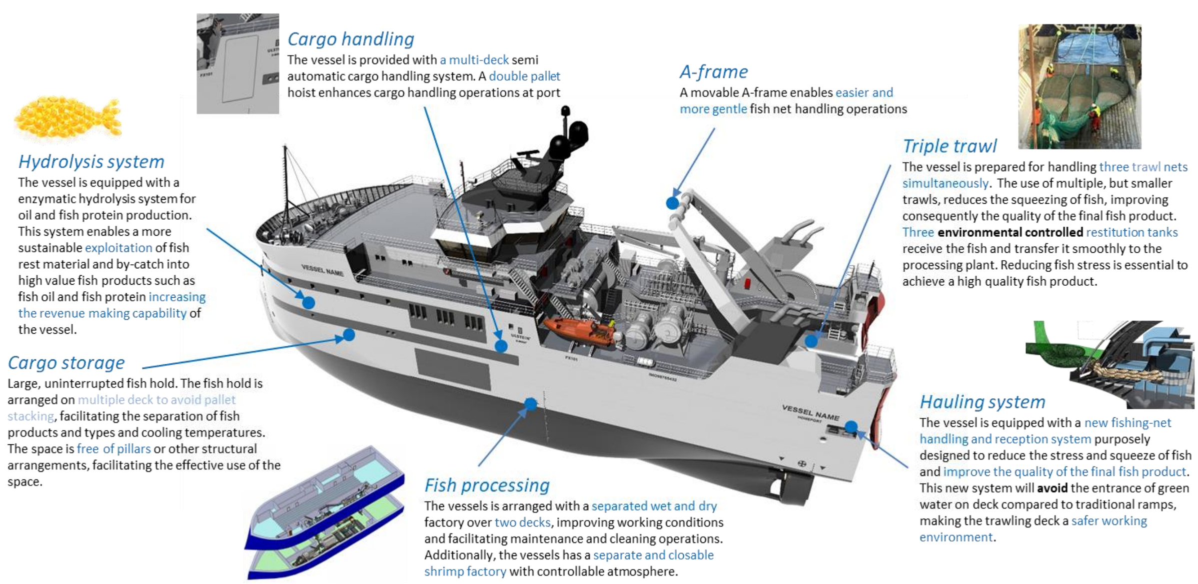


Figure 17: An overview (I) of the unique features of the novel FST developed.

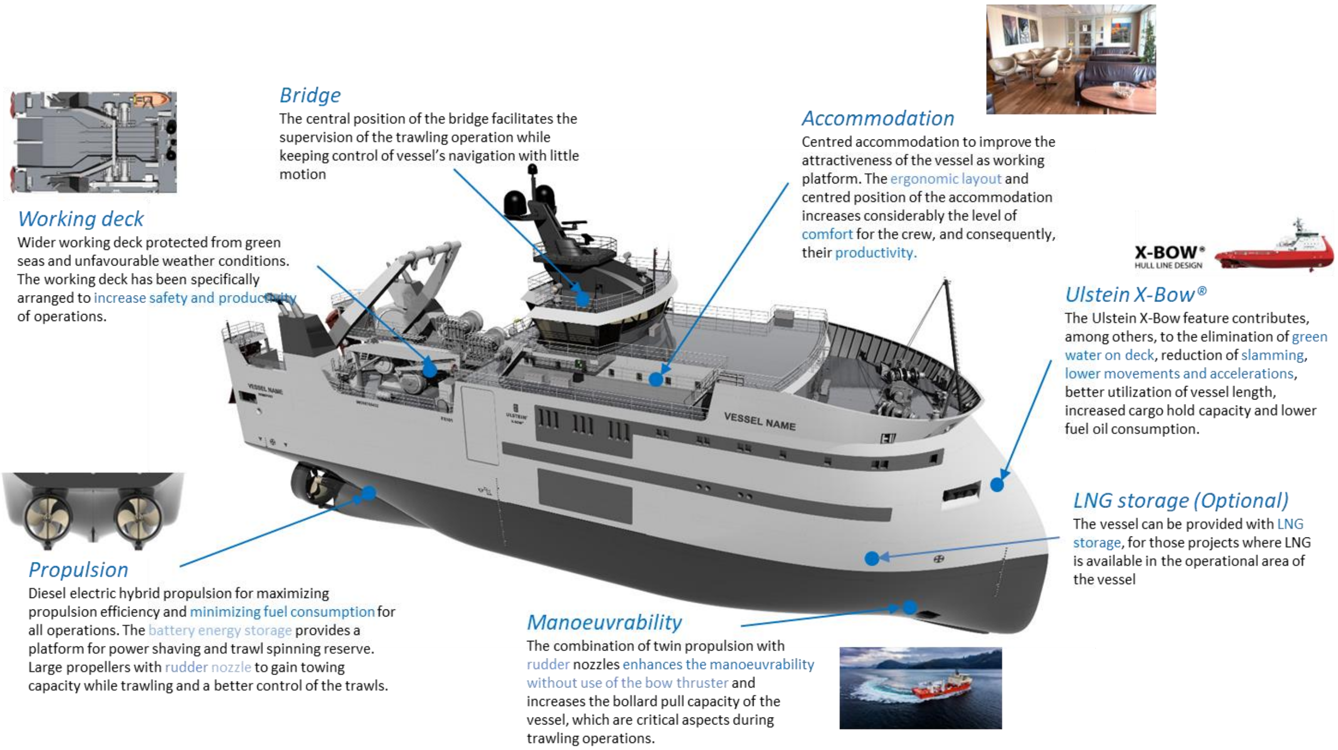


Figure 18: An overview (II) of the unique features of the novel FST developed.

CONCLUSION

This paper summarizes and describes a real-life ABD-guided development of a "family" of FST vessel concept design solution(s). The paper shows how a final ship design solution on a conceptual level, can look like, and consequently be built. This comprehensive and rather laborious article is developed with the principle of "seeing is believing" in mind. Over the years, so many interesting and most likely useful ship design approaches have been introduced and argued for as a must-have to state-of-the-art naval architecture and marine engineering practices. However, many of these methods are still only fragmentary. They tend to address only parts of the whole ship design process, rather than trying to deal with the full work process – concept, basic design, and detailed engineering. Many of the contributions are also very "toyish" in the sense that they have only been tested out as pilots and quite frequently user simulations have been based on "dummy" variables and the like. Practical real-life applications are scarce and therefore, custodians of the marine community have only to some extent, included them in their naval architecture and marine engineering toolboxes and daily ship design practice. For this paper, we felt it was important to share and demonstrate that in some cases, some of these novel approaches can be used in real-life situations. Yet, with the danger of exceeding the paper limit for IMDC papers, it was still considered useful to share pictorially, real project development experiences with the ship design community. We have shown in an anecdotal way, how the ABD approach can be executed, and findings meaningfully be used to produce successful vessel concept design solutions.

The paper starts with a recapitulation of what is still missing, or which loopholes still exist in the early ship design process. The tame and wicked problem aspects are addressed, and the authors argue that with the introduction and application of the much-referred and reviewed ABD approach in several IMDC papers, it is practically possible to master both tame and wicked ship design problems. A particular real-life use case of an ABD approach application has been introduced and reviewed in the paper. How it all started and how the process was continued are briefly documented and commented on.

The paper commences with a discussion about the fact that not all approaches fit all situations. Likely reasons for this are elaborated upon. The comprehensive (and successful) demonstration of the ABD approach in this paper makes a case for holistic design methodologies that explicitly address customer interaction and requirements elucidation as well as technical, operational, and commercial aspects in one go.

Practical implications to ship designers…

Although this particular use case study realization took a very long time, such an observation is, to our experience, uncorrelated with the ABD approach application. The ABD-approach-assisted novel vessel concept design solution development took place well within the timeframe experienced in other ABD projects we have arranged and performed – typically 4 to 6 months. Also, the separate basic design job was carried out within normal time limits. The extreme project time spent was primarily due to project externalities, such as customer firm upheaval, sickness, tightening market conditions and extreme price increases with corresponding slow and costly financing opportunities and other matters outside the control of the project. The authors argue that the ABD process went very smoothly and the customer in question was an ideal partner "playing by the ABD rules". They were highly motivated to pursue the goals and intent of the project. They were very patient and receptive to new approaches. Even when this was the first time, they tried to follow the systematic procedure. They were very disciplined with the process, open-minded and willing to go with the flow of the ABD approach regimen. An enormous amount of information sharing took place, resulting in a wider educational business operation both on the customer's side and the designer's side. Hence, it can be concluded that the ADB approach to the project was an effective one. It is also a learning process that more vessel innovation projects could benefit from a similarly facilitated ABD approach. As stated earlier in the paper, it is typically C-Ds4 and C-Ds5 customer-ship designer settings that easily lend themselves to ABD approach applications and where extraordinary ship design process effectiveness could be expected. In other situations, the ABD approach might be found too time-consuming or resource-demanding, and the customer or project owner might not be willing to adapt to the new way of doing things.

The example described in this paper, together with the authors' experience, suggests that this type of ABD-based project can be suggested and carried out in many more new building situations with substantial gains to all parties involved. Although the ABD approach has not yet been applied in a Navy vessel situation, to the knowledge of the authors, it is strongly recommended that such a new application test is initiated and reported. The more real-life projects being carried out and reported, the faster and more qualified ABD-approach "facilitator-pilots" are developed for the renewal and enhancement of the ship designer community.

Again, we can see the role of the naval architect and marine engineer being strengthened as an integrator of the ship design project – administering the new building project development on behalf of the customer, but at the same time, the architect must also develop stronger interpersonal and social expertise and skills to better facilitate these complex and uncertain development processes. That is, more naval architects and marine engineers need to expand their multi-disciplinary expertise and skills to better support such new development of the discipline, topic, and related subjects, not at the expense of deep discipline knowledge – but in addition. More than ever, it is suggested strongly that "the ship designer of the future" must master equivalent expertise and knowledge within the fields of commercial, operational, and technical challenges related to a new building project realization. Thus, a new type of competent naval architects and marine engineering candidates must be developed through academic training and put into practice in situations different from the past (Asbjørnslett et al., 2022).

It becomes clearer to the authors that the traditional transaction-based ship design approach, where two parties deal with each other via a negotiation-based information-sharing process, does not work very efficiently – particularly not where and when novel innovations are to be developed and realized. Consequently, the traditional information exchange formats in ship design settings need to be improved or completely substituted. The same applies to the contractual formats being applied today. Finally, but not least, various new forms for "open book" partnerships can or must be established between project parties – open book means full trust between parties, no hidden agenda or desires and free information sharing even of traditionally considered confidential information.

Implications to academia…

Academia should, therefore, extend or establish and offer multi-disciplinary training courses and marine technology educational programs with content and learning objectives to match this new situation. Some Naval Architecture and Marine Engineering schools are already trying out such multi-disciplinary educational programs with course syllabus including own and cross-institutional/faculty complimentary courses and students' participation. The suggested change in design practice is likely most effectively achieved through the influx of freshly educated, multi-disciplinary designers who are trained in ABD-like design approaches.

What are some personal experiences to share…

While the overall ABD approach has worked very well and successfully in the described project, there are always things that can be improved on. In the opinion of the authors, establishing the facilitator and complete ship design team as early as possible in the process and earlier than was practised in this project would have helped. Thus, the ABD team from the ship designer side should be fixed and be a fixed group along the way. Also, more in-house, multi-skilled and experienced naval architects and marine engineers would have helped the process carried out. It is not very productive to involve basic design engineers now and then – they should be a permanent part of the ABD team and participate in the process from the very beginning and all along the way. If the customer is lean, the ABD team should follow the project into the premises and internal discussions of the customer and partly become their permanent project support – avoid retaining a two-avenue process with transactional negotiations taking place between the customer and ship designer as the basic design and detailed engineering stages take place.

CONTRIBUTION STATEMENT

Per Olaf Brett: Conceptualization; data curation; structure and argumentation; methodology; writing – original draft.
Jose Jorge Garcia Agis: Conceptualization; data curation, writing – review.
Benjamin Lagemann: writing – a review.

ACKNOWLEDGEMENTS

This work reports on advances made in the Ulstein Group ASA and its affiliated companies as to how to modernize and enhance existing vessel concept design theory and practices, activities normally, performed together with customers. A sincere thank you to all of you. Much of the theoretical and methodological foundation and the exploration of improved vessel concept design is based on previous developments much of it being presented and discussed in previous IMDC 2006, 2009, 2012, 2015, 2018, and 2022 proceedings. This time the authors have intended to share first and foremost some practical experiences with applying novel naval architecture and marine engineering methods, theory, and approaches to demonstrate their applicability. Without the opportunity to consult with and exchange ideas around the topic, with colleagues at the Department of Marine Technology, NTNU Trondheim this study and article summary wouldn't be possible.

This paper reflects and presents the authors' viewpoints about the integrated customer-ship designer setting study taking place for a unique real-life ABD approach application in which both authors participated as facilitators and analysts. A sincere appreciation of contributions from several customers and their executives and experts is also conveyed hereby.

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