DESIGN OF AN ELECTRIC SUPERYACHT TENDER

N. F. Schaffers

TU Delft

DUTCH DC CRAFT

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Graduate student
Nicholas François Schaffers
Student number: 4156285

Chair of the supervisor team
Dr. ir. Jansen, A.J.

Mentor of the supervisor team
ir. Hoftijzer, J.W.

University
Delft University of Technology
Faculty of Industrial Design Engineering
Landbergstraat 15
2628 CE, Delft, the Netherlands

Master of Science
Integrated product design

Company
Zeelander Yachts
Dutchcraft
Gelkenes 44b
2964 AC, Groot-Ammers, the Netherlands

Mentor of the company
Mr. Koopmans, S. J.

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A **tender** is a vessel that provides support or entertainment for the owner, guests and crew of the superyacht. Tenders can come in different types that serve or entertain the users in various ways. Each superyacht needs at least one tender on board for support. Some superyachts even have up to six tenders to fulfill the needs of the users.




Tenders, (Lazzara, 2014)

Preface

Prior to this graduation thesis, I have been an active sailor enjoying the life on the sea which has accentuated my passion for yachts and their design. Therefore, I focused the last years of my education as industrial designer extensively on this subject. I choose to focus my master thesis on this subject as well. Although, finding a project as an industrial designer within the yachting business took me six months and an additional two months to formulate my project proposal.

This master thesis is submitted as final part for my Master Integrated Product Design at the Delft University of Technology. The research was carried out at and conducted for the company Zeelander Yachts. This research focuses on opportunities and challenges that arises with the implementation of the electric-drive train in an electric tender and presents a conceptual proposal for a successful market entry.

First of all, I would like to thank the members of my graduation committee Arjen Jansen, Jan-Willem Hoftijzer, and Sietse Koopmans for their guidance and advice during the progress meetings. Finding a graduation within the yachting industry was not that easy therefore I would like to thank Sietse Koopmans company owner of Zeelander Yacht for this opportunity. Furthermore, I want to thank all members of Zeelander Yachts and ir. Michael Vermeir for helping me out when needed. Finally, I would like to thank my parents, house-mates, Charlotte Beckers for their unconditional support and distraction when needed.

Nicholas Schaffers - Groot-Ammers - 3 December 2018

Executive summary

The Dutch yacht builder Zeelander Yachts is working on a new brand Dutchcraft wherefore they want to follow the transition from combustion drive-trains to electric drive-trains by creating a 25-feet electric tender. The company never built a tender or electric tender before. Causing, that the company has no knowledge about electric drive-trains or tenders.

The objective of this master project is to analyze the opportunities and challenges that are involved with the introduction of the electric drive-train for a tender, in order to know how the company Dutchcraft can enter the market successfully and which unique user benefits they can focus on.

To address the objective of this master project a research by design approach is performed. It starts with an internal and an external analysis that resulted in a design direction. From there, ideas were created and converged into a conceptual proposal that was further elaborated to show the feasibility of the proposal.

Concluding from the research, the transition to an electric drive-train for a tender creates new opportunities which Dutchcraft can use to enter the market successfully. The most important transition resulting from this project is the transformation of the shape of the deck which is due to the different electric drive-train configurations. This transformation was also achieved for a 25-feet Dutchcraft and created an entire flat and empty deck. This allows the users to customize their tender for the proposes they desire.

It is recommended that Dutchcraft focuses offering a multi-activity tender which is also able to support land activities. The design of the interior of tender should have a more luxurious look and feel than their current Dutchcraft 50 model but still match the exterior design. Because Dutchcraft never composed electric drive-train, it is recommended to use the complete package of Piktronik.

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1. Introduction

1.1 Introduction

This master graduation thesis was conducted for the group Zeelander Yachts, a company located in Groot-Ammers in The Netherlands and owned by Sietse Koopmans. Their portfolio consists of two brands; Zeelander (Figure 1) and Dutchcraft (Figure 2). The positioning of both brands in the market is different. The Zeelander brand focuses on the high-end market by producing "pieces of art" in the 44-164 feet range with high quality, superior finish, low noise and low vibrations levels ("Zeelander Yachts | Z44 & Z55 | Driven by Perfection", 2018). The Dutchcraft brand on the other hand reaches out to the lower market segments by creating yachts with a wide variety of activities, e.g. diving, exploring and fishing adapted to the users demands.

During the last years, drive-trains of vehicles have been subject to a transition from combustion engines to hybrids or fully electric drive-trains (Altenburg, 2014). This transition is also happening in the maritime sector. Dutchcraft wants to follow this transition by offering an electric tender. Dutchcraft wants to explore the opportunities and the challenges that result from these transition, such as: different weight distribution and a decrease of maintenance, emissions, noise and vibration, to offer a new product to the market.

The transition to an electric drive-train is not only a transition in the engine compartment but, it also leads to a completely different approach of the design of a tender. To pursue a solution, Dutchcraft has to develop the know-how on electric drive-trains and combine this with its strong interior and exterior designing experience. As the starting point for this project, Dutchcraft has an existing hull design which will be used as the foundation of the implementation of the electric drive-train.

Figure 1: Zeelander Z55
(Zeelander Z55, 2017)

Figure 2: DutchCraft 50
(Visual Presentation Rev, n.d.)

1.2 Problem definition

Dutchcraft is (a) unaware of the opportunities and challenges that are involved with the introduction of electric drive-trains. However, they want (b) to learn how they should enter the market successfully and (c) what unique user benefits to focus on. These questions will be addressed by performing a research by design project.

1.3 Assignment

The assignment consist of two parts (i) exploring the design space for an electric tender design for Dutchcraft and (ii) creating a conceptual design proposal that meets the requirements that will be set during this project.

1.4 Approach

In order to find the design space for an electric tender; the interests of the users, the technology and the business opportunities for Dutchcraft is approached by using a research by design study (Figure 3). The three topics will analyzed both form an internal- as well as an external point of view.

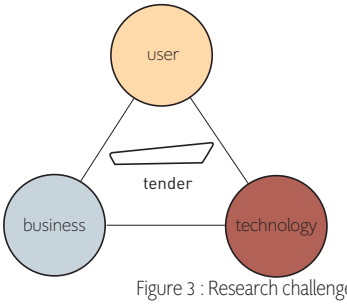


Figure 3 : Research challenges

Exploring the design space for an electric tender (i)
Firstly, the design space of the electric tender (i) is explored by a SWOT. The SWOT analysis exists out of two parts: an internal exploration and an external analysis. Within the internal exploration, the strengths and weaknesses (SW) are determined by exploring the company. The external analysis is conducted to determent the opportunities and threats (OT) for the development of the electric tender by Dutchcraft by analyzing the users, the context factors, the competing businesses and technological development of the electric drive-trains.

To converge the most important aspects from the analysis a SWOT is presented. This enabled that search areas are created which are to be used for further direction of this project.

In conclusion to this chapter an answer on the three topics of the problem definition and a design brief are formulated. These formulations include the main requirements that form the foundation for finding a design proposal.

Creating a conceptual design proposal that meets the requirements (ii)
After the exploration the design space, a conceptual design proposal is created. To do so, ideas are gathered to find solutions that meet the set requirements of the design brief. During the first ideation, ideas are created by using 2D prints of the scaled hull of the 50-feet Dutchcraft. One of the main challenges is the configuration of the electric drive-train since this affects the design solutions of the tender significantly.

With the drive-train as a foundation different design solutions for the arrangement of the functionalities on the deck are created. To cluster the ideation a morphological chart is used that resulted in three idea directions. These ideas are simulated in 3D-software for evaluation and converged into one concept.

The concept is further simulated in a 3D environment and evaluated to show the feasibility and the unique user benefits to Dutchcraft.

A complete overview of the approach is schematically presented in Figure 4.

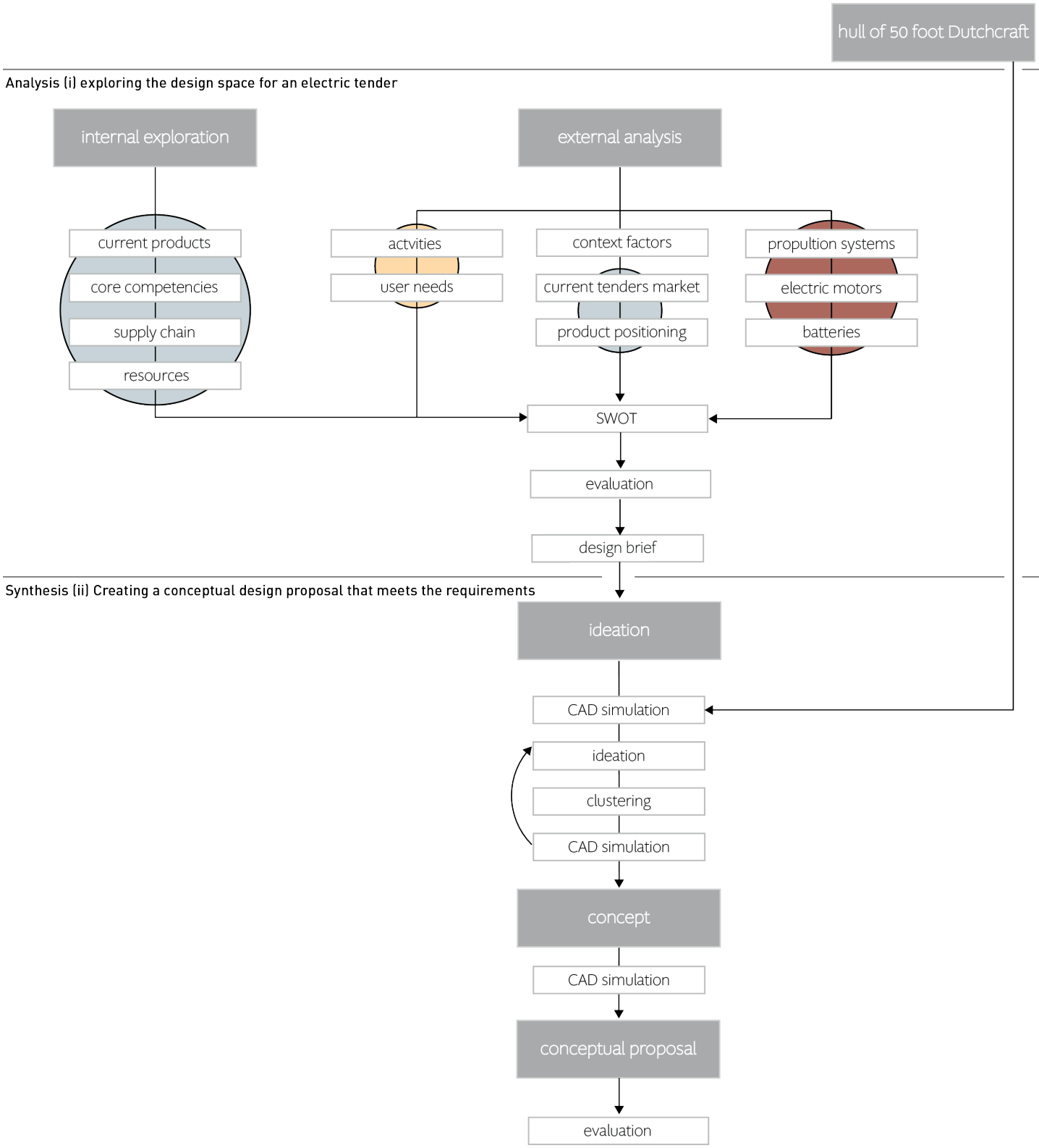


Figure 4: schematic approach

The shipyard of Zeelander Yachts
Sietse van der Meulen, 2018

2. Company exploration

An exploration of the Zeelander group presents the current portfolio, the competencies of the brand Dutchcraft, the insights about the way of working, and the resources. This exploration results in strengths and weaknesses the company is currently dealing with (Chapter 6). Although the project was done for the brand Dutchcraft, the brand Zeelander is included in the exploration as Dutchcraft is a part of the Zeelander group.

2.1 The history of the Zeelander Group

One of the dreams of Mr. Koopmans, founder of Zeelander yachts, was to design yachts. In 2002, a Turkish company produced the first yacht he designed. Mr. Koopmans noticed that the quality level delivered by the company in Turkey delivered, was not meeting his expectations. Therefore, he started his own shipyard specialized in detail engineering and building with the mission to "create high-end motor yachts that join shape to perfection and perform to the highest possible standard" in the Netherlands ("Zeelander Yachts | Z44 & Z55 | Driven by Perfection", 2018).

Zeelander

"Create high-end motor yachts that join shape to perfection and perform to the highest possible standard" (Koopmans S.)

In 2008, the first Zeelander Z44 was built and introduced at the Monaco Yacht Show; this was not a success because of the stock market crash (Van den Berg, 2018). Nonetheless, after the market restored, the Z44 was revealed in 2011 at the USA Fort Lauderdale Show, where the Z44 was successful and started to sell (Van den Berg, 2018). The company opened a sales office in Fort Lauderdale to be in close contact with their American clients. In 2013, the first Zeelander Z55 was also launched successfully. One year later, the company designed and engineered a Z164 which is 164-feet. Unfortunately, the buyer canceled the sale. (Koopmans, 2018). Recently, the hull of the Z72 arrived at the shipyard in Groot-Ammers to be completed in February 2019.

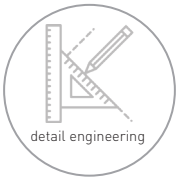
Dutchcraft

"Create motor yachts that facilitate a range of activities on the water for an affordable price" (Koopmans S.)

Comparing the price of the yachts of Zeelanders with yachts of the same length, Zeelander is the most expensive brand available on the market. According to Mr. Koopmans, this makes it difficult to have significant sales figures. Enough reasons to create a new product called Dutchcraft. In 2014, the brand Dutchcraft was embodied with the mission; "create motor yachts that facilitate a range of activities on the water for an affordable price". He started Dutchcraft in cooperation with Mulder Design. The project came on hold because of conflicting interest between the companies, and in 2017 the Zeelanders Group picked up the project again (Koopmans, 2018). The company hired additional employees to give the project a boost and to finish the first Dutchcraft 50 in September 2018. Immediately after the finalization, the next hull arrived to start the second Dutchcraft 50.

2.2 Company activities

The company is a shipyard with as main activities assembling, managing and detail engineering of the yachts of Zeelander and Dutchcraft. Within the company, there are two separated managing and building teams one of Zeelander and one of Dutchcraft. Naval architecture, designing, and visualization are outsourced.



2.3 Portfolio

Current and future products

The portfolio of the Zeelander Group currently consists of one Dutchcraft model (Figure 5) and six Zeelander models. The Dutchcraft model has a length of 50-feet. The company wants to broaden the Dutchcraft product portfolio with 25, 50, 75, 100, 125 and 150-feet range yachts. The range of Zeelanders models can be found in Appendix A.

Form language

In 2014, Mulder Design sketched the range of the six different Dutchcraft models. The sketches of the models are confidential, but they all have the same leitmotiv (language) which can be shared (Figure 6). The first element of the leitmotiv are the two lines that run parallel and rise from the back to the front of the hull. The second element is the fly-bridge. The bottom of the fly-bridge is the only horizontal line and is different from the rest of the design. The last element is the distance between the fly-bridge and the rest of the hull.

Specifications

LOA: 15,89 m / 51 ft
beam: 5,06 m / 16,6 ft
max. speed: 20 knots with Volvo IPS600
basic price: € 645.000

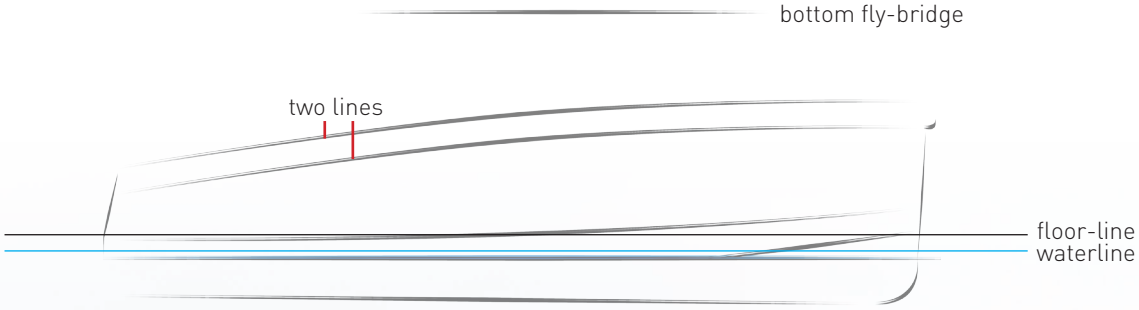


Figure 5 : Leitmotiv

Figure 6: DutchCraft 50
(Rolf van de Wal, 2018)

2.4 Core competencies

What are the company's most distinctive competencies?
Each year the company uses an external firm to conduct market research. This research (Draper, 2017) provides them with insights into the market of all yachts that were produced during the last eight years worldwide with a length starting from 20-feet until 300-feet. Based on the results of this research (Draper, 2017), the company detected the opportunity to create differentiation by launching a new brand, Dutchcraft, with core assets; a semi-custom-function-driven design with a lower selling price than currently available on the market. They converted these assets into three core competencies:

Value for money

The first competence Dutchcraft offers is a design solution that has an incredible quality over cost performance. Therefore, Dutchcraft is constantly trading between the costs and design solutions (Koopmans, 2018). For cost reduction, the design is limited to simple curved surfaces and fillets. The brand aims to replace elements which have the same quality but are less expensive and are less maintenance-sensitive on the outside and inside of the yacht (e.g., chrome parts are now RVS powder coated (Brinkhorst, 2018)). Their selling price is based on external market research. The company compares their product with yachts of the same length that have the same purpose. The company sets a price lower than their competitors and builds within this budget. As a result they can offer a product that is designed at low costs.

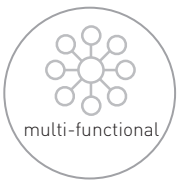
Function-driven

The second competence Dutchcraft offers is an "all-in-one product". The company experienced that yachts are limited in activities. Therefore, Mr. Koopmans came up with the idea to create a yacht that can be used for multiple activities. The first product of Dutchcraft is the Dutchcraft 50-feet model and was designed to cover a broad range of activities;

> A family yacht that can let the user play, swim, snorkel, water-sports, carry jet-skis, carry a small submarine,...
> a fast cruising yacht with speed over 20 knots,
> a fishing and diving yacht,
> a entertainment yacht, on events like the Volvo Ocean Race, it is certificated to transport up to 36 people,
> a shuttle yacht to transport people from A to B.

Semi-custom

The third competence Dutchcraft offers is semi-customization of more than just the finishing elements like fabrics, colors, and options. They also offer e.g. customization for the propulsion-system for which changes are required on the hull. Such customization requires adjustments to the initial design which takes extra time (Brinkhorst, 2018). The overall design cannot be customized (Stevens, 2018).



The three core competencies Dutchcraft is currently focusing on, are also core competencies they want to implement into the other Dutchcraft models and the 25-feet electric tender.

2.5 Supply chain

When does the company start a new build?

A critical factor influencing the design and management of the value chain is the position of the CODP (Customer Order Decoupling Point). This position identifies the point where the product is linked to a specific customer. The earlier this point is happening in the process, the more influence a customer has on the customization of the product (Olhager, 2010). In Figure 7 an overview of all the different customer order decoupling points of the value chain can be found. E.g., when buying at point "buy 4" the customer has more influence on the design then when buying at point "buy 1".

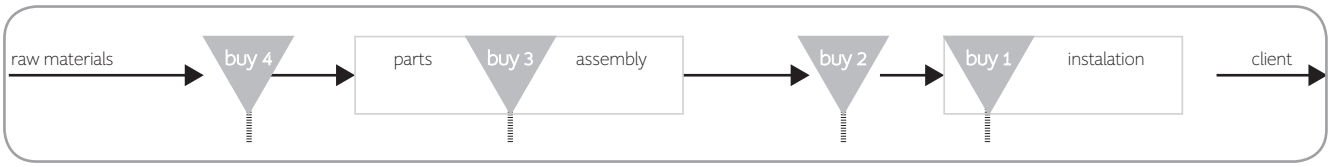


Figure 7 : CODP positions, all points

Yachts are often entirely custom made which means that the process starts after the customer makes an order at point "buy 4" (Figure 8). Yacht brands which use semi-custom designs (at "buy 3") can already start building the first parts before a client order, to speed up the building process.

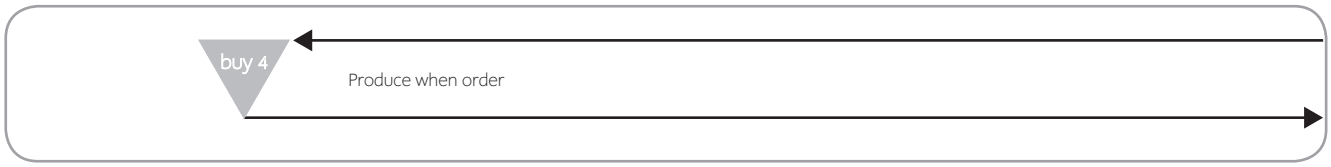


Figure 8 : CODP position, buy 4

After investigating the Zeelander group, it appeared they build semi-custom yachts and start the building process after an order (at "buy 3"). Although, in 2018 they built two yachts without a customer's order (at "buy 1" Figure 9): one Zeelander Z44 and the first Dutchcraft 50. However, having these two yachts in stock is a significant risk for the Zeelander group because of the fixed cash flow (Van den Berg, 2018).

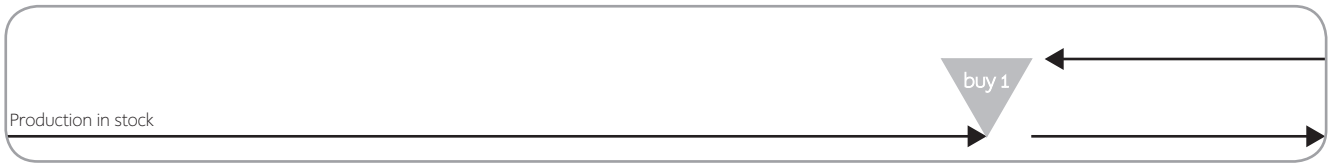


Figure 9 : CODP position, buy 1

2.6 Resources

Which resources are available to start this project successfully?
Entering the market successfully requires the right resources (A guide to the project management body of knowledge, 2004). Typically, resources are assets that are transformed to produce benefits. Such as human skills or production resources (A guide to the project management body of knowledge, 2004). A research was conducted to asses which resources from the Zeelander group are available for Dutchcraft. A map of the current resources was made to clarify and can be found in Appendix B. Figure 10 presents an overview both the available resources and unavailable resources.

> The currently available resources of the company are:

Suppliers
Dutchcraft has about 50 suppliers. The amount of the suppliers in the yacht industry is limited which makes it difficult to switch between the suppliers (Mark Monster, 2018). The Zeelander group has already good longterm relations with their suppliers and other business partners. (Mark Monster, 2018). Because of the strong relations, the company can ask the suppliers to keep their parts in stock until they need them. As a result, the Zeelander group does not need to pre-finance the parts and storage of the parts (Koopmans, 2018).

To verify, the strong relationship of the company with its suppliers, a small interview with five different suppliers was conducted. During this interviews it became evident that all interviewees were positive about the collaboration.

Production
Dutchcraft already has a resource for the production that can help with this project. A company that is specialized in electrical engineering. E.g., installed the electronics on board of the 50-feet Dutchcraft. This company also has experience and knowledge about electric drive-train technology.

Naval architects
Dutchcraft is working on finding a resource for the naval architecture for the tender. A first contact took place with the company of naval architects in The Netherlands to discuss the project.

> The company still has some unavailable resources which are:

Project management
The company currently works with two teams; one team works on the Dutchcraft 50-feet, and one team works on the Zeelander 72-feet, they have never built more than two yachts at the same time.

Marketing and sales
There is one person responsible for the marketing and one person responsible for the sales of Zeelander. For Dutchcraft there is one person responsible for marketing and no one for the sales.

Costumers
Dutchcraft and Zeelander do not have any yachts in their portfolio available that could fit a 25-feet tender. The Zeelander Group does not have any leads to potential customers to sell their 25-feet electric tender.

Brokers
Brokers are not always part of a deal. The only effective goal of a brokers is when they will have a client. They mainly wait until money can be earned (Van den Berg, 2018). Therefore, DutchCraft mainly sells directly to the client.

The Shipyard
Building a 25-feet tender requires space. Currently, both Dutchcraft and Zeelander are using all the space at the shipyard.

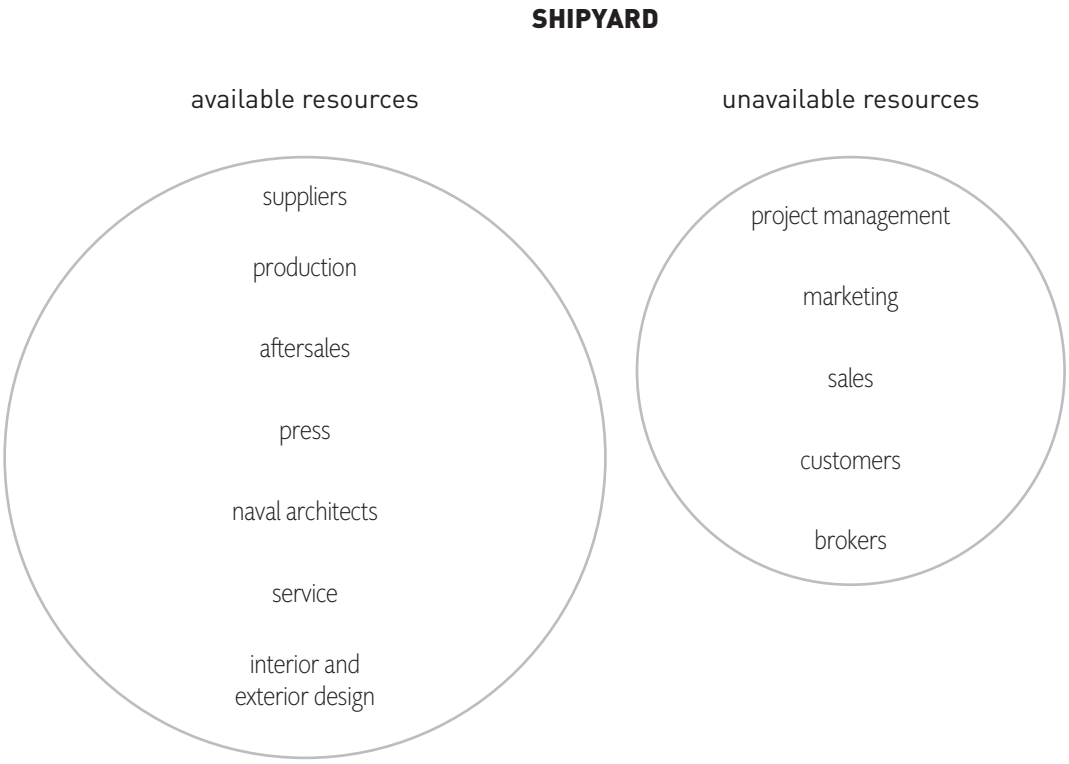
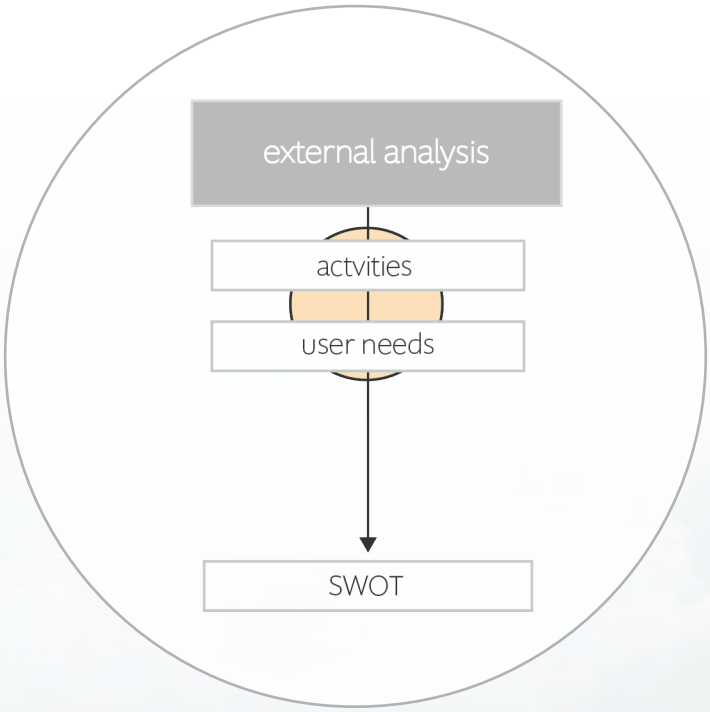


Figure 10 : Resources

3. User research

In this chapter, a user research was conducted to asses which unique user benefits to focus on. By using a process tree the different activities that encounter during the tenders life cycle were schematically presented in a diagram. In conclusion the diagram of activities was used to develop a list of criteria.



Tender users
(What Does a Boson Do?, 2017)

3.1 Activities

Which user activities to focus on?
A process tree analysis (Roozenburg, N.F.M. and Eekels, J.,1995) was made as a starting point (Appendix C). The outcome gave a structured overview of the activities which helped to define the functionalities and requirements. This list of requirements can be found in Appendix D. The process tree was divided into four main stages; originate, distribute, use and discard.

For this project, the use-stage was the most interesting process because it gave insights into the user activities. The following activities resulted from the process tree:

Activity	Seating		To store		Time full speed
transport ship to shore	6 Pax.	2 crew	bags	drink and snacks	40 min.
diving	6 Pax.	2 crew	diving items		60 min.
fishing	4 Pax.	2 crew	fishing items		20 min. + 4h (6kts)
beach landing	6 Pax.	2 crew	BBQ items		40 min.
explore trip	2-4 Pax.	2 crew	trip items		40 min.
water-skiing	4 Pax.	2 crew	water-ski items		120 min.
transport groceries	-	2 crew	groceries		40 min.
transport garbage	-	2 crew	garbage		40 min.
mooring superyacht	-	2 crew	mooring lines		20 min.
cleaning the tender	-	-	cleaning items		-
emergency situation	-	-	rescue items		-
charging the tender	-	-	charging items		-
storing the tender	-	-	-		-
launching the tender	-	-	-		-

Figure 11 : Tender activities

It appears that the user activities variate depending on; the passenger capacity, the amount of storage space, and the range. An overview in Figure 11 shows the main variations between the different activities.

The specifications of the "to store" items in Figure 11, were further determined to clarify the storage space needed for every activity, these specifications can be found in Appendix E.

3.2 User needs

What are the essential user needs for the various activities?
A tender is used by the owner, guests, and crew whom all have different needs. To obtain insights, literature research and five interviews with experts on building, owning and selling tenders, was conducted. The obtained insights were clustered and visualized in Figure 12.

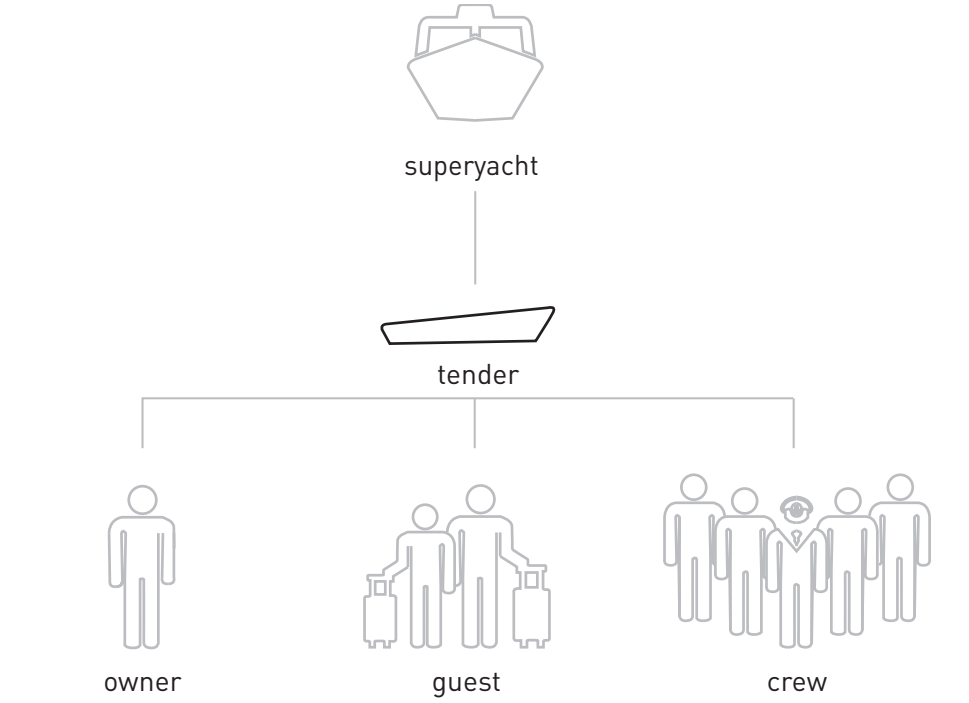


Figure 12 : user needs

Due to the depth and time spent on this thesis, not all user needs could be included. This thesis does not offer a solution for charging the tender and the interior specifications.

User research

The crew and captain are the ones who use the tender more than the owner and guests. Because the crew is using the tender the whole year to support the superyacht, even when the guests or the owner are not on board. The crew does all the maintenance and services of the tender and ensures that the tender is always in an optimal condition.

"The owner or guests are almost never taking over the steering wheel or helping the crew" (Stevens, 2018).

When the guests arrive for the first time and the superyacht is anchored in a bay, the tender transfers the guests to the superyacht. Thus, the first impression they get of the superyacht is the tender. This impression is important as the owner wants to impress and show his status to the guests (Van den Berg, 2018).

A comfortable ride is essential for the owner and the guests but not necessary for the crew. The owner is interested in the quality of the tender because they want their tender to have a long service life (Superyachttimes, 2016).

User research

"It appeared that the performance and safety of the tender is an essential need for all the users "(Koopmans,2018).

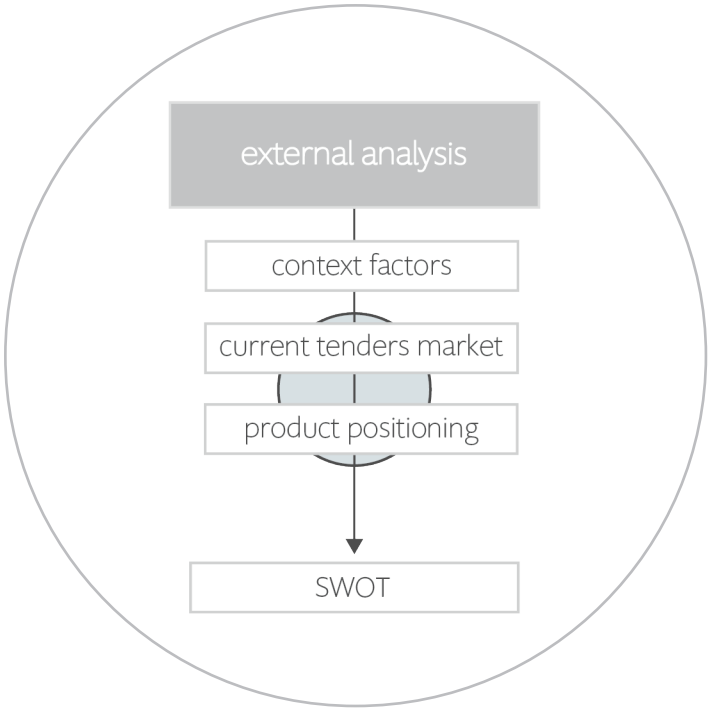
Tender owners are ultra-high-net-worth individuals (UHNW) who can consume whatever they like. However, they still look at the price (Koopmans, 2018). Moreover, when buying a tender, the owner asks the captain for advice because the owners are not always aware of the specifications of the tender garage and the functionalities the tender has to support (Van den Berg, 2018).

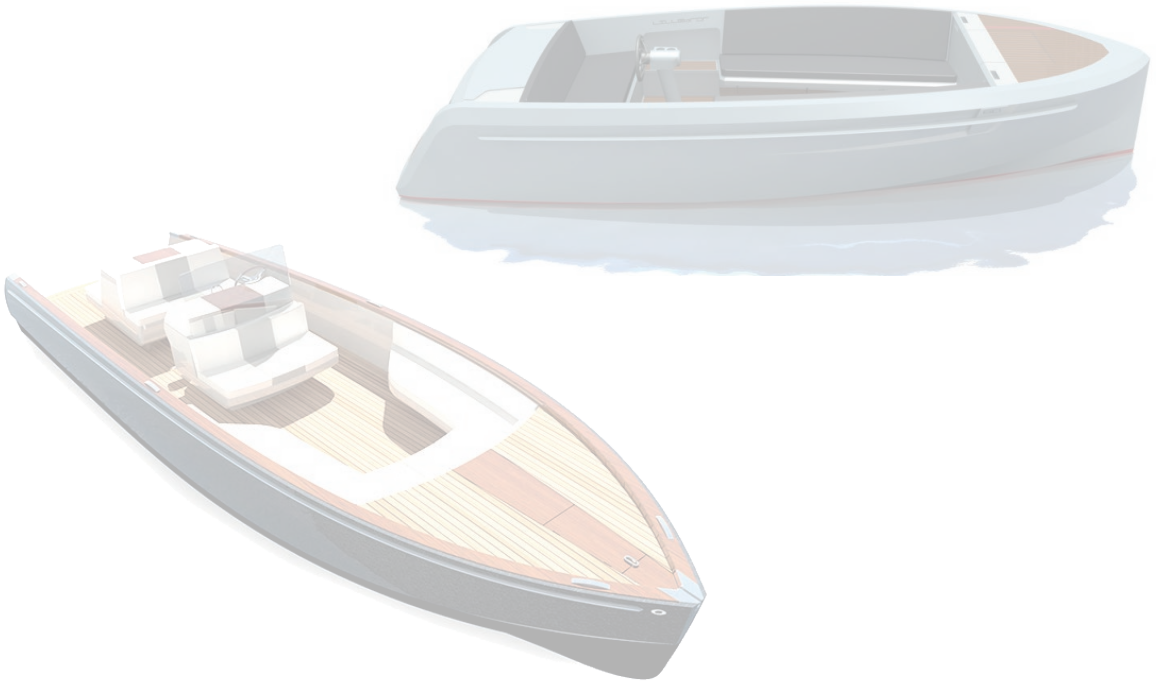
In the tender market, customization is of vital importance. Tender-owners want to have their tender custom and as unique as possible (Richardson, 2017). There are yacht-owners who wish that their tender would have the same appearance as their superyacht (full-custom) (Merl, 2015).

Tender activity
(Purchasing superyacht tenders - the data, 2017)

4. External analysis

A trend analysis was conducted to find upcoming technology that Dutchcraft can apply to their new product. Afterwards, the competitors were analyzed to find out how Dutchcraft needs to position their product into the market.





4.1 Future factors

Which are the future factors Dutchcraft could follow?

Dutchcraft wants to bring their tender project on the market within a year. Therefore, context factors were searched that are relevant for the near future. The factors are observations, facts, theories, opinions, and thoughts, and were found by doing a literature study. There are four different types of context factors, developments, trends, states and principles (Hekkert, P., & van Dijk, M., 2011 - p. 141-147). For the relevance of this project there was only focused on the factors: developments and trends in the field of technology. The factors presented are not about the final solutions, they are about possible solutions for the final product.

> Adjustable rooftop in height

An upcoming development on the tender market is a rooftop that can change in height so it will fit in more yachts. Currently, the market leader of tenders is Xtenders. Their lowest storage height of a limousine tender is 1,65 meters (combustion engine).

> More land-based activities

"Lately we are seeing more and more interest in land based activities. The water sports market is perhaps getting a little saturated and people are looking to new sports and more land-based activities such as beach cinema set-ups and motor sports. We have outfitted larger yachts with toys such as 4 x 4 Polaris Rangers, Harley Davidson and KTM motorbikes, amongst others." (Watson, 2016)

> Larger multi-activity tenders

"Another trend on bigger yachts is to have a larger number of specific boats such as sailing boats and wakeboard boats. It may be a better option to create a dedicated space for a larger multipurpose tender instead of stuffing the yacht with numerous smaller ones." *(Fottles, 2017)*

> Support vessels

Superyacht owner are more and more buying support vessels to store their toys because their superyacht has not enough space to store all their tenders and toys (Yachts, 2016).

> Functionality

"Functionality is taking precedence over aesthetic, although luxury and design are crucial. They want to push the boundaries of design and innovation, breaking away from the norms of classic yacht design." *(SUYG,2017)*

> Regional manufacturers

"It is a bit of a generalization, but we do see a tendency for yachts to favor manufacturers from their region. Regarding the production toys, European yachts tend to like Aqua glide and Jobe products whereas US yachts might prefer Rave and O'Brien. What is probably a result of marketing in those regions." *(Whatson, 2016)*

> Foilers

Companies are applying foilers on their hull. This development provides less displacement and can improve the performance. (Mets trade 2018)

4.2 Current tenders

What are the main properties current tenders possess?
To find an answer to the question, a literature research was conducted. The literature showed that there are four main properties brands use to position their product in the market; ("How To Choose the Best Yacht Tender | Yachting Pages", 2018) the purpose, the capacity of passengers, the performance, and the storage space on the superyacht (Figure 13). In this part, these four factors are clarified and analyzed.

For the capacity of the passengers and the storage space on the superyacht, data of combustion tenders that fit the range between 12-feet and 30-feet were used. For the analysis of the purpose and performance, data of electric boats was used.

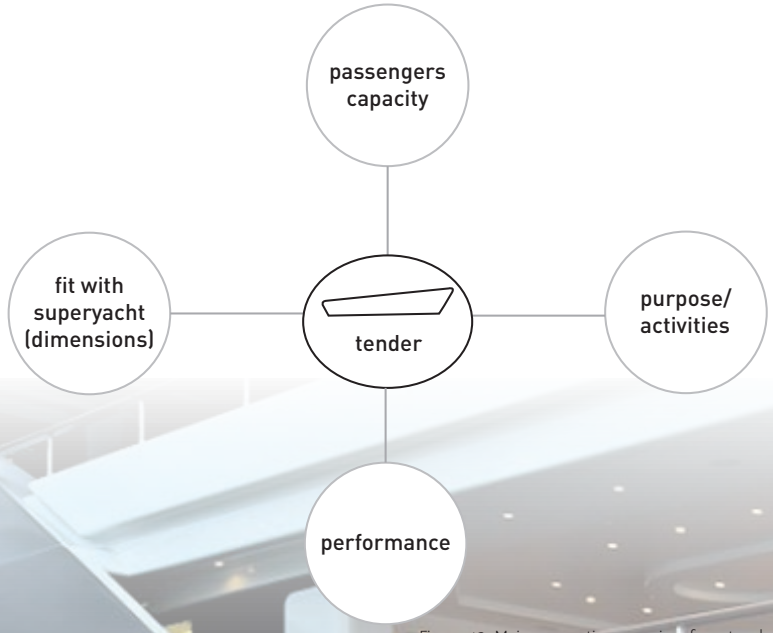


Figure 13: Main properties overview for a tender

Figure 14: Drive-in tender garage
Tenders, (Lazzara, 2014)

External analysis

Storage space available on board of the superyacht

A tender is stored in or on the bow, back or side entrance of the superyacht. Therefore, it needs to be lifted on the superyacht. An upcoming trend is the drive-in tender bay (Figure 14) (Smith, 2017). The dimensions of the tender are depending on the space available on the superyacht (Figure 15). Tenders are often custom made because superyacht builders are firstly defining the space where the tender should fit into the superyacht and afterwards, they explore the tender market (Watson,2016).

"Tender requirements are always based on size – the yacht wants the biggest tender they can get that will fit in the available space so clearances can be very slim at times!" *(Whatson, 2016)*

To store the tender, the following dimensions of the tender are decisive:

> height:

Looking at the current tender market, there is an upcoming trend that makes it possible to adjust the height of the sprayhood so it would fit inside more superyachts. In the leitmotiv of Dutchcraft, a fly-bridge or a sprayhood are one of the essential elements. For this thesis, the sprayhood is kept out of scope, but it is a feature that should be included after this project.

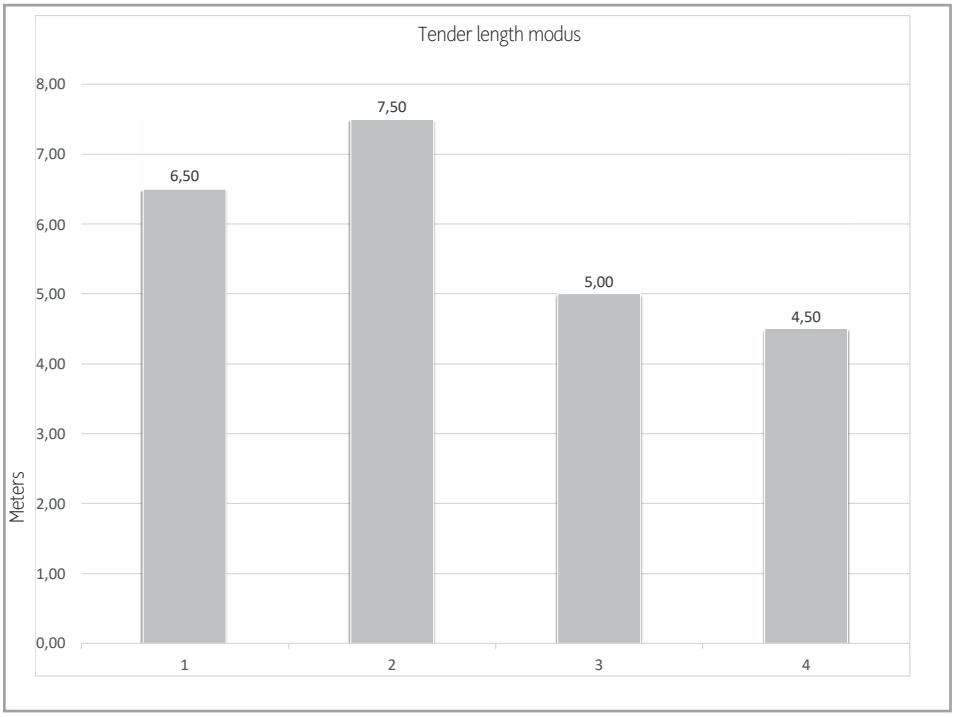
> length over all (LOA):

For the electric tender of Dutchcraft it is essential to know what the length over all (LOA) of the tender should be to maximize sales. Therefore, an analysis about the most common lengths of combustion tenders was performed. 315 superyacht with a length between 130 and 330-feet where analyzed to determine the length of the tenders on board.

The results of the analysis can be found in Graph 1, and 2 and all the collected data can be found in Appendix F. From Graph 1, most superyachts with a length between 130-feet and 330-feet do have more than one tender, and some even have up to five tenders on board. If there is only one tender, the modus is 6,50 meters (21,3-feet) (the superyachts that have more than one tender were excluded). When there are two tenders, the

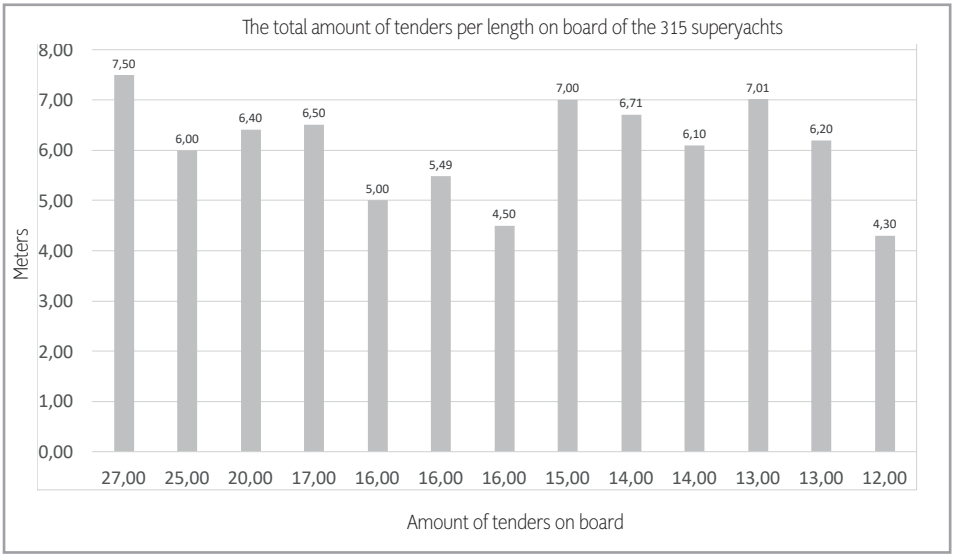
Figure 15: Space inside a superyacht
(Purchasing superyacht tenders - the data, 2017)

modus is 7,50 meters (24,6-feet) (the superyachts that have more than two tenders were excluded). When there are more than two tenders on board, the modus increases to 9,45 meters. Due to the little data about superyachts with three or four tenders, this data is not reliable. However, when there are more than three tenders on board the length of the tenders shorten to 4,50 meters (14,7-feet).



Graph 1: The modus of tenders when there are a certain amount of tenders on superyachts between 130 and 300-feet.

Graph 2: When looking to all tenders on board of all superyachts between 130-feet and 300-feet, it appeared that the modus is 7,5 meters (24,6-feet). The graph also shows that most tender's standard length ranges between 4,5 (14,7-feet) and 7,5 (24,6-feet) meters.



Graph 2: The tot amount of tenders per length on board of the 315 superyacht between 130 and 300-feet.

> width:

The research on the competitors has shown that a tender (electric and combustion) with a length of 7,5 meters (24,6-feet) has a width between 2.20-2.80 meters (Appendix G). When scaling the hull of the Dutchcraft 50-feet to 24,6-feet the beam would be 7,71-feet (2,35 m).

External analysis

Passenger capacity

Although, some tenders have the capacity to transport twelve people they often run ashore with a limited number of guests on board ("How To Choose the Best Yacht Tender | Yachting Pages", 2018). To choose the right capacity of passengers for Dutchcraft, the capacity of current tenders that are on the market were analyzed.

Research is conducted to evaluate how many people can board the current tender with an LAO between 5,5 and 10,0 meters. To see if there is a difference between electric boats and the current combustion tenders on the market, the passenger's capacity of the combustion tenders has also been studied. In Appendix E this data is visualized.

The number of passengers of combustion tenders and electric boats varies between six and sixteen passengers. Although, it is remarkable that the maximal capacity of electric boats is ten passengers and the maximal of combustion tenders is sixteen. The data showed that eight passengers is the average amount of people that can board the current electric boats. For combustion tenders, this average is ten passengers. As can be seen in the data the length of combustion tenders is longer than the electric boats. Although, this is not significant, because there are also combustion tenders with an LAO of 9,60 meters which can board only eight passengers.

Comparing the average passengers of electric boats with traditional combustion tenders, the average capacity of an electric boat is two passengers lower.

Figure 16: Transporting
(Tender Image Gallery from Tender to Tender, 2018)

Purpose/Activities

The primary activity of a tender is to transport people (Figure 16) (owner, guests and crew) and/or supplies from ship to shore and from shore to ship. (Crouch, 2015). Tenders are also often combined for other activities such as the entertainment of the guests like water-skiing, fishing or diving. In some cases, they are used for cleaning and maintenance of the superyacht by the crew. Hence, they are sometimes also used as a lifeboat (Superyacht Tenders & Toys", 2017). The activities of a tender are supported by the functions that the tender is equipped with. E.g., a function can be a water-ski pole for the activity water-skiing which determines the functionality of the tender.

To compete, Dutchcraft has to know what the competition is offering. Research showed that there are currently ten electric boats on the market. The activities of ten electric boats were evaluated by the activity list created form the user research. For every boat it has been evaluated whether the electric boat can support the activity. To do so, the list of items in Appendix E was used. The research looks into: the storage space, passengers capacity, performance, options and embarkation that is needed for each activity, if the boat is able to support the activity the brand is marked as a competitive brand in Figure 17.

Activity \ Brand	Boesch	Electric boat co.	Frauscher	Hickley Dasher	JP Ribs	Lillebror	Mylne	Q Yachts	Symphony boat	X Shore
transport ship to shore	V	V	V	V	V	V	V	V	V	V
diving	V	V	V	V	V	V	V	V	X	V
fishing	X	X	X	X	X	X	X	X	X	X
beach landing	X	X	X	X	V	X	X	X	X	X
explore trip	X	X	X	X	X	X	X	X	X	V
water-skiing	X	X	X	X	X	X	X	X	X	X
transport groceries	V	V	V	V	V	V	V	V	V	V
transport garbage	V	V	V	V	V	V	V	V	V	V
mooring superyacht	V	V	V	V	V	V	V	V	V	V
cleaning the tender	V	V	V	V	V	V	V	V	V	V
emergency situation	V	V	V	V	V	V	V	V	V	V
charging the tender	V	V	V	V	V	V	V	V	V	V
storing the tender	V	V	V	V	V	V	V	V	V	V
launching the tender	V	V	V	V	V	V	V	V	V	V

Figure 17 : Activity evaluation

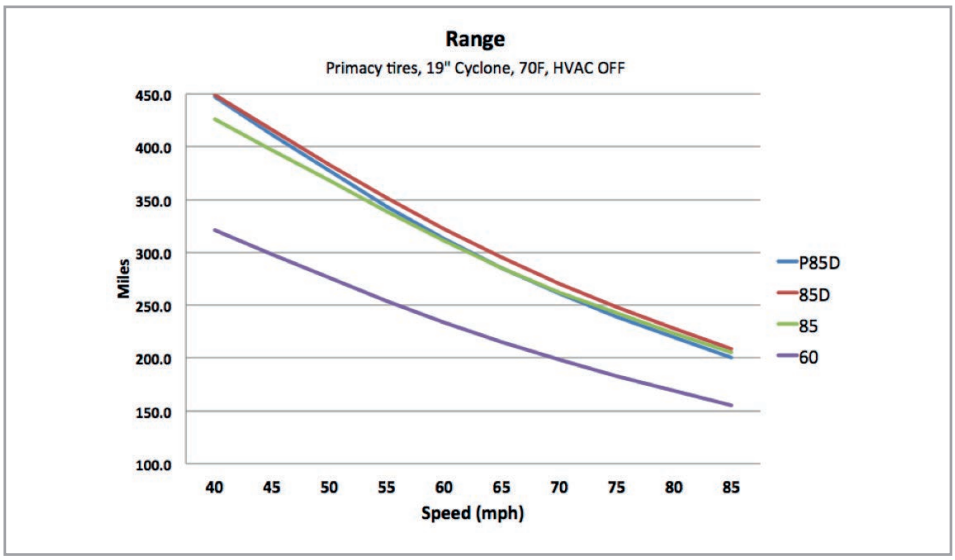
Transports and supporting the superyacht can be done by all boats. Climbing in and out the water to swim, cannot be provided by Symphony boats. Q-Yachts is the only boat that has a small cabin in the front that allows to sleep and includes a small bedroom. X-shore has an open deck to carry toys. Fishing, and water-skiing are not supported by the current electric boats. There is a speedboat on the market from JB-Ribs that is fully electric and allows water-skiing, but it is still in a conceptual stage. The problem with water-skiing is that the boat has to go full speed and this requires a lot of battery capacity. With the technology right now this will allow water-skiing for only one hour (5. Technology). The only electric boat that can do a beach landing is one of the JP-Ribs because it has a jet-propulsion and all the other competitors have a straight shaft drive which does not allow to navigate in shallow waters. Since, this boat is still a conceptual 3D-drawing, and therefore, there are technically no electric boats that do provide a beach landing.

The research also looked into tenders with a combustion drive-train (Appendix E) and it seems that there are tenders on the market like Xtenders that provide more activities into one tender. They do not yet make electric tenders.

External analysis

Performance

Two factors, speed and range, determine the performance of a tender. Those two factors are inversely proportional with each other because more speed will ensure less range (within same power efficiency). Graph 3 shows this inversely proportional effect with the different types of Tesla models and their battery packs.



Graph 2: The modus of all tenders on superyachts between 130 and 300-feet.
(Driving Range for the Model S Family, 2014)

"A tender that is primarily used for water-sports, for example, will need to have a fairly large fuel tank due to the speeds needed and also to keep guests entertained." *("How To Choose the Best Yacht Tender | Yachting Pages", 2018)*

The performance of tender is depending on its purpose. For water-sports or trips, the tender needs to have a more extended range (larger battery capacity) and higher speed (larger engine). For transporting from and to shore, the range is of less importance. A water-sport such as water skiing requires performance up to 25 knots (Bostian, 2018) and needs more than one hour of full throttle.

"Some owners love to go fast. However, most guest transfers are under 30 knots, and speed is not especially important. Limousine tenders typically do between 16-25 knots. Otherwise, guests are rattling around in the cabin like a can of baked beans." *(Richardson, 2017)*

According to Richardson, it is not clear what the cruising speed should be for the electric tender of Dutchcraft. Therefore research was conducted to determine what the current electric tenders are offering.
In the next part, the performance of ten electric competitors is analyzed.

4.3 Electric competitors

How can Dutchcraft enter the market with a competitive product?
To indicate how Dutchcraft can enter the market with a competitive product it is necessary to know how they can distinguish themselves. It appeared that, nowadays there are ten competitors on the market that have an electric inboard motor. Those are analyzed to show Dutchcraft how they could enter the market with a competitive product. The data of the analysis is presented on page 28 and 29. This rough data can be found in Appendix G and H. To gather all this data, a literature study was conducted.

First, for every brand, the main specifications of the electric drive-train were researched (motor and battery). The summery can be found on page 28 and 29 in the left column.

Secondly, a spiderweb diagram presents a comparison of the four main properties of each tender brand. The performance was divided into speed and range and additionally, the price is added as a parameter to evaluate. The price was added due to the core competencies of Dutchcraft, since they want to offer a low-cost product. When taking a closer look, the selling price is the only parameter that has his maximum in the middle of the diagram. The diagram shows that when the price is high, the area of the diagram is small, and the competition with the brand is less (page 28 and 29). The score of th total functionalities in de spiderweb diagram was the restult of the activity evaluation that was made in 4.2 Current tender.

Lastly, a bar chart (page 28 and 29) was made with values about the options that the tender has or can have. These options were divided into five categories; electric, sanitary, comfort, design and other extra options. To quantify the five categories of the bar chart, one point was given to each option the tender has. Then all scores for each category were summarized. The score list for each brand can be found in Appendix H. The total score of each category resulted as a score, that is represented as one bar on the graph (page 28 and 29).

The spiderweb diagram shows that the diagrams with the biggest gray areas are the most competing brands for Dutchcraft. These are:

1. Electric boat co.
2. X-shore
3. Q-Yacht
4. Frauscher

Cruising
(Tender Image Gallery from Tender to Tender, 2018)

Drive-train specifications

Spiderweb diagrams

Bar charts

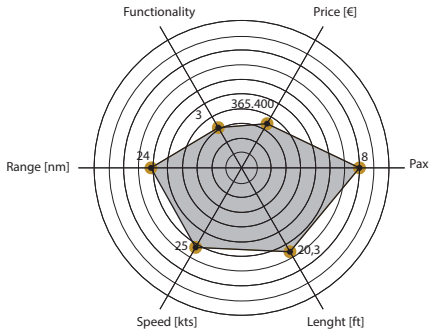
Straight shaft drive

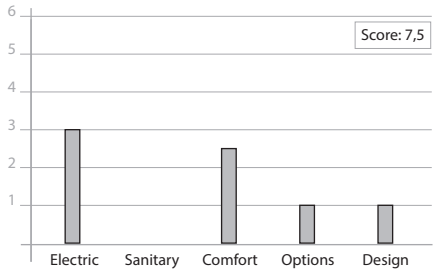
2*50 kW

SAMSUNG 2* 37 kWh

Options
2*80 kW
2*100 kW

2* 50 kWh

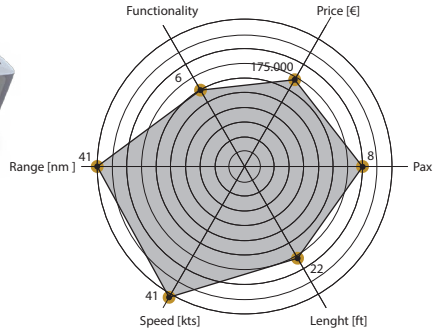


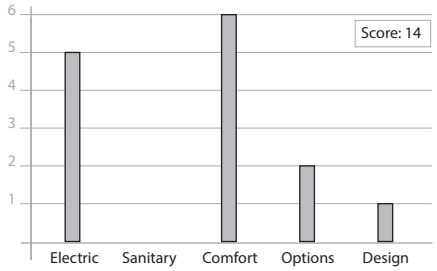


Straight shaft drive

100 kW

SAMSUNG 100 kWh

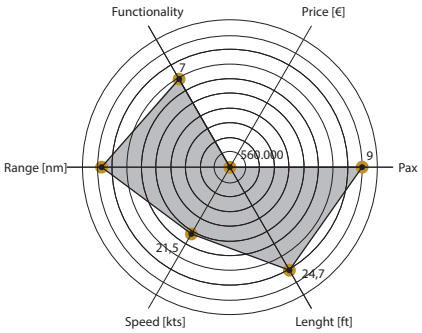


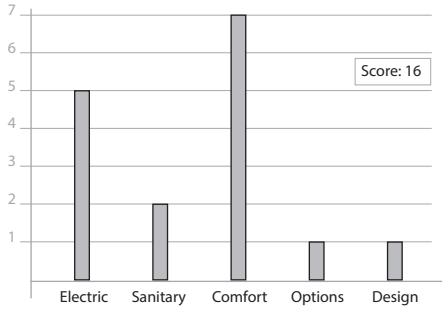


Straight shaft drive

55 kW

30,5 kWh

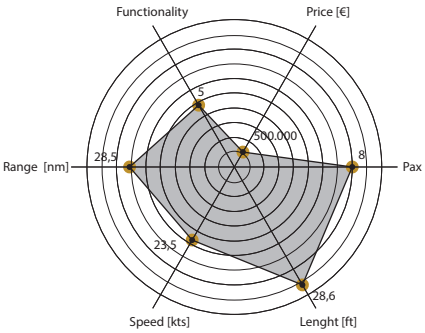


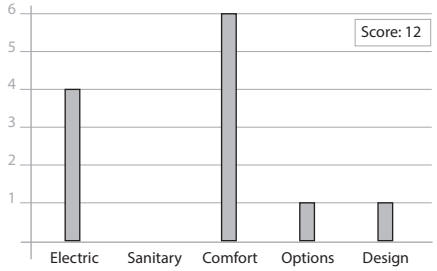


Straight shaft drive

2*55 kW

2*30,5 kWh

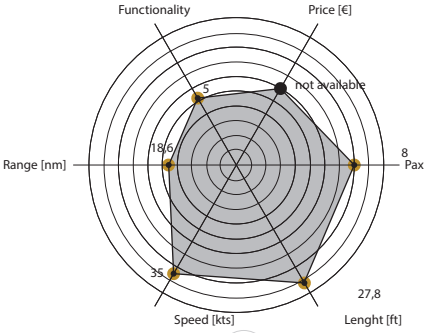


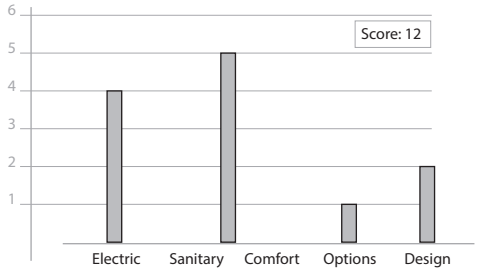


Jet drive

220 kW

kWh



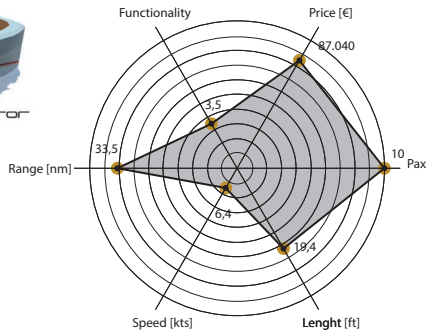


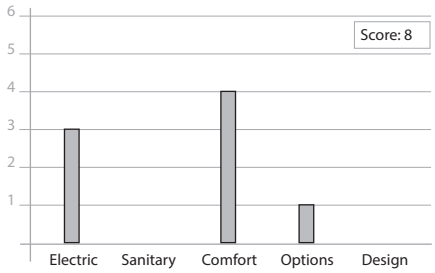
LILLEBROR

Straight shaft drive

torqeedo STARNBERG GERMANY 10 kW

torqeedo STARNBERG GERMANY 12,2 kWh



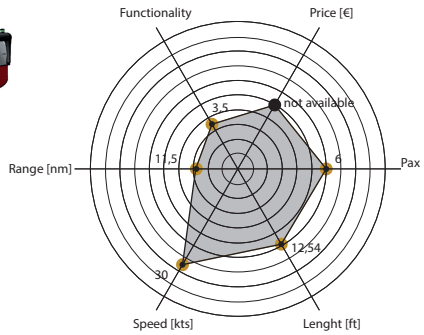


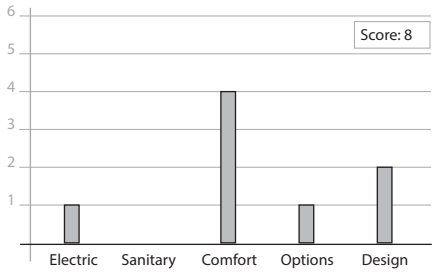
MYLNE CLASSIC YACHT DESIGN 1896

Straight shaft drive

20 kW

30 kWh



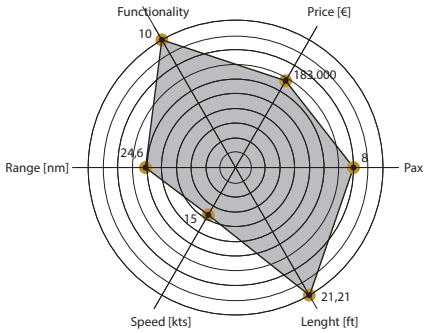


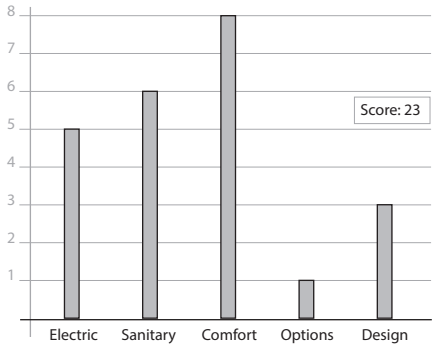
Q YACHTS

Straight shaft drive

OCEANVOLT 20 kW

OCEANVOLT 30 kWh



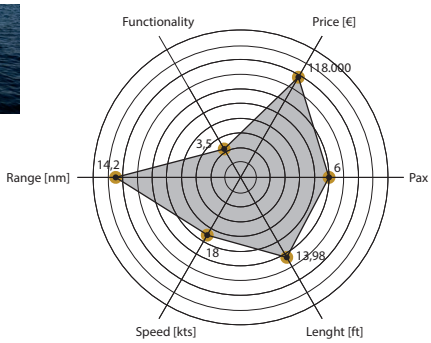


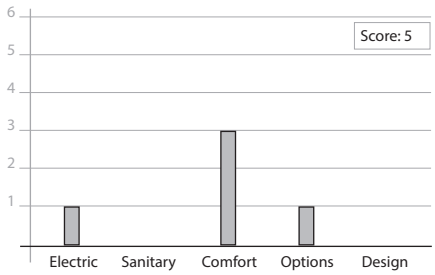
Symphony boat

Straight shaft drive

torqeedo STARNBERG GERMANY 55 kW

BMW i 30,5 kWh



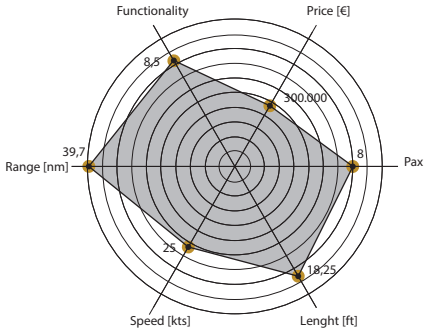


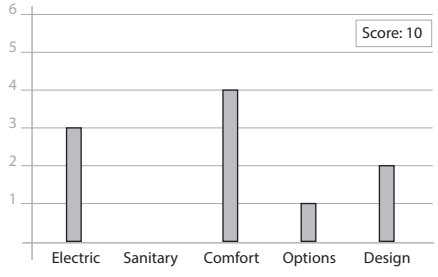
X SHORE

Straight shaft drive

torqeedo STARNBERG GERMANY 2*55 kW

BMW i 2*30,5 kWh





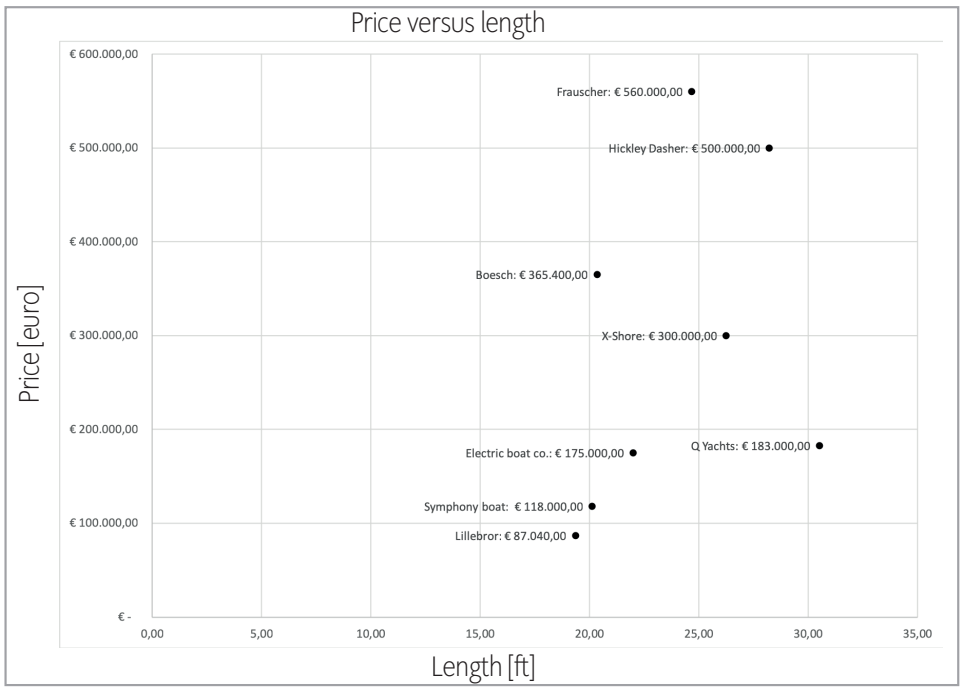
4.4 Product positioning

How does Dutchcraft need to set its price to be competitive?
An indication of the selling price is made based on three customer needs/specifications; length, speed and range. The length was the only specification that was determined during this thesis. The speed and range are specifications that will be determined in a later stage of this project because they have to be calculated by a naval architect. Three graphs are created for every specification for Dutchcraft so they can set the selling price later in the project:

> Length versus price
What is the selling price for a 24,6-feet electric tender so Dutchcraft can compete?
The first question people always ask when they see a boat is; what is the length and selling price of that boat? Accordingly, the length of a tender is also used as a measurement tool for the selling price to make a consideration when buying a tender (Van den Berg, 2018). Therefore, it is essential for Dutchcraft to know what the selling price is for a 24,6-feet (7,5 m) tender.

A graph was created (Graph 4) with the same data that was used to create the spiderweb diagrams. In Graph 4, the selling price versus the length of the current electric tenders can be found. The graph shows where Dutchcraft can position their electric tender to have an advantage over their competitors.

When plotting the 24,6-feet (7,5 m) in the graph, the indication of the selling price is between 175.000 and 280.000 euro. Competing with Q-Yachts is not necessary, their drive-train performance is too low (40 kW engine). If they would implement a bigger drive-train, with higher performance up to 100 kW, the selling price will be 40-50.000 euro higher (5. Technology)

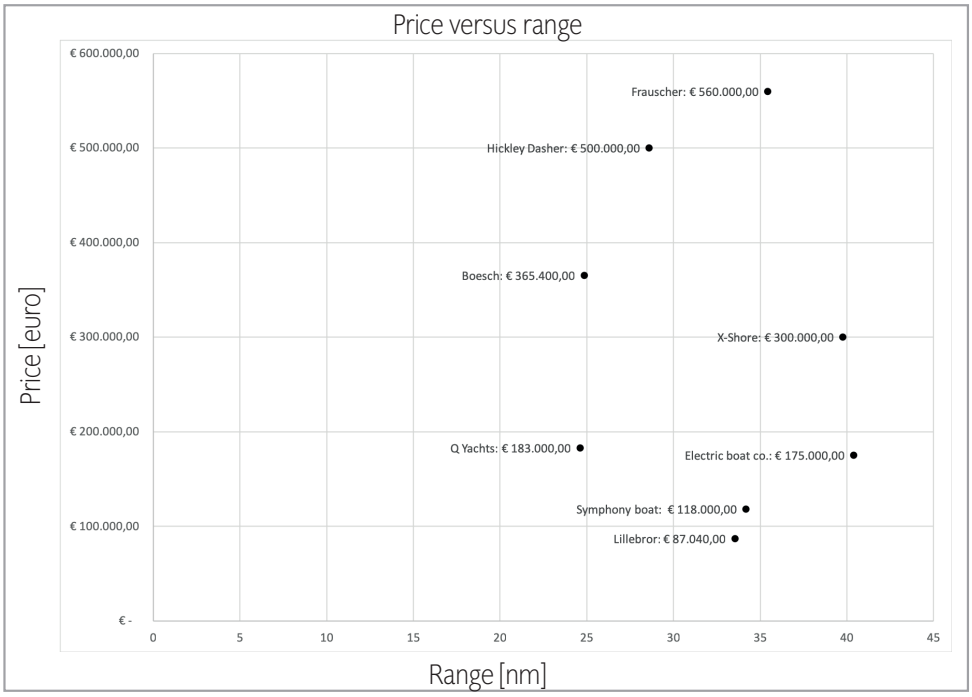


Graph 4: Price versus length

> Range versus price

What selling price can DutchCraft ask if they offer a tender with a certain range?

Therefore, Graph 5 shows the selling price and range of the ten competitors. In the graph a blue line indicates the average selling price for a certain range. The range will depend on the battery pack that will be selected for the tender, therefore, no price could be indicated yet. Together with the price estimation for the length of the tender, Dutchcraft can find a price positioning for their electric tender. The maximal range currently offered by the competitors is 40 nm.

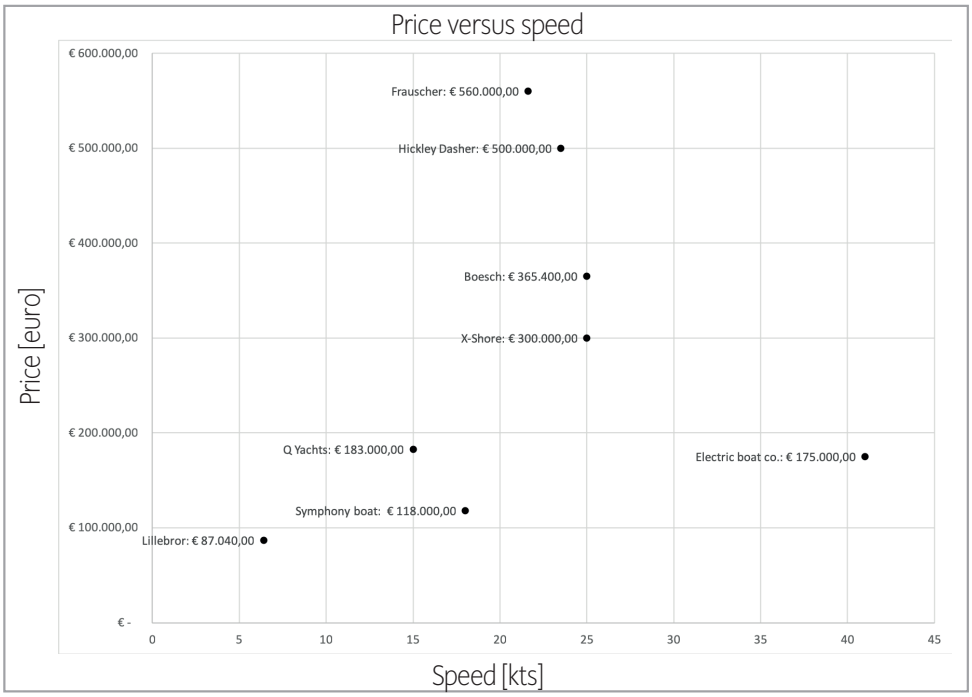


Graph 5: Price versus range

> Speed versus price

What selling price can DutchCraft ask if they offer a tender with a certain speed?

The actual speed of the tender cannot yet be determined; this has to be done by a naval architect. Thus, the selling price for this specification cannot be set. If Dutchcraft knows the speed, they can set a selling price on the speed their tender can provide. In Graph 6 they can plot their speed to see what the price will be. The maximal s currently offered by the competitors is 41 knots.



Graph 6: Price versus speed

4.5 Regulations

What standard regulations does Dutchcraft need to follow?
The global regulation SOLAS for pleasure craft, has requirements that must be respected for vessels longer than 7 meters (Solas V Safety of Life at Sea, 2018).

> Navigational system and equipment
This regulation requires vessels at sea to carry specific equipment on board which will enable someone to navigate safely. Such as:

- A properly adjusted standard magnetic compass
- A hand-bearing or other compass
- Charts and navigational publications
- Radar reflectors

> Electromagnetic compatibility
The regulation requires that electrical and electronic equipment shall be installed so that electromagnetic interference does not affect the proper function of any navigational systems or any other equipment on board that is relied on for the safety of the vessel.

> Records of navigational activities
If you are on an international voyage, you must keep a record of navigational activities and incidents which are important to the safety of navigation and which are sufficiently detailed to be able to restore a complete record of the voyage.

> Life-saving signals
The regulation requires you to have access to an illustrated table of recognized life-saving signals. (e.g., flares)

5. Technology

Dutchcraft is unaware of the current electric drive-train technology that is available on the market. Dutchcraft wants to finish this project over one year. Therefore, the company is looking for a drive-train that can be implemented immediately. Because of this, research into the currently available technology was conducted and a suitable drive-train was recommended in chapter 7. The focus of the research was on three components of the drive-train; the propulsion system, the electric motor, and batteries (Figure 18)

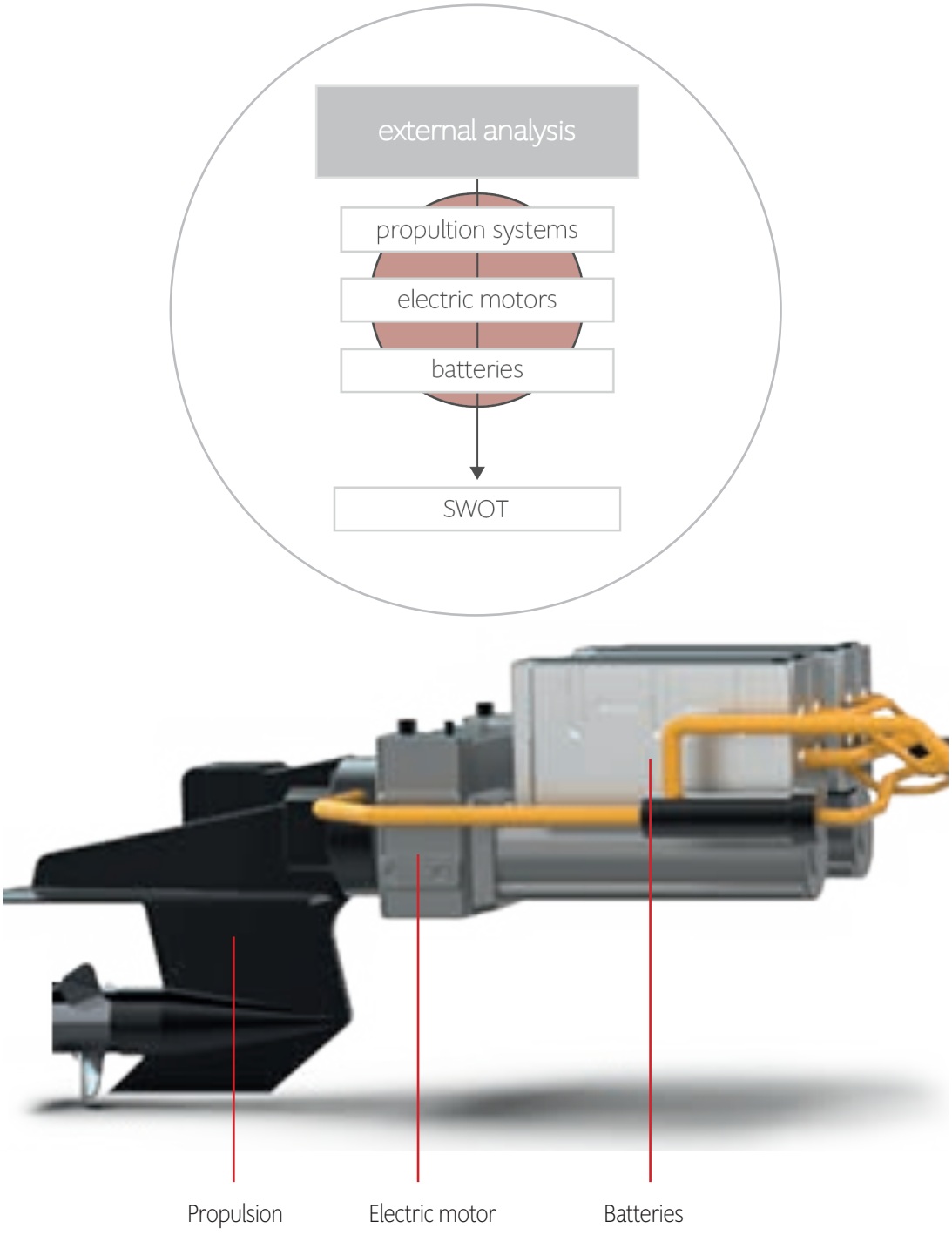


Figure 18: Electric drive -train

5.1 Propulsion

Which propulsions are suitable for the tender of Dutchcraft?
This project looked into three main components for the drive-train; the propulsion, the electric motor and battery pack.

When studying the competitor analysis it is clear that both the straight shaft drive and jet-propulsion are already being used on existing electric boats. Experts confirmed that a sterndrive could also be used in combination with electric motors. This makes that three options could be used as a propulsion system for the electric tender of Dutchcraft (Figure 19). An outboard motor could be an option as well, but it does not address the form language of the tender.

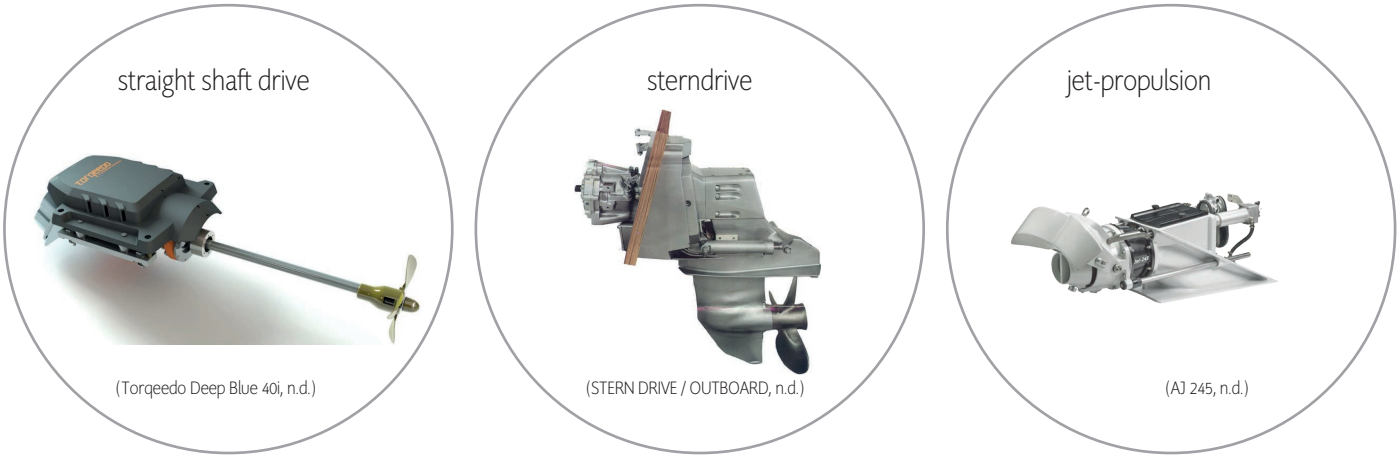
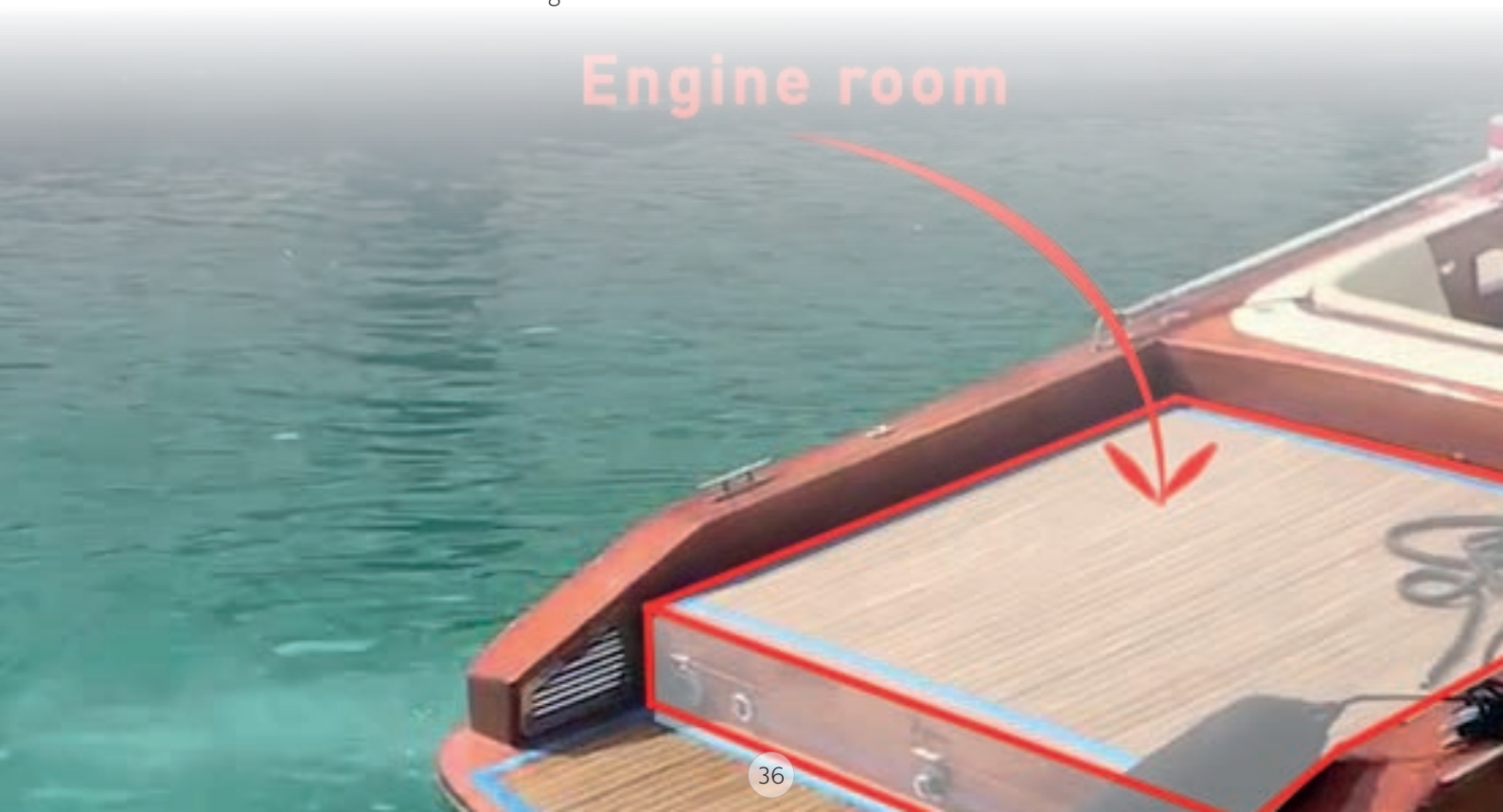


Figure 19: Propulsions systems

When comparing a sterndrive and a jet-propulsion, it seems a jet has a lower efficiency than a sterndrive (Linn, 2017) and a jet-propulsion will be more efficient with speeds up to 25 knots (Alamarinjet, 2018). Efficiency is significant because the energy density of the battery compared to diesel or gasoline is lower ("Will Batteries Ever Match Gasoline's Energy Density? | Menlo Energy Economics", 2012). When comparing the three options, it shows that a straight shaft drive is the only driver which is not able to navigate in shallow water and therefore not able to make a beach landing.



5.2 Electric motor

In total ten different brands were found and compared with each other (Appendix K). In chapter 7 recommendations are made to select the right drive-train for the tender. The most interesting comparison is between the combustion engine and the electric motor because there is a significant difference between the dimensions and weight.

In Figure 20 an electric motor with an equivalent performance is compared with a combustion engine. The electric motor with an equivalent performance is smaller than a combustion engine. Therefore, it needs less space to implement. When observing combustion tenders it can be concluded that the deck in the back is higher (Figure 21) because of the size of the combustion engine that needs this space for implementation. Another solution that is often used is a fixed bench or seating on top of the engine to increase the engine room. Due to the smaller size of the electric engine, the deck does not have to increase which can offer new opportunities.

The weight of the electric engine is 95 kilograms and the weight of the Yanmar is 400 kilograms (wet). This results in a weight reduction of 300 kilograms or 75%.

Yanmar 125 kW (combustion engine) versus the Piktronik 125 kW (Electric motor)

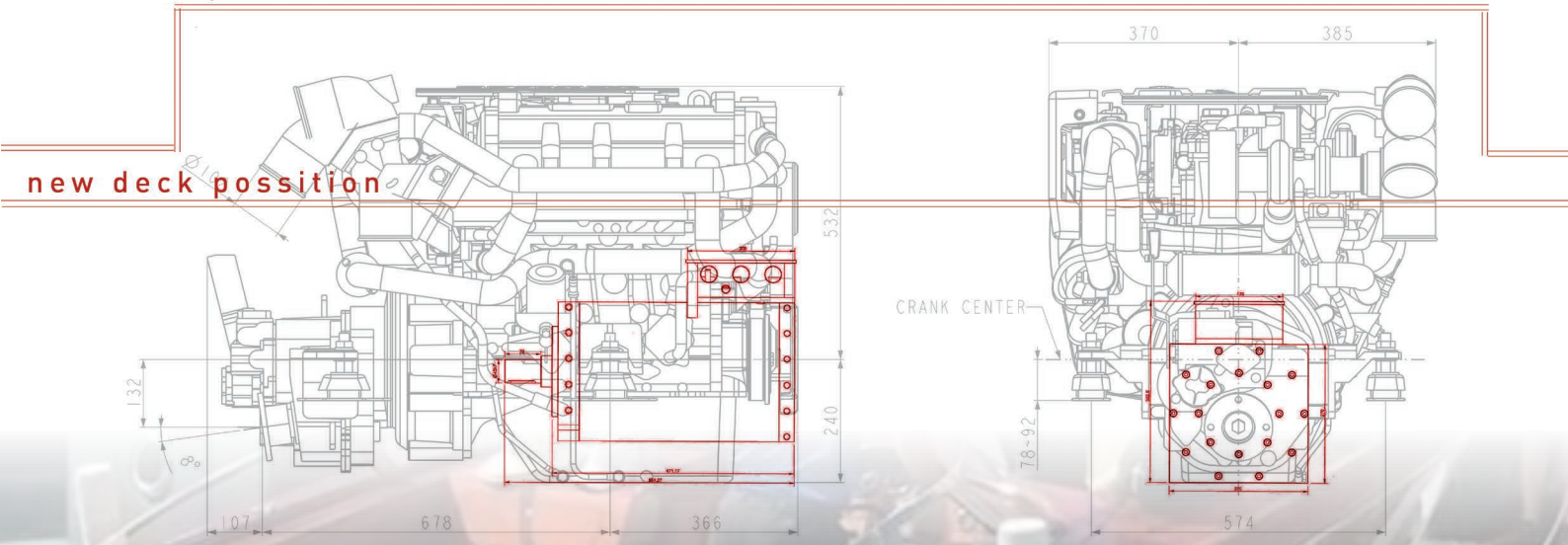


Figure 20: comparison of both equivalent engines

Figure 21 :High engine room
(Onboard a Superyacht: Recovering Tenders James Bond style!, 2018)

5.3 Electric battery pack

Like the electric engines, there is a whole range of battery packs available (Figure 22). Although, gathering specifications about the battery pack technology is hard and mostly confidential. The difference in the battery packs is mainly the price per kW and the energy density. The energy density is a major issue with battery packs. Nowadays, the density is still too low which makes that constructors of electric cars, trucks or boats are not able to offer a product with a range that is similar with combustion engines. However, the technology of electric batteries is still improving and suppliers are constantly launching new battery packs.

The actual weight of a 100 kWh battery is 600 kilogram but the manufacturer of UQM is working on a plan to introduce new cells next year with 30% more capacity (Montagne, X. 2018). According to the electric battery specialist from the company UQM in France, the energy density is about 200 kW/m3, and according to the company Piktronik, this is 220 kW/m3.

The energy density of electric battery packs degrades. According to the last data of the company Tesla motors, their battery packs have a degradation of 10% after 250.000 kilometers (Lambert, 2017). With an average speed of a car of 60 km/h, this is 4000 hours. Since, the average recreational boat logs only about 200 hours per year ("The Life Expectancy of the Marine Engine - BoatSafe.com", n.d.), this means the lifetime of the batteries would be 20 years for a degradation of 10% .

The price of battery packs is divergent. The car builder Tesla motors proclaims that battery prices will drop within ten years with 80% (Lambert, 2017). The cost of electric battery packs is currently between 500 and 650 euro for one kWh (Piktronik,2018 - Akasol, 2018). If this drop to 100 euro for one kWh will happen it is not sure since it has been said that the battery price in 2010 would also drop from 1000 euro to 227 euro for one kWh in 2016, and this did not happen (Lambert, 2017).

Comparing the battery pack and the fuel tank for 125kW motor

From the data of the combustion competitor analysis Appendix G; a fuel-thank for a combustion engine with 125 kW is around 100 liters. The consumption of the 125 kW (Yanmar) is around 40 l/h. When performing full speed, the vessel can navigate for 2,5 hours.

If 2,5 hours is the starting point, the tender should have a battery pack of 312,5 kWh when performing full speed and the weight of the battery pack needs to be 1.875 kilograms to have the same performance. That is a difference of 1.775 kilograms and too heavy for a tender, even after the reduction of the weight of the engine.

Figure 22: Some available battery packs
(BATERÍA MARINA 24 V / LITIO / DE IONES, n.d.)
(RS SERIES, n.d.)
(AKARACK | AKASYSTEM AKR - THE FLEXIBLE ENERGY PACK, n.d.)

5.4 Advantages and disadvantages of the electric drive-train

Comparison of the advantages and disadvantages of an electric and combustion drive-train.
The list was created with all the information gathered during the research of the electric drive-train and ordered according to the needs of the target group. The list can help the company with selling their product.

Advantages

Maintenance
> There is no need to winterize the motor.
> No oil changes needed.
> Low maintenance (once a year).
> No fuel filter to clog.

Comfort
> There is no exhaust smell.
> The owner does not have to worry about fuel quality or water contamination in the fuel.
> Low no noise and vibration.
> It acts as a hydro generator when sailing.

Safety
> No risk of carbon monoxide poisoning.
> There is no risk of oil leaks or oil spills.
> It is environmentally friendly since it uses no oil or fossil fuels.

Storage space
> The engine is smaller than a combustion engine in size and light weighted.
> The deck does not have to be adjusted to the shape of the engine.
> The battery packs can be arranged to create more weight distribution.

Practice in use
> It starts up immediately without needing to warm up.

Performance
> It provides instant torque and has speedy throttle response.
> Less moving parts to fail.
> It can recharge with solar panels and wind generators.

Price
> Long and short-term costs are less.
> The cost of replacing dead batteries is less than the cost of fuel consumed over the same distance.
> The owner will save much money on fuel costs.
> The electric motor is cheaper to buy, and the parts are also inexpensive when compared to a similarly powered diesel motor.

Disadvantages

Maintenance
> Parts are not readily available around the world, as they are not standard components.
> Skilled and qualified labor are hard to find.
> When it fails, the cause is not always apparent.

Safety
> High voltage provides extra safety requirements.

Storage space
> The range is limited to the size of the battery bank.

Performance
> The weight of the battery bank can add up quickly.
> The range can be supplemented by using a generator, but the speed will be limited by the size of the battery charger.
> Electronic components on a boat are prone to corrosion caused failure.
> Deep discharging is damaging to the batteries.
> Battery technology has a long way to go to provide the amount of the range of a fuel tank.

Price
> The battery bank is still an expensive investment.

6. SWOT

A SWOT structure (Ansoff, H.I., 1987.) was used to point out the opportunities and challenges that Dutchcraft is dealing with. The SWOT was based on the strengths and the weaknesses that resulted from the internal exploration of the company (Chapter 2) and the opportunities and the threats that came out of the external analysis (Chapter 3, 4, and 5). To find new business opportunities the insides form the SWOT were used in a matrix to find relevant search areas (Appendix H). The results were implemented into the design brief (Chapter 8).

Strengths

- Dutchcraft is strong in offering a multi-activity product.
- The company does have in-house knowledge about electric drive-train technology.
- Dutchcraft is able to deliver a product with a high quality to their potential customers.
- Zeelander is strong in building with high-end finishing. (SWOT analysis of Zeelander, 2016)
- The company offers more than semi-custom products.
- Dutchcraft is strong in designing at low costs.
- The company is strong in detail engineering, management and assembling.
- The company has a well-established network with suppliers that could help them out with the electric drive-train technology.

Weaknesses

- The company has no experience in 25-feet electric tenders.
- The core competences are not hard to copy or to pursue by competitors.
- The company sometimes builds without any customization what makes it hard to sell .
- The company does not have enough employees to work out the project.
- The company does not have enough space to build.
- The company does not have enough marketing and sales teams to bring this product into the market.
- The company does not have a naval architect in-house.

Opportunities

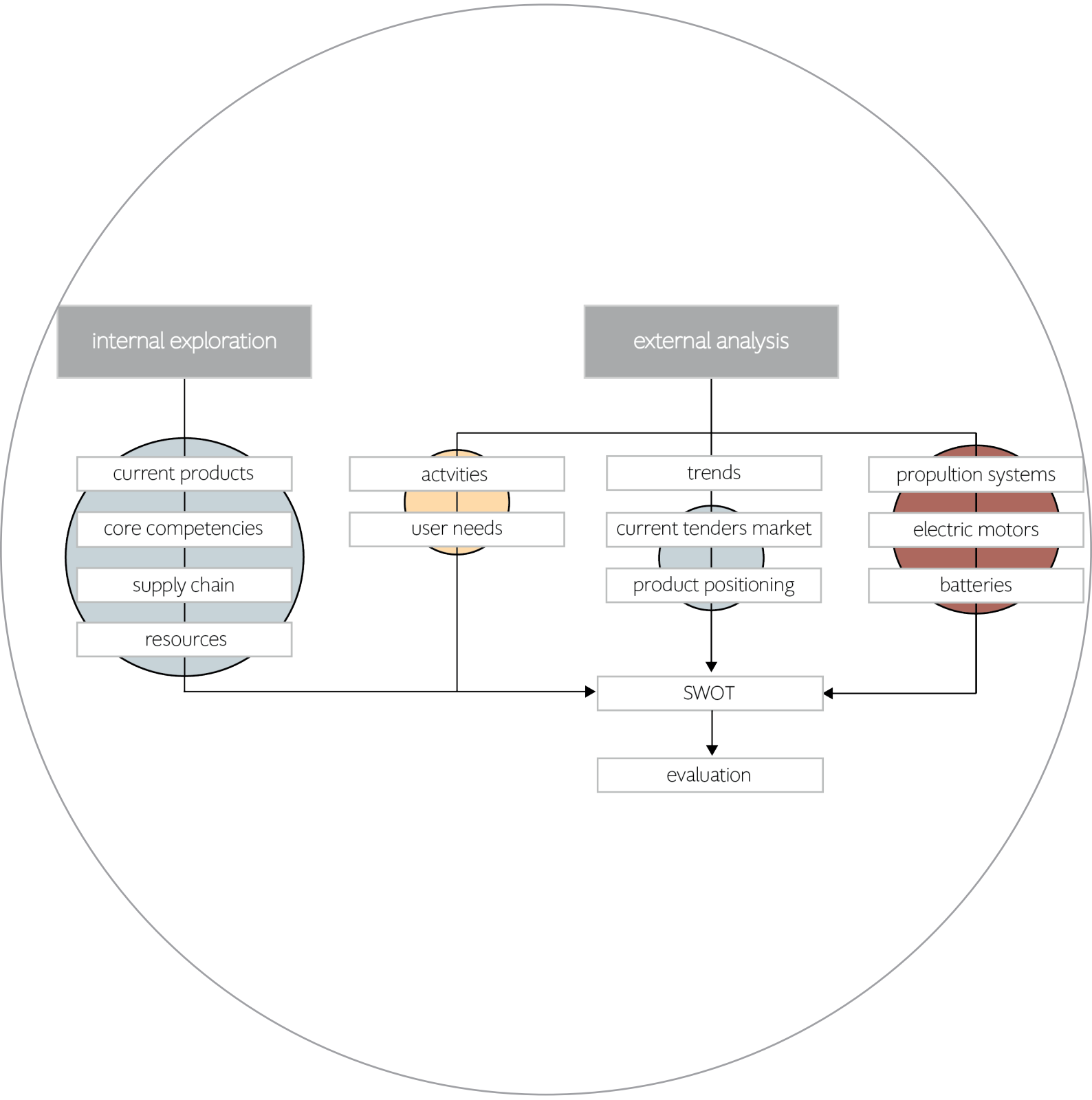
- An electric tender that is able to do a beach landing.
- An electric tender with a length of 24,6-feet (7,5m).
- An electric tender for a selling price lower than 280.000 euro.
- An electric tender with a broader range of activities than the current competitors so superyacht can have less tenders on board.
- An electric tender that supports more land activities.
- Getting involved in a yacht project at the start of the project. So they can adjust the superyacht to the tender of DutchCraft and not the DutchCraft to the space of the superyacht.
- Flexible range of tenders with different lengths to serve even more superyachts.
- An electric tender that has more passengers capacity than eight.
- A limousine electric tender.
- Keep up with the changing technology of batteries. The battery capacity per volume is getting higher.

Threats

- Current brands offering tenders with a combustion drive-train who offer a broader range of activities can make the switch easily to electric.

7. Evaluation

Before creating a conceptual proposal for Dutchcraft an evaluation of the previous analysis is made. In this evaluation, the conclusions and recommendations for Dutchcraft are described. Also the first part of the problem definition is answered; exploring the design space for the electric tender design for Dutchcraft (i). Afterwards, the evaluation is converted into a Design brief which is the starting point of the Synthesis. These will give further direction for the conceptual proposal.



7.1 Conclusion

Competencies

The company based their new brand Dutchcraft on experience and market research which they conduct each year. These sources are reliable and substantial for their core competencies. Dutchcraft can use the same core competencies as they did with their 50-feet model.

Although, the three core competencies of Dutchcraft (Function-driven, Value for money, Semi-custom) are not that hard for competitors to copy. Dutchcraft is aware of this and therefore, they did not make their first model public until it was finished. However, the company has two yachts now that are finished and still in stock (one Dutchcraft 50-feet and one Zeelander 44-feet). The finished yachts are not able to be customized making them less attractive for customers to buy. This is contrary to their core competencies of offering a semi-custom product.

Superyacht owners like to show their status with their tender and want their tender to have a luxurious look and feel. As Dutchcraft can use the expertise of Zeelander, creating a more luxurious tender is not a problem.

Resources

Currently, the company does not have enough resources (Figure 23) to start this project. Since they are currently missing an extra project manager, a marketing manager, and a sales team to build and promote the tender. However, the relations the company has with their current suppliers are strong and will give them support to develop, promote and sell the electric superyacht tender. Besides this, there is not enough space available at the shipyard to develop or to build the electric tender. They also do not have customers in their current customer database that could store a tender of 25-feet on their yacht.

Figure 23: Unavailable resources

Users

The owner expects that the tender is always in perfect condition and uses the tender only a couple of times per year. The owner considers the image and first impression of the tender. The guests are interested in entertainment, comfort, and safety and, they use the tender the least of all users. For the crew, it is essential that the tender is practical in use, has a fit with the superyacht and, is easy to clean and maintain. Concluding, the needs and demands of the owner and guests are more critical even though, the crew uses the tender most.

Fit with superyacht

The most common tender length on board of most superyachts with a length between 130-feet and 330-feet is 7,5 meter (24,6-feet) . The second most common length is 6,5 meter (21,3-feet). The width of a tender with 7,5 meter is between 2.20-2.80 meters.

Passengers

For the passengers capacity there is concluded that the tender needs a maximal capacity of eight people (Figure 28) to support the required activities. When it comes to the seating arrangement each activity requires a different amount of seats and stored items.

Activities

Dutchcraft is focusing on facilitating different activities on the water according to the opportunities in the market. From the research, there can be concluded that the activities Dutchcraft is offering with their 50-feet yacht are different and are not covering the activities a tender should fulfill. The missing activities are: water-skiing, charging the tender, launching the tender, storing the tender, mooring the superyacht and making a beach landing. Besides the water activities Dutchcraft does not focus on land activities such as transporting bicycles or quads. Concluding from the user research, it appears that a tender has to support the following activities and therefore needs a certain amount of seating and storage space (Figure 24).

Activity	Seating		To store	
transport ship to shore	6 Pax.	2 crew	bags	drink and snacks
diving	6 Pax.	2 crew	diving items	
fishing	4 Pax.	2 crew	fishing items	
beach landing	6 Pax.	2 crew	BBQ items	
explore trip	2-4 Pax.	2 crew	trip items	
water-skiing	4 Pax.	2 crew	water-ski items	
transport groceries	-	2 crew	groceries	
transport garbage	-	2 crew	garbage	
mooring superyacht	-	2 crew	mooring lines	
cleaning the tender	-	-	cleaning items	
emergency situation	-	-	rescue items	
charging the tender	-	-	charging items	
storing the tender	-	-	-	
launching the tender	-	-	-	

Figure 24 : Activities and seating

Electric competitors

From the market analysis, it can be concluded that there are currently no electric boats on the market that combine more than 78% of the activities (Figure 24). The storage space on superyachts is becoming too small for all different toys and tenders.

There is currently only one brand that provides beach landings and not one brand that provides fishing.

Performance

The performance of the electric drive-train is still lower than a combustion drive-train. Whereas, the battery capacity does not yet allow to cover the same range as a combustion drive-train. To offer the same range as a combustion drive-train, the battery pack is 1875 kg and 175.000 euro. Concluding, the performance of an electric boat with a length of 7,5 meters is still limited for activities that need more than one hour full speed navigating such as water-skiing.

Product positioning

Superyacht owners are UHNW individuals who can consume whatever they like. However, they are sensitive when it comes to the price. Therefore, if Dutchcraft succeeds in reducing the design costs and creating a luxury look and feel they can offer a competitive product in the market of electric tenders. On the other hand, reducing the design costs is also important due to the high purchase price of the drive-train. To conclude, the price of the tender should be between 175.000 and 280.000 euro to offer a competitive product.

Deck

The electric drive-train requires a different arrangement than a combustion drive-train. The electric motor is smaller, and therefore, the deck does not need any increases to fit the motor. Allowing the deck to be one flat surface creating new opportunities for the arrangement on the deck.

7.2 Recommendations

Supply chain

To have the biggest purchasing chance on the market, Dutchcraft should build a 7,5 m (26,4-feet) tender. When Dutchcraft wants to start building, it is recommended not to start before an order is placed, or if they start to build before an order is placed they should keep enough space for the customer to customize their tender. The customization should include not only the aesthetics (color, materials) but also different activities the tender can offer. The tender should give a solution for every activity to enable customers to choose what activities they want their tender to support.

Resources

A good marketing and sales strategy is crucial to sell the tender before the start of "buy 4". When the clients are involved earlier, the tender can be more customized. Therefore, it is recommended, that an extra marketing team should be recruited. Next to this, the company should make publicity via Tender and Toys as this is a well-known magazine in the yachting world and would be a good starting point for marketing the electric tender. As Richardson, the owner of Tenders and toys stated "Increasingly manufacturers come directly to us, however, sometimes it is the owners, captains and crew that come to us. If they see something they like, either on another yacht or in an article somewhere, they come to us with a request." (Richardson, 2017)

To increase the sales of the tender, brokers have to be motivated as well.

The space of the shipyard is too limited to build both Dutchcraft and Zeelander models. Creating more space for the build of the 25-feet tender is thus necessary.

Moreover, the scaled hull should be analyzed by a naval architect, as they are able to improve the performance, stability, and calculations of the speed. This is an essential step before the detail engineering. E.g. naval architects could be used to calculate the position of the foilers. Since the foilers can reduce the water displacement and improve the performance. Applying them to the tender of Dutchcraft is recommended and has to be further discussed with a naval architect. Therefore they were out of scope for this project.

The company does have resources which could be helpful for the further development of this project. As the company has obtained a strong network of suppliers that could provide them with upcoming features. Dutchcraft is new in the market of full electric drive-trains, and therefore it is essential to gain new in-house knowledge about technology. They should use knowledge of the electric engineering company they work with as a starting point.

Activities

If Dutchcraft wants to offer a unique product on the market, they should offer a full electric tender that can combine more than 78% of the activities that were found in the process tree and they should keep their core competencies but improve the luxury look and feel. Two activities that must definitely be included are a beach landing and fishing because none of the competitors is supporting these activities. Next to water-activities, they should also offer a tender that can support activities on the land. Such as, transporting bicycles, quads, segways etc. Combining more activities into a new product will allow the owner to have fewer tenders on board and create more space for other toys. It is recommended that the company does not focus on the water-ski activity because in this case a high-speed performance is required which cannot be provide by the current electric battery packs .

To make a beach landing this tender should have a front embarkation solution as the design of the hull of has a high bow of 165 cm and is very sharp.

Recommended drive-train

The performance of the competitors was analyzed before a recommendation could be made. For this project, a maximal cruising speed of 20 knots is recommended. From the competitor research, there can be concluded that the power of the combustion engine should be 110 kW when the tender has a maximal cruising speed of 20 knots and an LOA of 25-feet. This 110 kW boat uses a straight shaft drive (Appendix G) which has a higher efficiency than a sterndrive. The efficiency of the shaft drive depends on the angle the shaft makes with the water which differs from boat to boat (Linn, 2017). Because of the lower efficiency of the sterndrive, it is recommended that the electric motor should provide 125 kW.

> Propulsion

When designing a drive-train for a boat, it starts with selecting the propulsion system (Stevens S.,2018). To serve the activity of making a beach landing, and to have the highest efficiency, it is recommended to use a sterndrive and not a jet-propulsion because the efficiency is higher.

An exploration was performed on all different sterndrive on the market and can be found in Appendix J. Selecting the right sterndrive will depend on the performance of the tender, the weight of the sterndrive and the price. With those three requirements, the sterndrive of Mercury alpha one (Figure 25) was selected, this driver is currently the smallest sterndrive on the market and can handle a maximal input of 186 kW and 4400-5200 rpm ("Mercury Marine | Drives Alpha One®", n.d.)

> Electric motor

After selecting the sterndrive, the electric engine was recommended. In total ten different brands were found (Appendix K) and compared with each other. The requirements to select the engine were: the power of 125 kW, 4400-5200 rpm, size, price, accessibility and communication with the brand. Five out of ten brands offer a suitable performance and were presented to the company before making a choice. Three of them offer a solution for the whole drive-train which means that other elements like, chargers, starter locks, alarm units, converters, control units, and relays are included. These solutions are tuned to each other and do not need further engineering. The three brands that offer this solution are; Piktronic, Torqeedo, and Oceanvolts. UQM and TM4 only offer the electric engine with the inverter. The five remaining brands were compared and the advantages and disadvantages were highlighted (Appendix L). The comparison was suggested to Dutchcraft, and together with them there was chosen for the full solution of Piktronik (Figure 26). The choice was based on two decisive points; the price and the attractiveness that they do not have to compile and fine tune the components. When the comparison was presented to the company, Piktronik was recommended. More specification about the full package of Piktronik can be found in Appendix M.

Figure 25: Mercury sterndrive

Figure 26: Electric motor of Piktronik

> Battery pack

The different battery packs that are currently on the market were evaluated. The company should not yet purchase a battery pack due to the constant improvements of the battery capacity. Therefore, it is recommended to purchase it as late as possible in the assembly of the project. The tender of Dutchcraft should have a capacity of at least one-hour of full speed navigation if they want to offer a product with more range then their competitors. For now, it is recommended to reserve a space for the batteries so the tender can navigate for one-hour full speed, 125 kWh, and when the battery capacity improves the company should implement a better battery capacity than is currently available on the market in order to offer a more competitive product.

For the first build of the electric tender of Dutchcraft, it is recommended to use the battery pack of Piktronik (Samsung) the price for the battery pack is 580 €/kW which is acceptable and because they already fine-tuned the whole drive-train. Another advantage is that they have to deal with only one stakeholder which improves communication. If Dutchcraft chose for different battery pack, they also have to find different charger, and the price of these chargers is between 10.000 and 20.000 euro.

> Price

An indication of the costs was composted for Dutchcraft. The costs for this recommended drive-train was requested to the suppliers and resulted in the 115.515,40 euro exclusive of VAT (Figure 27).

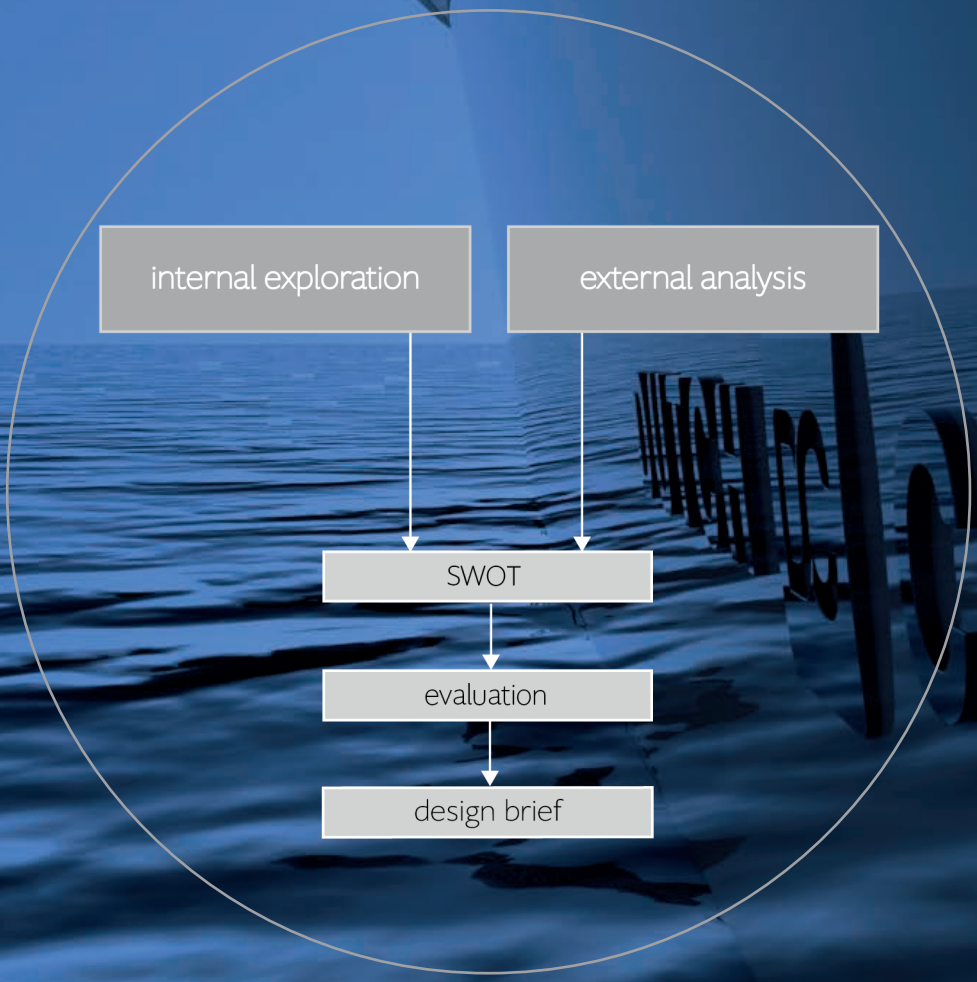
€ 115.515,40

Item	Price
Sterndrive (Alpha one)	€ 4.057,00
Transom	€ 2.858,00
Propeller	€ 226,00
Trim pump	€ 1.609,40
Electric engine (125 kW) + all components (Piktronik)	€ 36.765,00
Battery (125 kWh)	€ 70.000,00
Total	€ 115.515,40

Figure 27: Price calculation drive-train

8. Design brief

After the analysis, a design brief was composed. The design brief is the starting point for the next phase. The design brief includes a design direction, a design vision, a design goal and main requirements for the conceptual proposal.



A multi-purpose electric superyacht tender

Design direction

The implementation of the electric drive-train creates a deck that has a flat surface. It is clear that the flat surface can create a different general arrangement of the deck, but it is not yet clear which advantages this has on the activities of the users.

Dutchcraft has to offer an electric tender with a length of 24,6-feet. Next to the activities on the water, the tender should support land activities (e.g., transporting bicycles). A broader range of activities would be an excellent opportunity for DutchCraft to offer because it matches their core competencies, and there is still space to extend the number of activities to serve the needs of the users. Providing embarkation in the front is necessary to provide a beach landing. The solution concerning the design of Dutchcraft will be presented to the company.

Design vision

"A multi-activity electric superyacht tender that is comfortable and has a luxury expression for the owner, guests and crew."

Design goal

The design goal is to make a conceptual design proposal (ii) of the general arrangement for the hull of the 24,6-feet DutchCraft. This includes;

- The arrangement of the drive-train with the chosen drive-train of Piktronik after which the level of the deck can be determined.
- Different arrangements of the various activities to show the opportunities of the flat deck.
- A solution for embarkation at the beach.

These solutions will be combined into one conceptual proposal. A 3D CAD-model will be used to simulate and evaluate.

Main Requirements

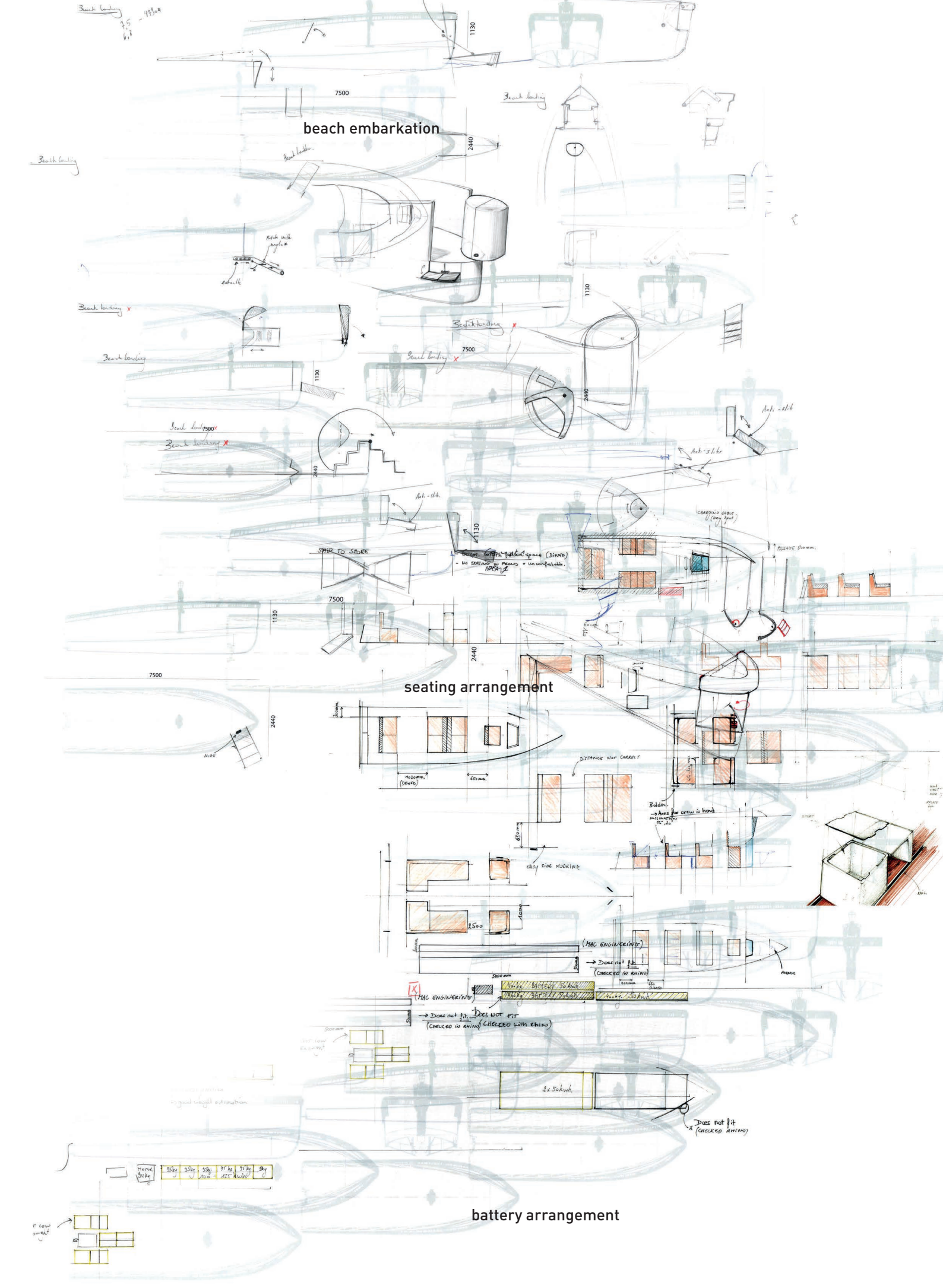
(A extended list of requirements can be found in Appendix D.)

>The tender should facilitate the owner, guests and crew with all their activities.

(A more detailed overview can be found in Appendix E)

Activity	Seating		to store		Time full speed
transport ship to shore	6 Pax.	2 Crew	bags	Drink and snacks	40 min.
diving	6 Pax.	2 Crew	diving items		60 min.
fishing	4 Pax.	2 Crew	fishing items		20 min. + 4h (6kts)
beach landing	6 Pax.	2 Crew	BBQ items		40 min.
explore trip	2-4 Pax.	2 Crew	trip items		40 min.
Water-skiing	4 Pax.	2 Crew	Water-ski items		120 min.
transport groceries	-	2 Crew	groceries		40 min.
transport garbage	-	2 Crew	garbage		40 min.
mooring superyacht	-	2 Crew	mooring lines		20 min.
cleaning the tender	-	-	cleaning items		-
emergency situation	-	-	rescue items		-
charging the tender	-	-	charging items		-
storing the tender	-	-	-		-
launching the tender	-	-	-		-

> An efficient use of space is required to implement all the activities.
>The tender should be designed at a low cost (selling price under 300.000 euro).
>The tender should have a length of 24,6-feet.
>The tender should have room for customization.
>The tender should offer a high-end finish.

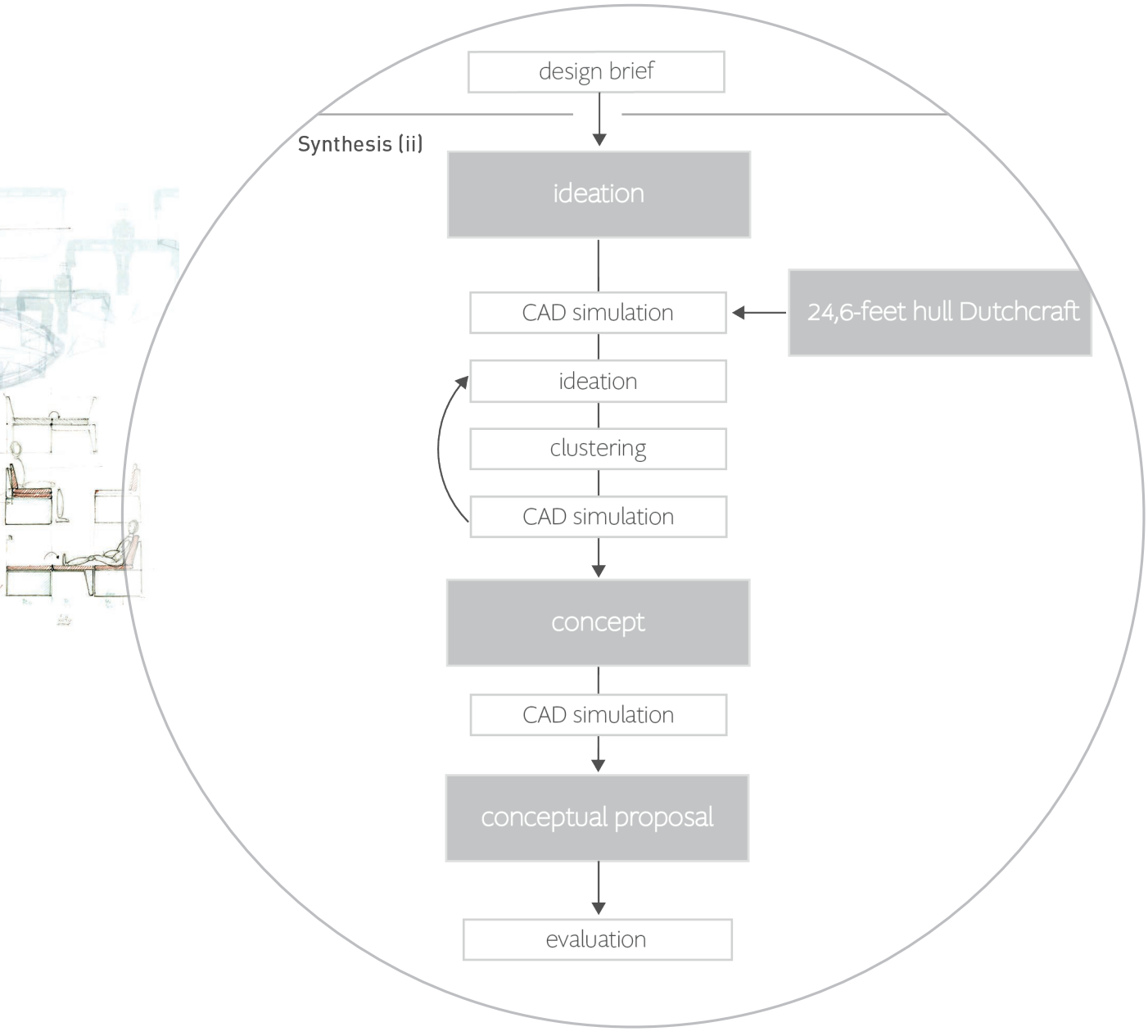

beach embarkation
seating arrangement
battery arrangement

9. Synthesis

After exploring the design space (i), the next step is creating a conceptual design proposal (ii) to show which opportunity comes with the implementation of the electric drive-train. In this phase, ideas were developed into one conceptual proposal. The focus was on "How the implementation of the electric drive-train influences the design of the tender and adds more value to the tender?".

Firstly, the drive-train was arranged to define the level of the deck. Secondly, three idea directions were created, presented to Dutchcraft and merged into one concept. Furthermore, the seating and a solution for providing a beach landing were further elaborated to show the feasibility of the concept to Dutchcraft.

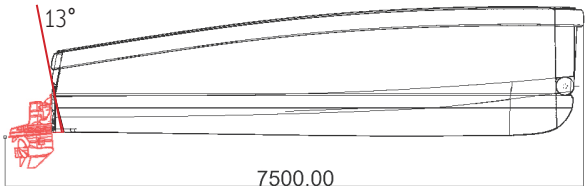
During the whole ideation, a 3D CAD-model was used to simulate and evaluate the different solutions.



9.1 Drive-train arrangement

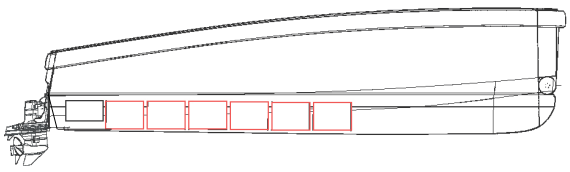
To determine the space on the deck and the level of the deck, the drive-train, including the sterndrive, the electric engine, and the batteries, were arranged. The first part that was arranged was the sterndrive therefore, the transom of the hull was adjusted to an angle of 13° and moved forward to keep the overall length (incl. sterndrive) of the tender 24,6-feet (Figure 28). After positioning the sterndrive, the engine was positioned. Therefore, the shaft of the engine was aligned with the shaft of the sterndrive. When the engine was set, different battery positions were sketched in 2D and evaluated with Dutchcraft. During an evaluation, the best solution was to position the batteries as close as possible to the bilge and on a straight line, due to stability performance. Next, the water tank was placed in front of the batteries, as close as possible to the bilge. Finally, the arrangement was simulated in a 3D-model, and the level of the deck was determined.

Sterndrive arrangement

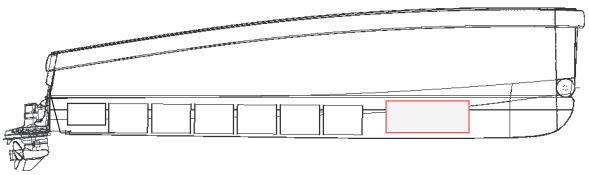


Engine arrangement

Battery arrangement



Water-tank arrangement



Deck level

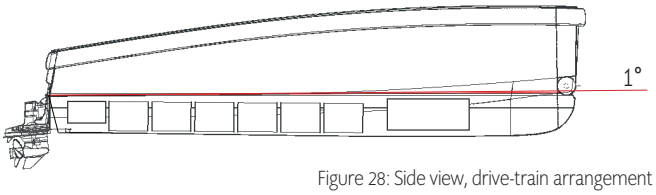


Figure 28: Side view, drive-train arrangement

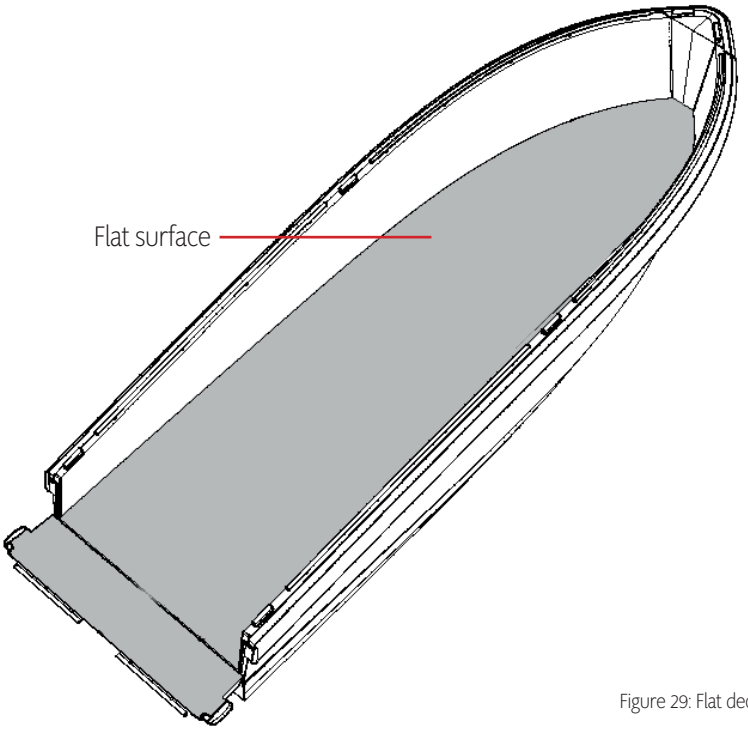


Figure 29: Flat deck

The drive-train arrangement under the deck allows creating a flat deck (Figure 29) from the bow until the transom and does not need any higher spots for the engine or batteries. Actually, it is the sterndrive which needs a specific position within the hull, and therefore it is the sterndrive which determines the height of the deck. The top of the sterndrive needs to be placed 596 mm from the bottom of the transom. The dimensions and positioning of the sterndrive can be found in Appendix N. For the drainage of the deck the deck is placed under an angle of 1°.

Waterline

During the drive-train arrangement, an estimation of the weight was taken into account because it influences the level of the deck and the position of the waterline. If the overall weight of the tender is too heavy and the deck level is too low, the deck of the tender will float with water. A simulation in the CAD-model was conducted to find the volume of the hull. The volume of the hull in cubic meters is equal to the floating capacity in kilogram (Archimedes' law). Although this displacement depends on how it floats in salt (1025 kg/m^3) or freshwater (1000 kg/m^3). It appeared that the hull volume was 2500 m^3. The estimated weight that was calculated from the competitor analysis is between 1300 and 1500 m^3. Therefore, the hull was scaled down to create a more realistic volume before the drive-train arrangement was determined. A more precise calculation has to be performed by a naval architect.

The weight of the current drive-train with the 125 kW motor, 125 kW battery pack and Alpha Sterndrive is about 750 kg (motor 94 kg, battery pack 600 kg and sterndrive 45 kg).

9.2 Activity idiation

To generate an overall solution for all the fourteen activities, a morphological chart was used (Appendix O). To create this chart, a list of functionalities was generated that originated from the activities that were determined during the user research. Internet resources were used as inspiration during the research (Appendix P). All the solutions (Figure 30) were clustered and implemented into the morphological chart which resulted in three ideas. The ideas were further evaluated and combined into one concept.

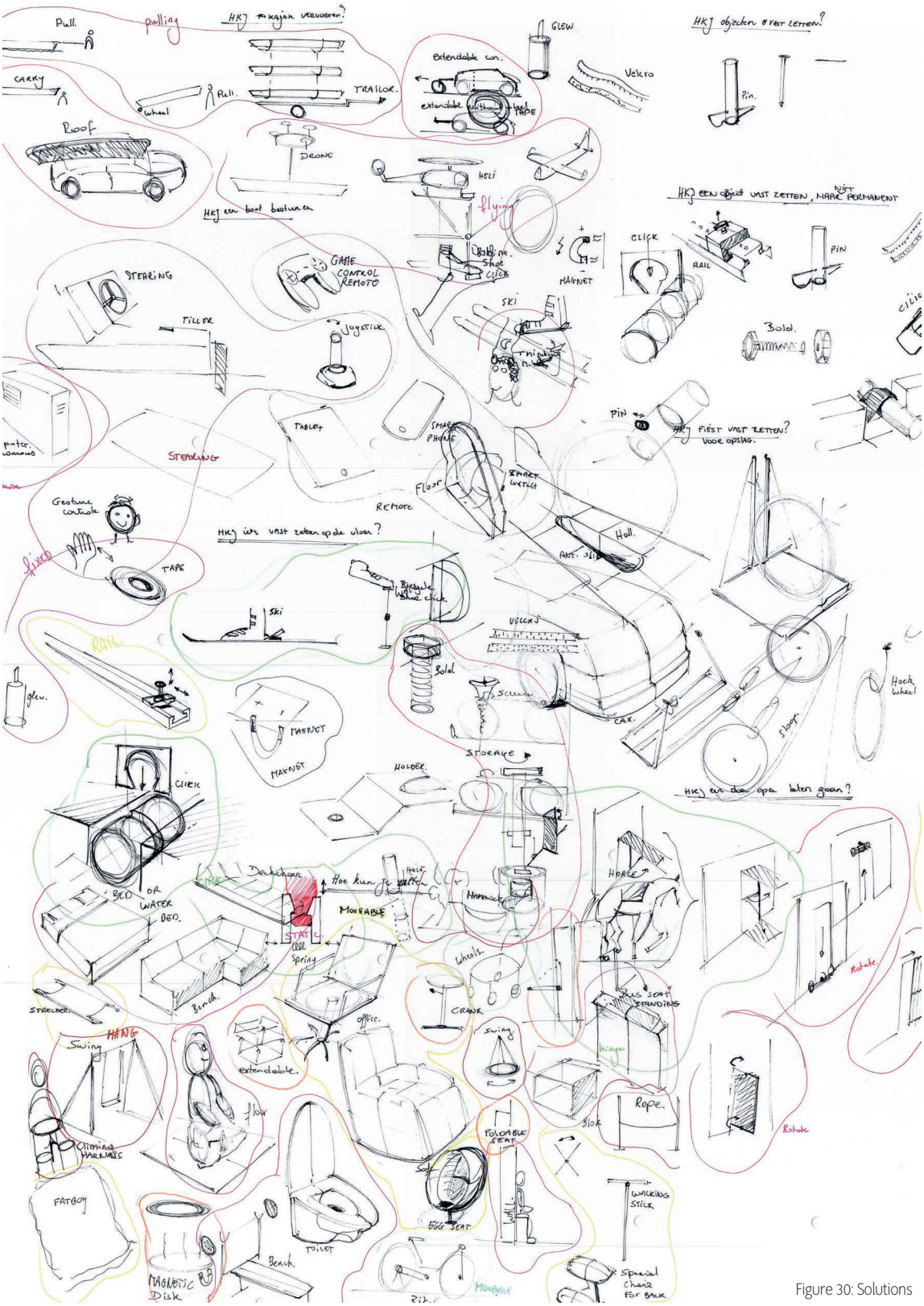


Figure 30: Solutions

Idea 1: Less is more

The core of the first idea is that it is controlled from a distance. The control unit is located on the superyacht and is controlled by the captain. On board of the tender there are several cameras that have a 360° view and radar system. This data is sent to the captain on the superyacht. This way, the tender has less passengers on board and the weight is reduced. Although, one crew member has to stay on board of the tender to support the activities such as mooring the tender and take care of the owner and guests.

The seating blocks are going over the battery packs into the floor. This way the deck is flat and can be used for other purposes.

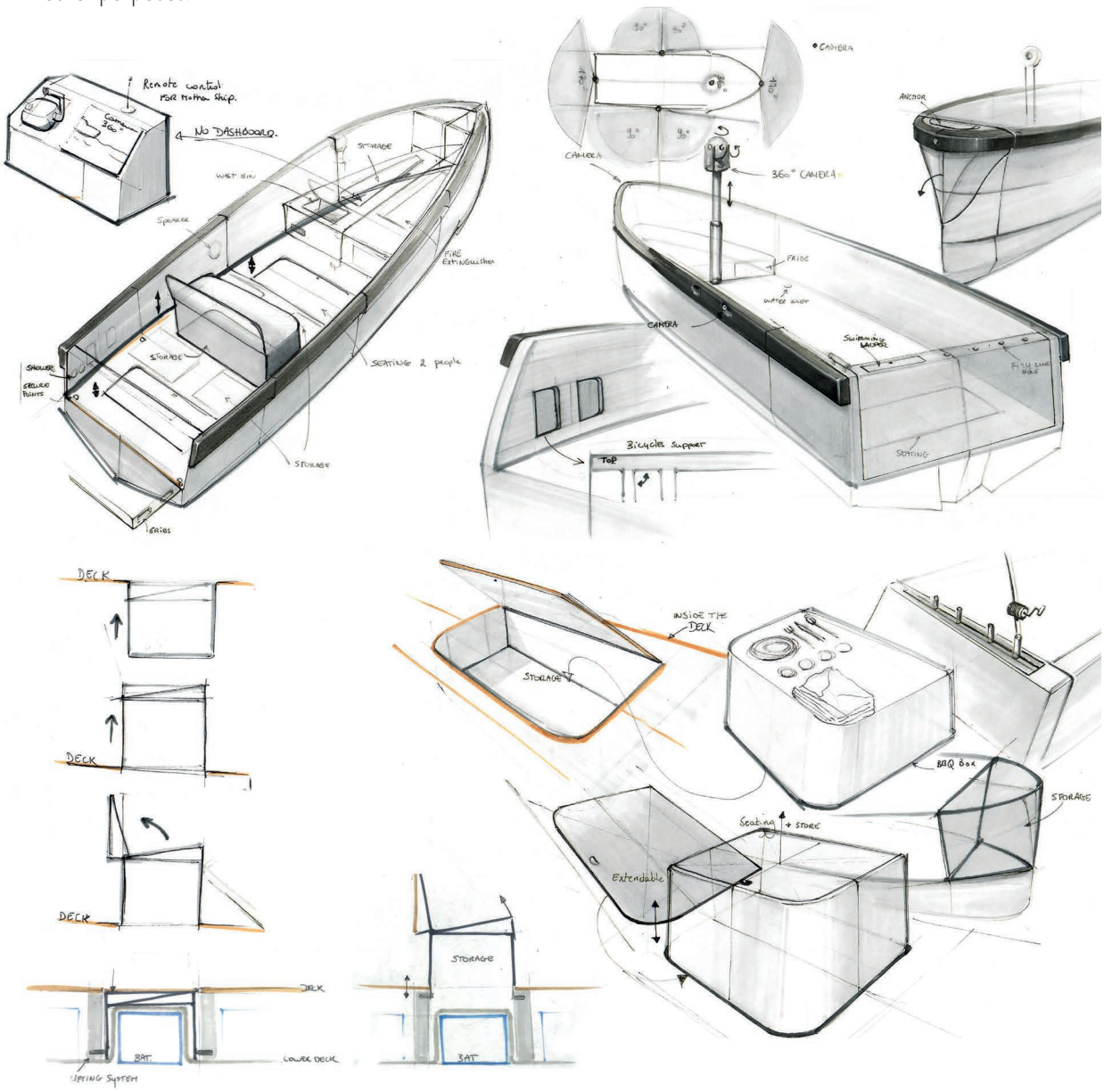


Figure 31: idea one

Synthesis

Idea 2: Atoi

The focus of this idea is the transom hatch which can be used as a multi-functional trailer. The trailer can transport different items such as bicycles or boxes. In this idea everything is foldable e.g. the supports for diving bottles or foldable seats in order to keep the deck empty when they are not used and so the deck can be used for other purposes.

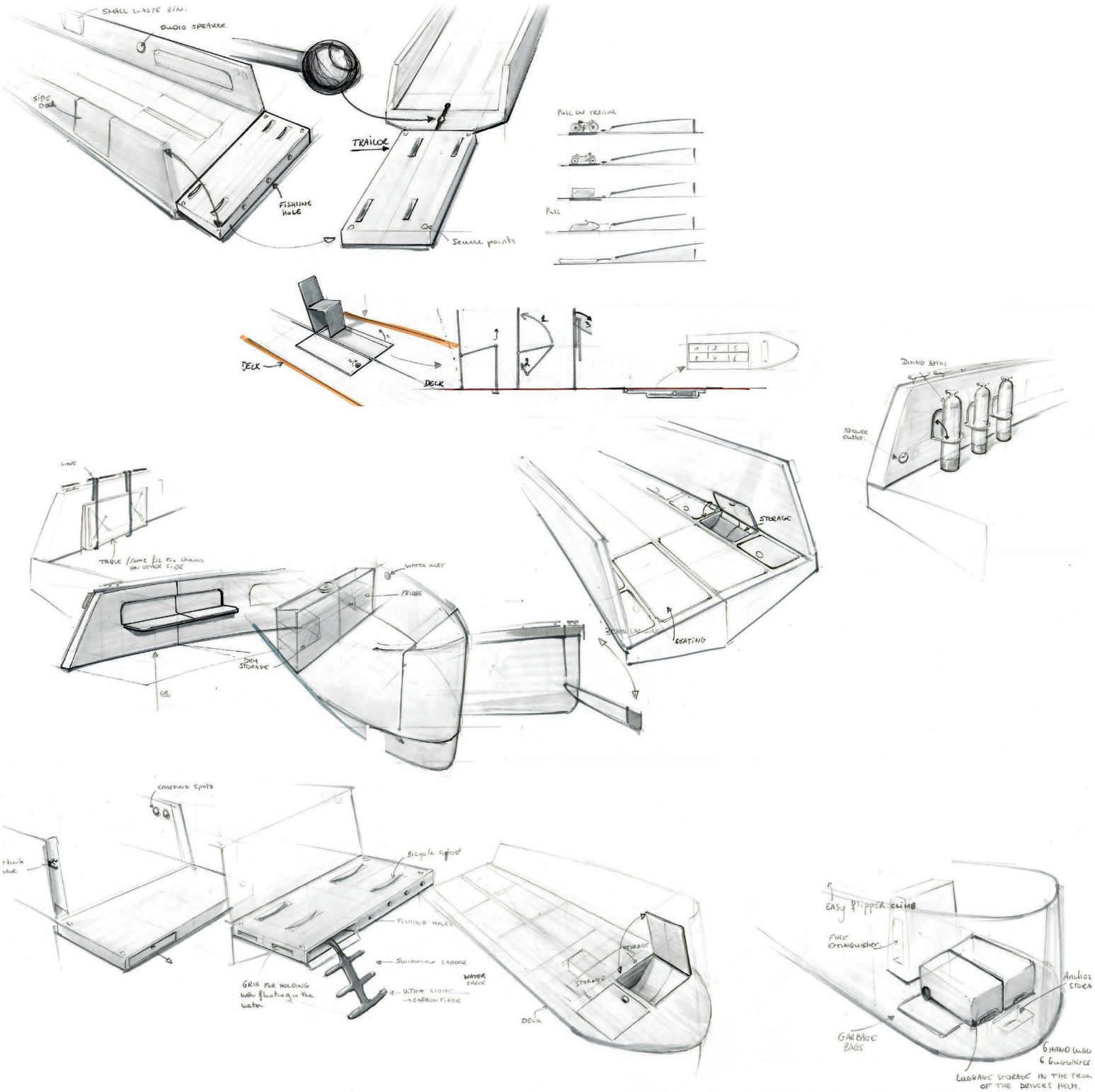


Figure 32: idea two

Proposal 3: Extend

In this idea the horizontal flat deck is provided with mounting rails. The rails allow to fix all items on the deck and to arrange it as the user desire. The tender can be arranged so that there are just enough seats for every user. Also the drivers helm can be relocated to create more or less privacy on board for the guests and owner. The drivers helm has a small battery. Induction charging provides the battery with extra power that is coming from a bigger battery under the deck. If toys or gadgets have to be transported, the seating arrangement can be removed and the rails can function as a fixation for the toys. The seating can be transformed into a bed. Unused seats or furniture can stay on board of the superyacht. This way, weight can be reduced.

With this concept Dutchcraft is able to start the production of the tender without having a customer (2.5 Supply chain). As such in a later stage of the production, the users can still customize the deck as they wish and choose the items they want to do the activities they disire.

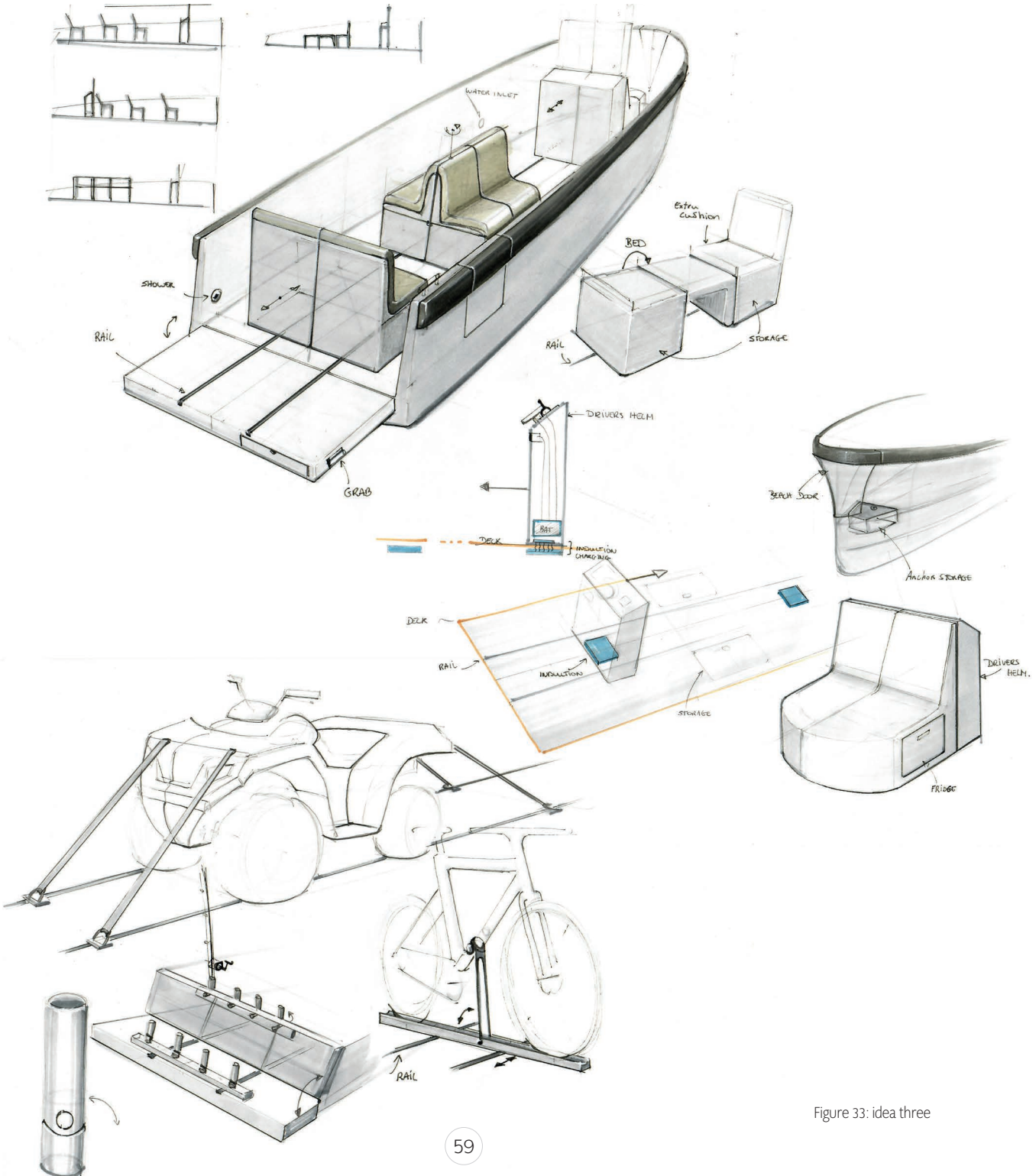


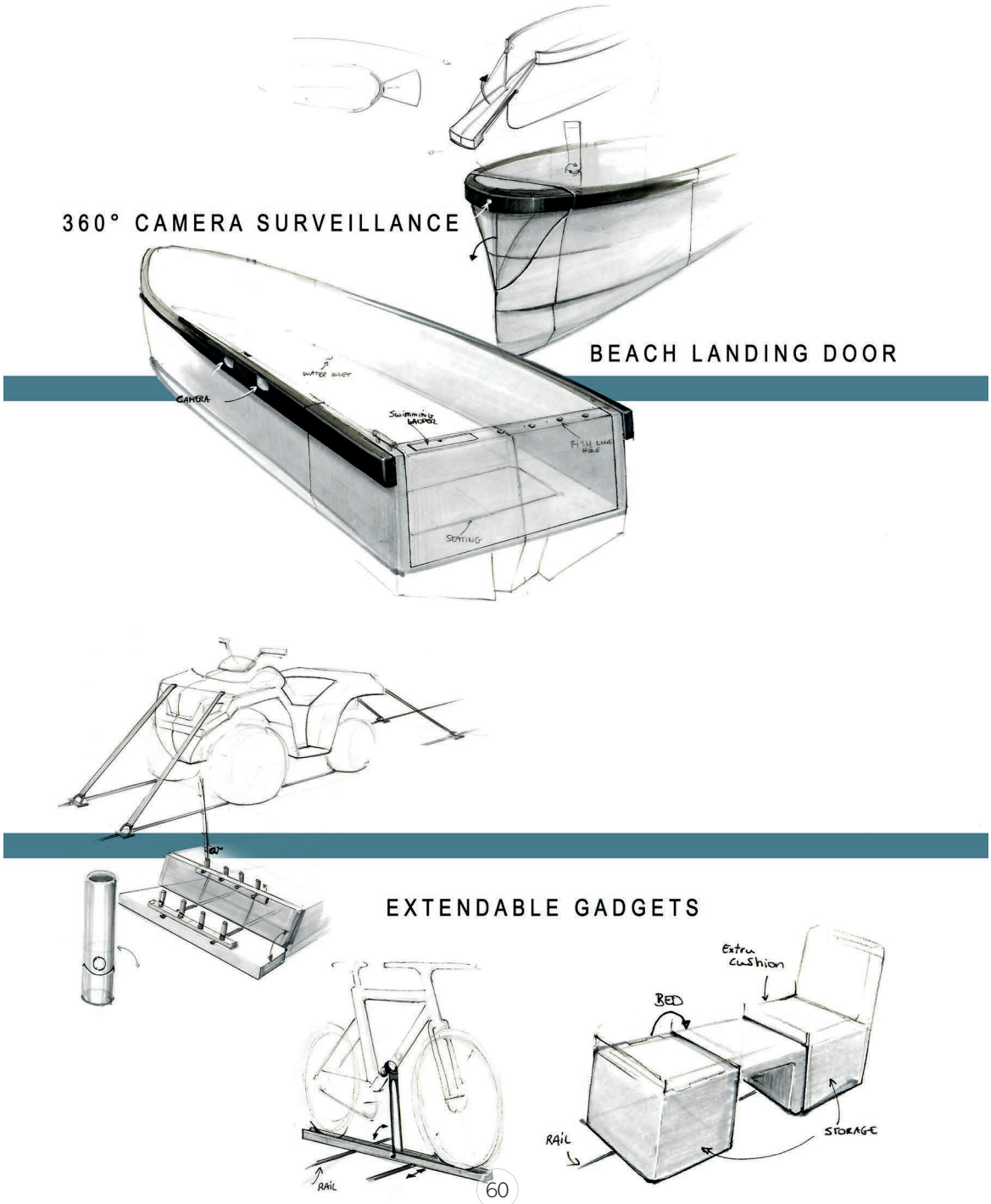
Figure 33: idea three

9.3 Concept: DutchCraft 25 **E**-xtend

After evaluating these three ideas, one concept was created. From idea one "Less is more" the 360° camera observation was implemented. The cameras are placed into the black fenders. This way, when the tender is moored in a harbor the users can check if the fenders are still in the right spot. The users can check the footage on their smart phone or on the bridge of the superyacht. The camera system was not further implemented within the further elaboration of the concept because it is not a unique factor of the electric drive-train.

From the second idea "Atoi" no elements were used because it had too many challenges like stability.

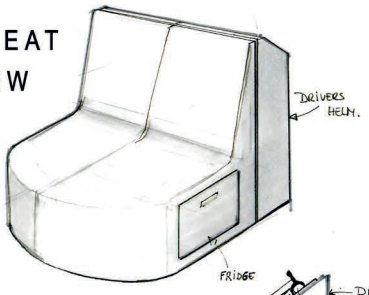
The third idea "Extend" was the basis of this composed concept. The only thing that changed was the driver's helm, as the induction charger was removed and a bigger battery was placed so the driver's helm can be moved as well.

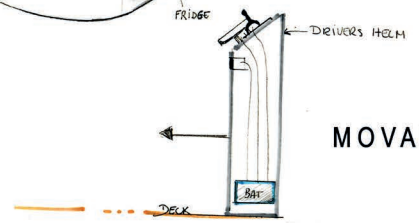


DUTCH DC CRAFT E-XTEND

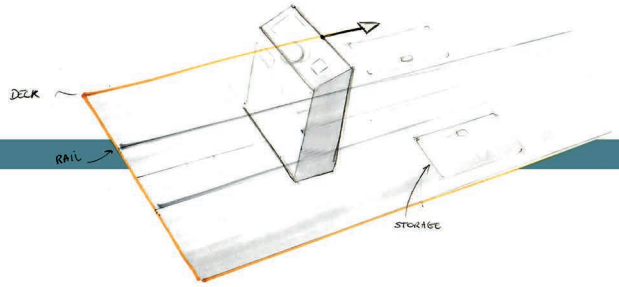
FULL ELECTRIC TENDER WITH MULTI - EXTENDABLE PURPOSES

FRONT SEAT
FOR CREW

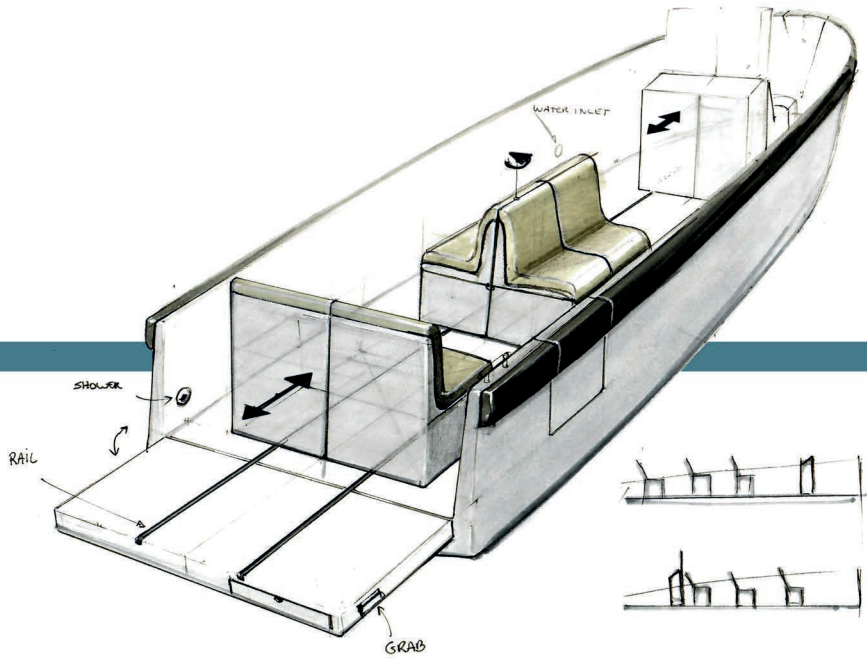




MOVABLE DRIVERS HELM



MOVABLE SEATING



MULTI-SETUP FURNITURE

9.4 Activity arrangement

In the previous part, the concept was presented in an early and sketchy stage. In this part, the concept was further simulated to evaluate the feasibility and to show the different possibilities of this concept. Firstly, a search for different mounting rails was performed to show the possibilities of the fixation systems. Secondly, the seating was further explored as this is essential to allow the tender to serve different activities.

Mounting rail

The rail that is presented is used in airplanes Figure 34. Three different options for quick and easy fixation on the rail are shown. The deck will need cutouts to fit the rails. The rails can be fixed with screws on the deck.

Figure 34 :Mounting rails in a truck
(L-Track Bed Rails, 2011)

Seating

In a later stage of the project, it appeared that the different user activities also require different seating positions. E.g. with fishing, the seating is positioned backwards so the user can watch the fishing lines. Also the privacy on board is important for the guests and owner. Consequently, the crew is positioned for all activities with their face forward. The drivers helm was placed in the front of the tender so the guests and owner have more privacy and comfort. The concept does also allow to change the drivers helm to the back if the users want more interaction with the owner or guest. An overview (Figure 35) was conducted to show the outcome of the research.

Activity	Passengers	Seating possition
transport ship to shore	6 guests/owner	looking forward/backward
	2 crew	looking forward
diving trip	6 guests/owner	looking sideway
	2 crew	looking forward
fishing trip	4 guests/owner	looking backward
	2 crew	looking forward
beach landing	6 guests/owner	looking forward
	2 crew	looking forward
explore trip	2-4 guests/owner	looking forward/backward
	2 crew	looking forward
transport groceries	2 crew	looking forward
transport garbage	2 crew	looking forward
mooring the mothership	2 crew	looking forward
emergency situation	2 crew	looking forward

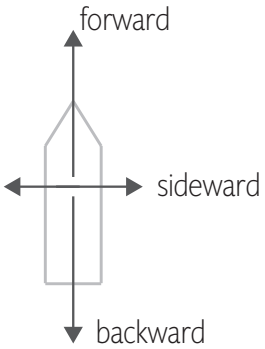


Figure 35: Different seating positions for different activities

To determine the dimensions of the seats, the dimensions of the Dutchcraft 50 model were used as a starting point. Although, research showed that the most comfortable seating arrangement has an angle of 5°. This inclination, offers more support under the legs and places the user more backwards to avoid sliding off the chair. ("Bestuurdersstoel bus - Ergonomie site", n.d). The seating of the Dutchcraft 50 model area is horizontal (Figure 36). To compromise this angle, Dutchcraft uses different kind of foam layers in the cushions which should simulate the angle of 5°. However, after testing the seating of the 50-feet Dutchcraft it is proven that the cushions do not stop the sliding enough. Therefore, there is chosen to create a seating for the tender with an angle of 5°. A new seating was created with the 5° angle and the ergonomics were checked with the P95 of adults between 31-60 years old (Figure 36) (Dined, 2018).

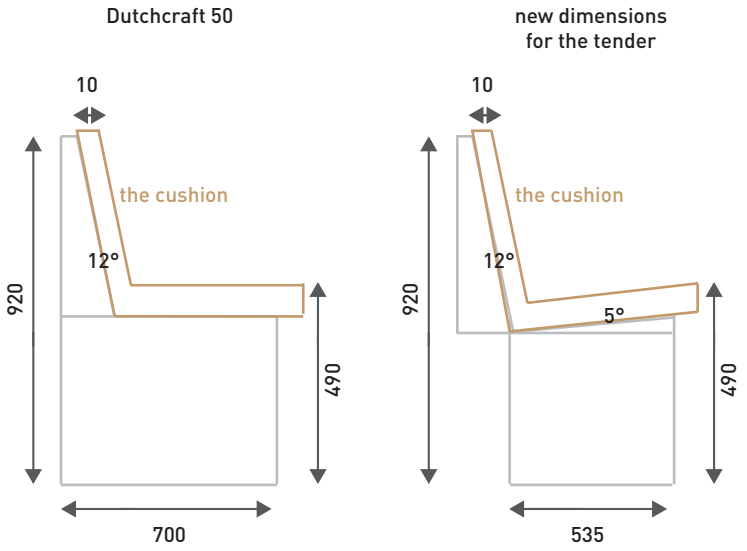


Figure 36: Comparing seating to Dutchcraft 50 (dimentions are not on scale)

The seating can be used as storage space for personal belongings of the users. The storage space is 570 x 535 x 400 (Figure 37, blue).

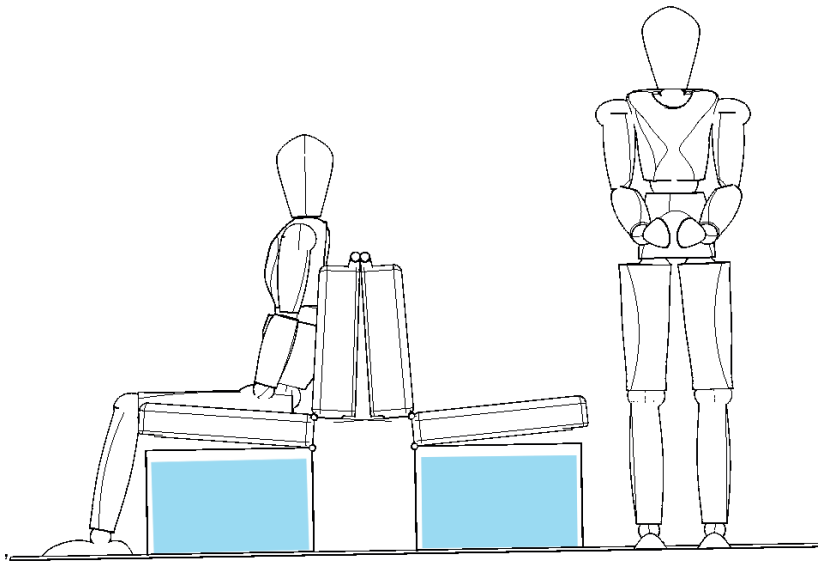


Figure 37: Storage space (blue) in seating, verification

To evaluate the positioning of the seating, scaled 3D-humans (P95 adults between 31-60 years old (Dined,2018)) were used in the 3D simulation (Figure 38). It was checked if three rows and a driver would fit in the tender and if they would have enough space for their legs. The distance that can be created between every seat is 1200 mm. As a reference, the distance between two business class seats of airplanes was used. The smallest distance that is used in business class airplanes is 1110 mm (Brussels Airlines). Therefore, a distance of 1220 mm is comfortable enough for short distances. The distance of 1220 mm is the minimum distance when six seats are placed in front of each other. When there are only four seats used in the tender the distance between the seats will not influence the legroom

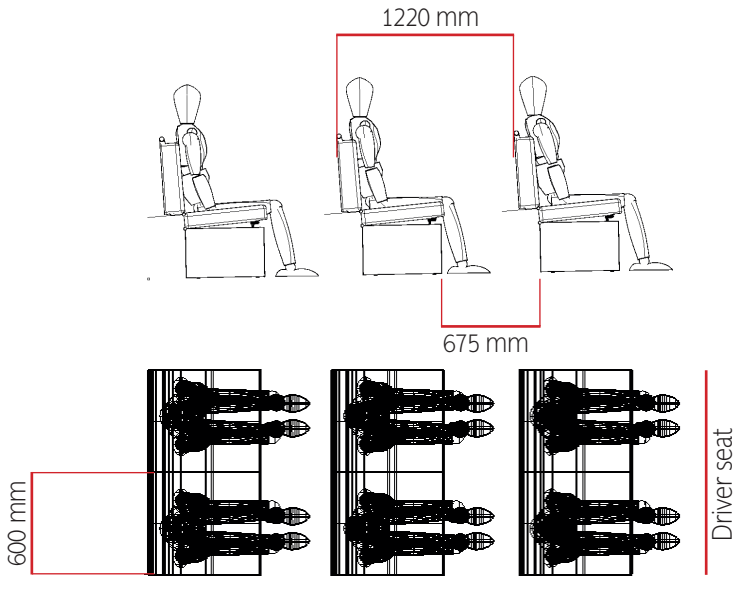


Figure 38: Seating positioning

The seating was slightly further elaborated to show the functionalities to the company. The seating is provided with mounting locks to fix the seating on the rails. To protect the deck from sticking out mounting locks, there are four legs in each corner with a spring that are sticking out further than the mounting locks. The springs can be pressed by putting extra weight on the seating. When they are pressed the mounting locks can fall into the mounting rails, and they can be locked. To unlock the seating, the locks are unlocked, and when there is no extra weight on the seating, the legs will stick out again to protect the deck.

The seating can be opened so the users can reach the mounting system (Figure 39) Storage space can be locked.

On top of the seating, a handle is made which the users can hold.

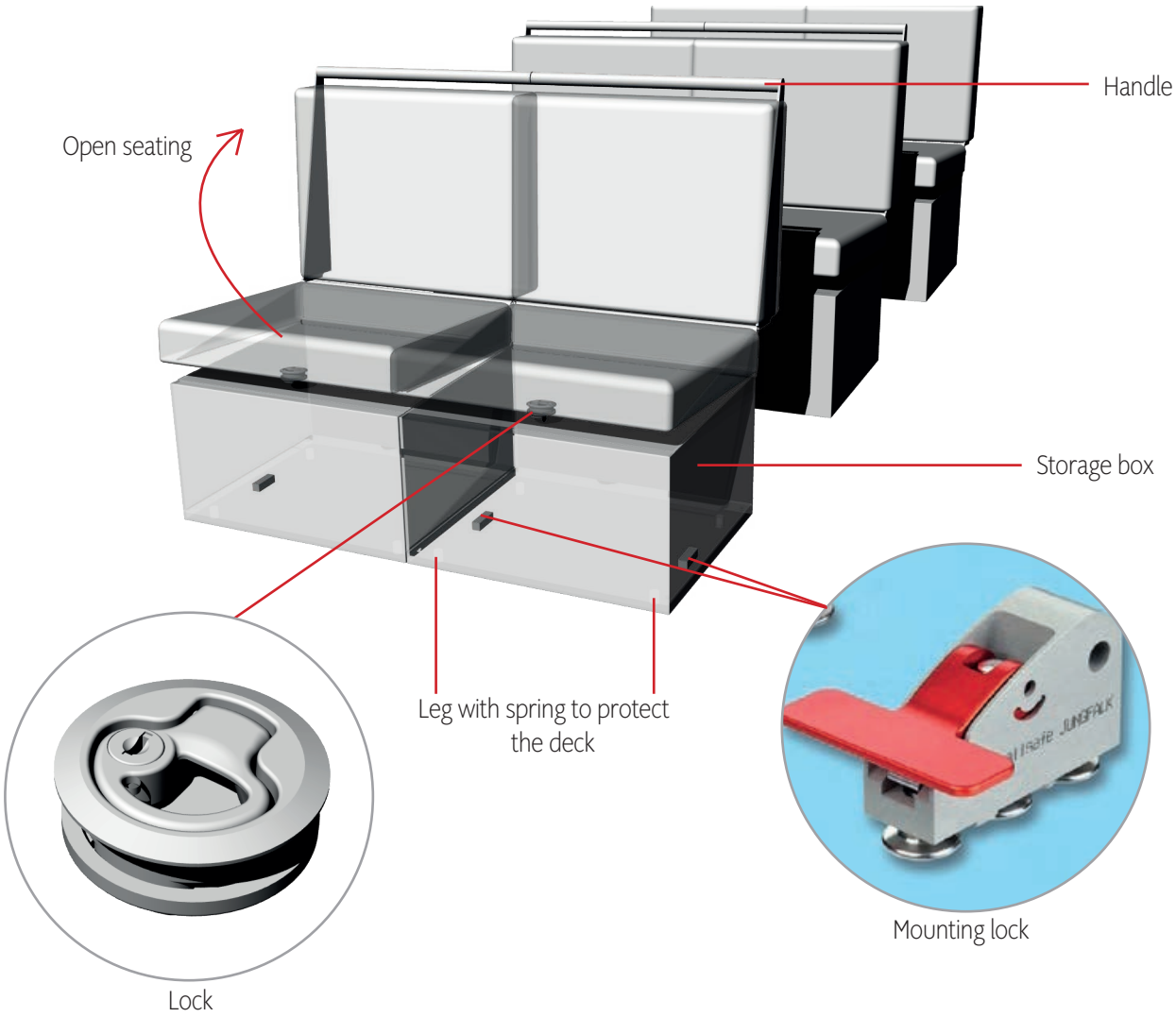


Figure 39: Seating

A simulation was made to determine the distance between the mounting rails. They were adjusted to the seating so the seating can be moved and turned in different positions the user wants (Figure 39). The distance from the mounting rails is 570 mm.

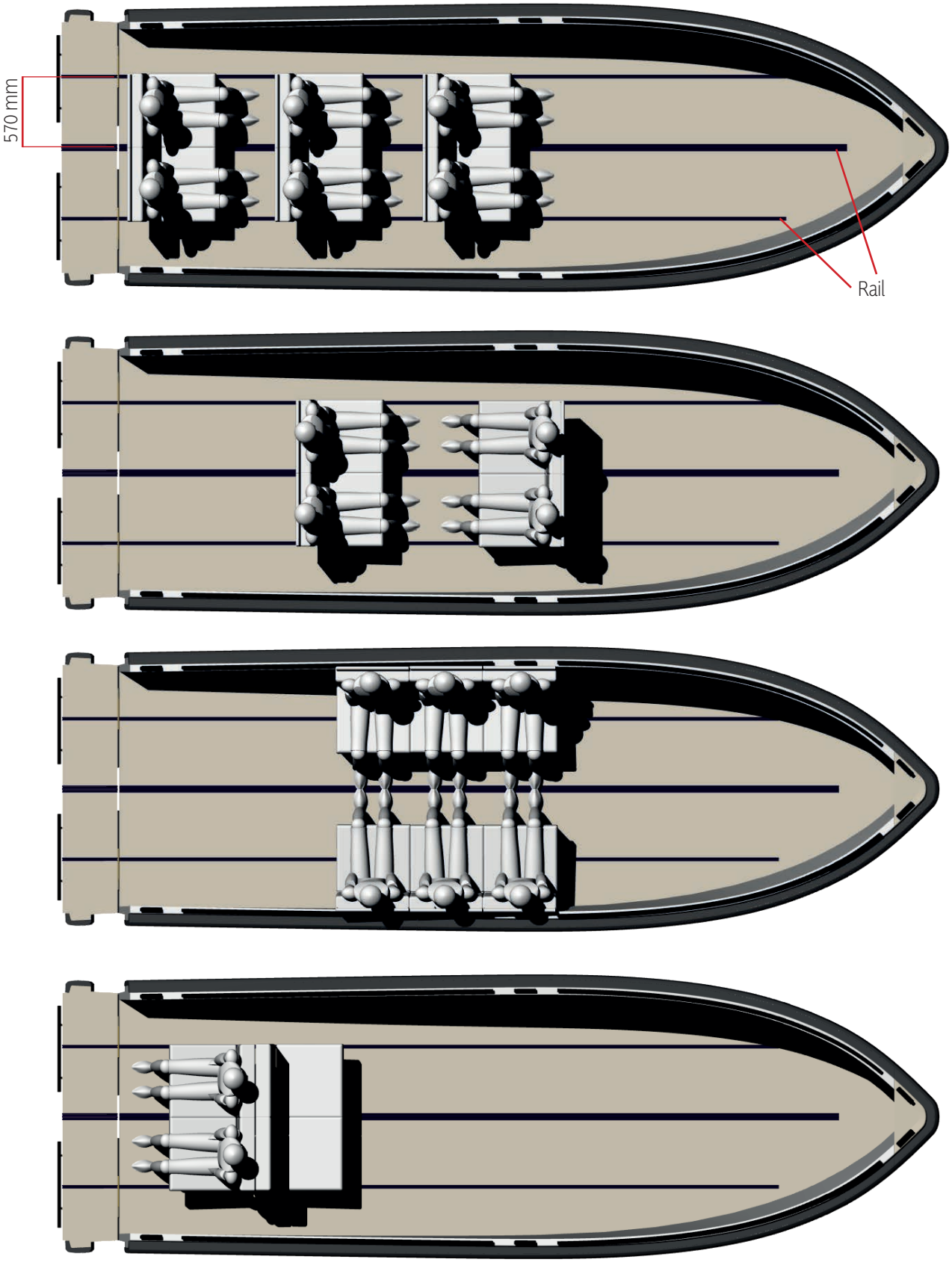


Figure 39: Different seating positions

Drivers seat and helm

The driver seat and helmet are also movable therefore they have to be equipped with the mounting system (Figure 40). The seating is a standard part and will need some adjustments to fix it to the mountain system. There is also an option to place two driver seats next to each other. The drivers helm is simulated to evaluate the different possibilities. The drivers helm is provided with a battery and is not depending on the electronics under the deck. Al the connections are wireless, and therefore the helm can be placed over the whole deck on the mounting system.

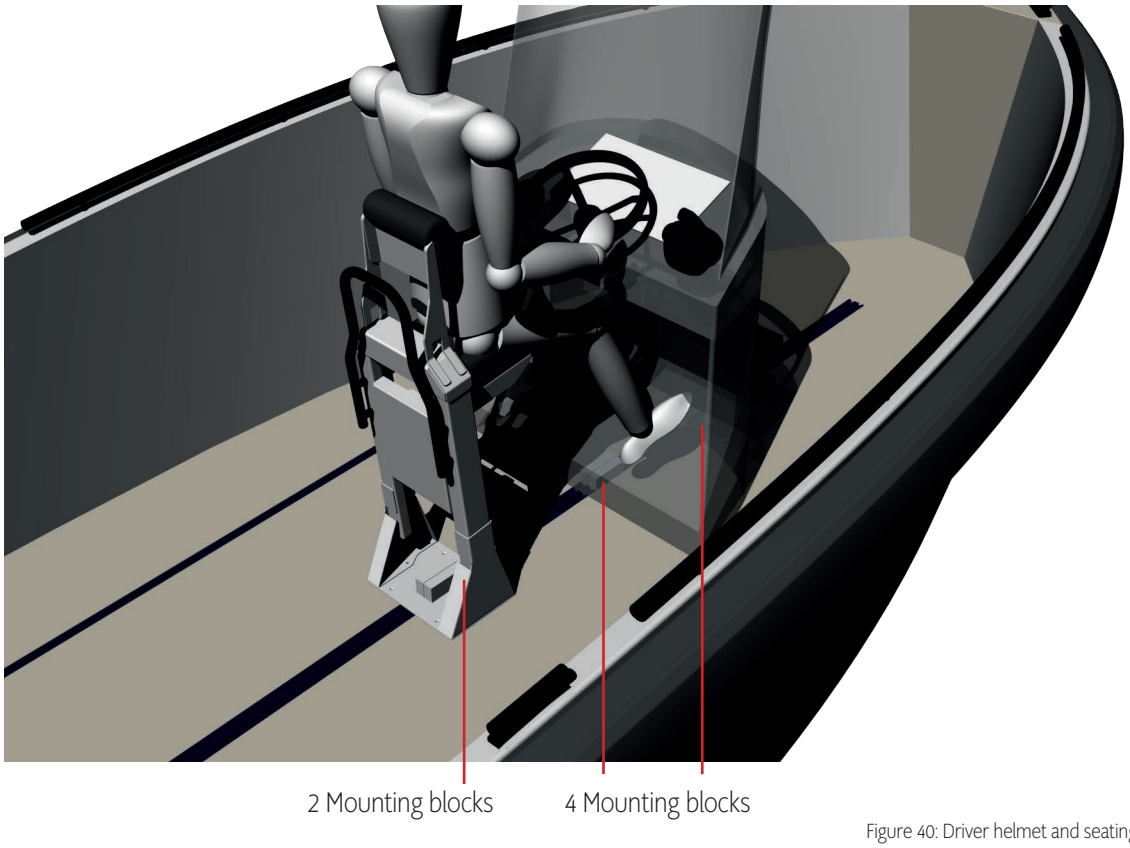


Figure 40: Driver helmet and seating

The height of the window of the drivers helm is adjustable. When the window is down, it is 1000 mm (Figure 41). This way, it does not stick out when it is placed in the tender garage.

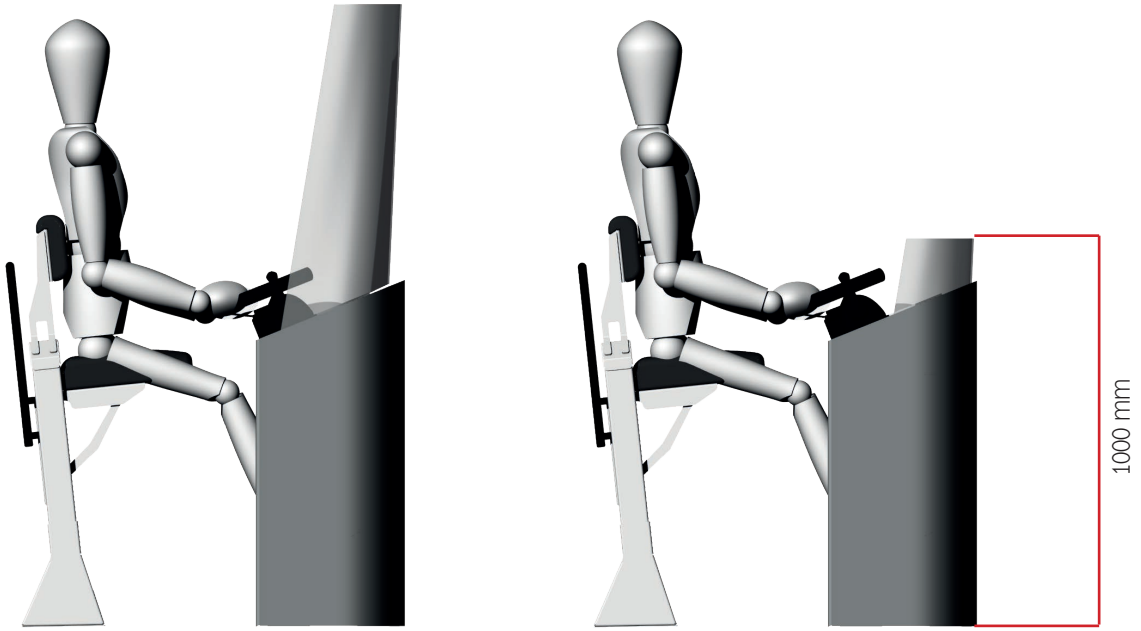


Figure 41: Adjustable window

9.5 Beach landing

Extra attention was given to the activity of making a beach landing because this is an essential feature that offers a unique user benefit. However, it is also a challenge to integrate it in the hull design of Dutchcraft.

A tender that makes a beach landing approaches the beach with the front towards the beach and allows the user to embark the tender in the front of the tender. A crew member navigates the tender towards the beach when moving the sterndrive up to avoid the propeller hitting the seabed. Another crew member will prepare the embarkation.

During the project, it appeared that the sharp bow (Figure 42) of Dutchcraft does not allow to implement an existing solution (Figure 43).

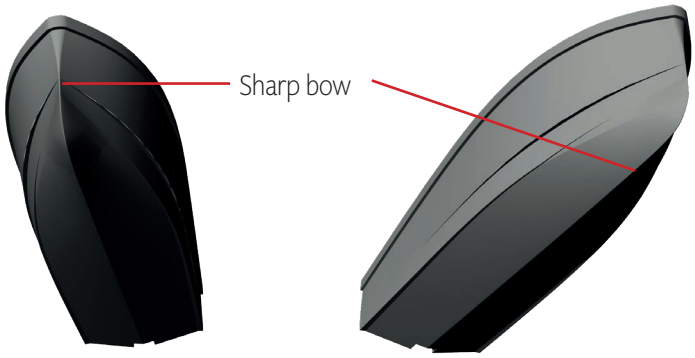


Figure 42: Hull of the 24,6-feet Dutchcraft

In Figure 40, the bows of the tenders are much wider which makes it possible to make a hinge over a large and straight surface. However, these solutions are expensive (Koopmans, 2018). Therefore, the company wants a solution that is simple and less expensive.

Figure 43: Current beach landing solutions
(www.pascoeinternational.com, 2011)

An ideation was conducted to explore different solutions to embark the high and sharp bow (Appendix Q). The ideas were evaluated with additional requirements that were set up together with Dutchcraft:

1. feasible
2. stability/comfort
3. hull strength
4. price
4. speed
6. aesthetics
7. storage/space

A Harris profile was used to evaluate the different solutions (Appendix R). The best solution resulting from the evaluation was the tip down. Therefore this solution was simulated in a 3D model until the feasibility was proven.

Solution

The front (in light brown, Figure 44) can be opened by detaching both egg box closures. When the locks are open, the door is pushed outside, and the electric button is pushed down to unwind the rope. When the door is over its tipping point, the door will drop due to gravity. By releasing the button the electric motor will stop, this way the front door can be adjusted to the angle of the beach. To bring the door back up the button is pressed upwards and the rope winds up. The locks tighten the door back to the hull to improve the hull strength.

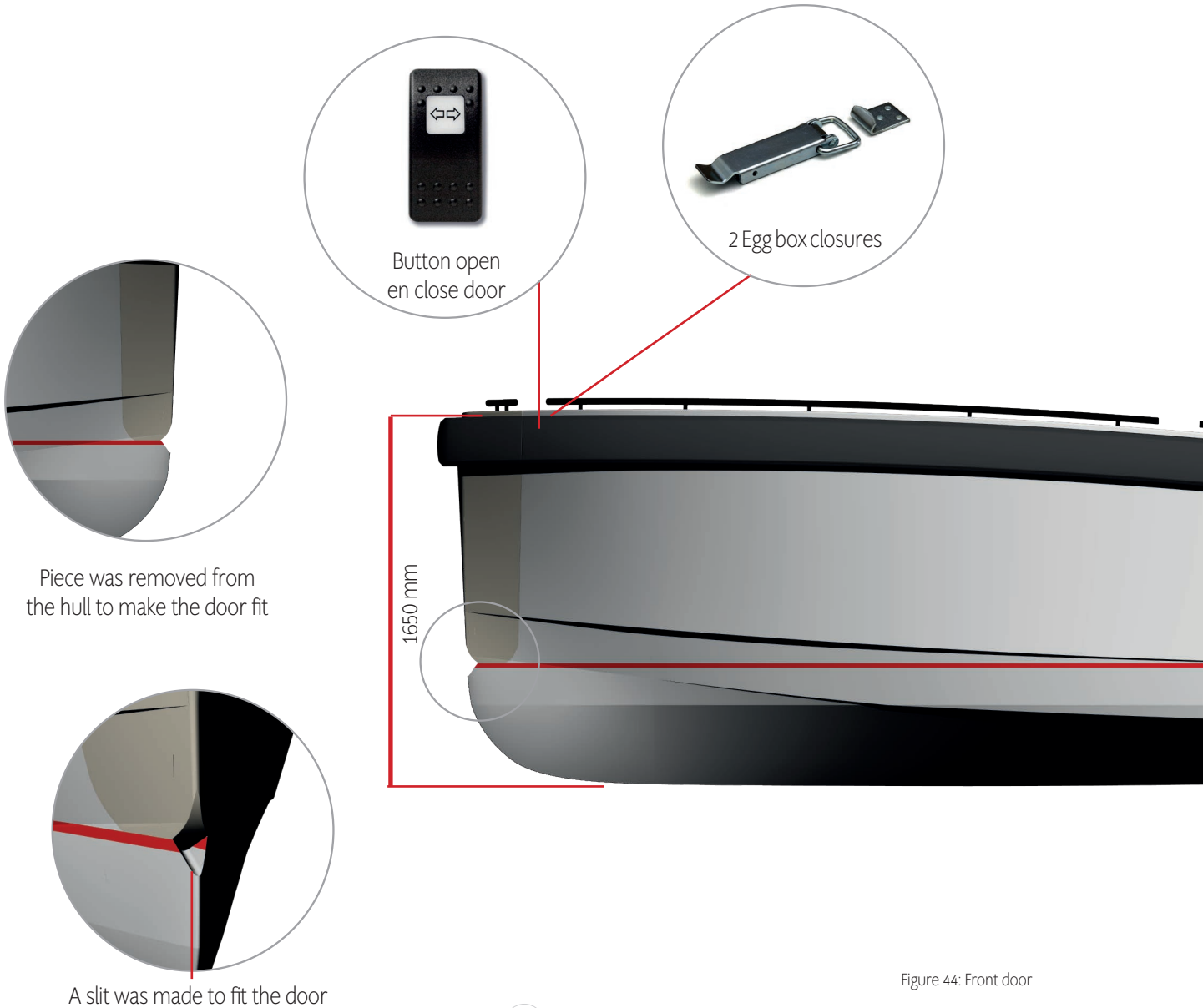
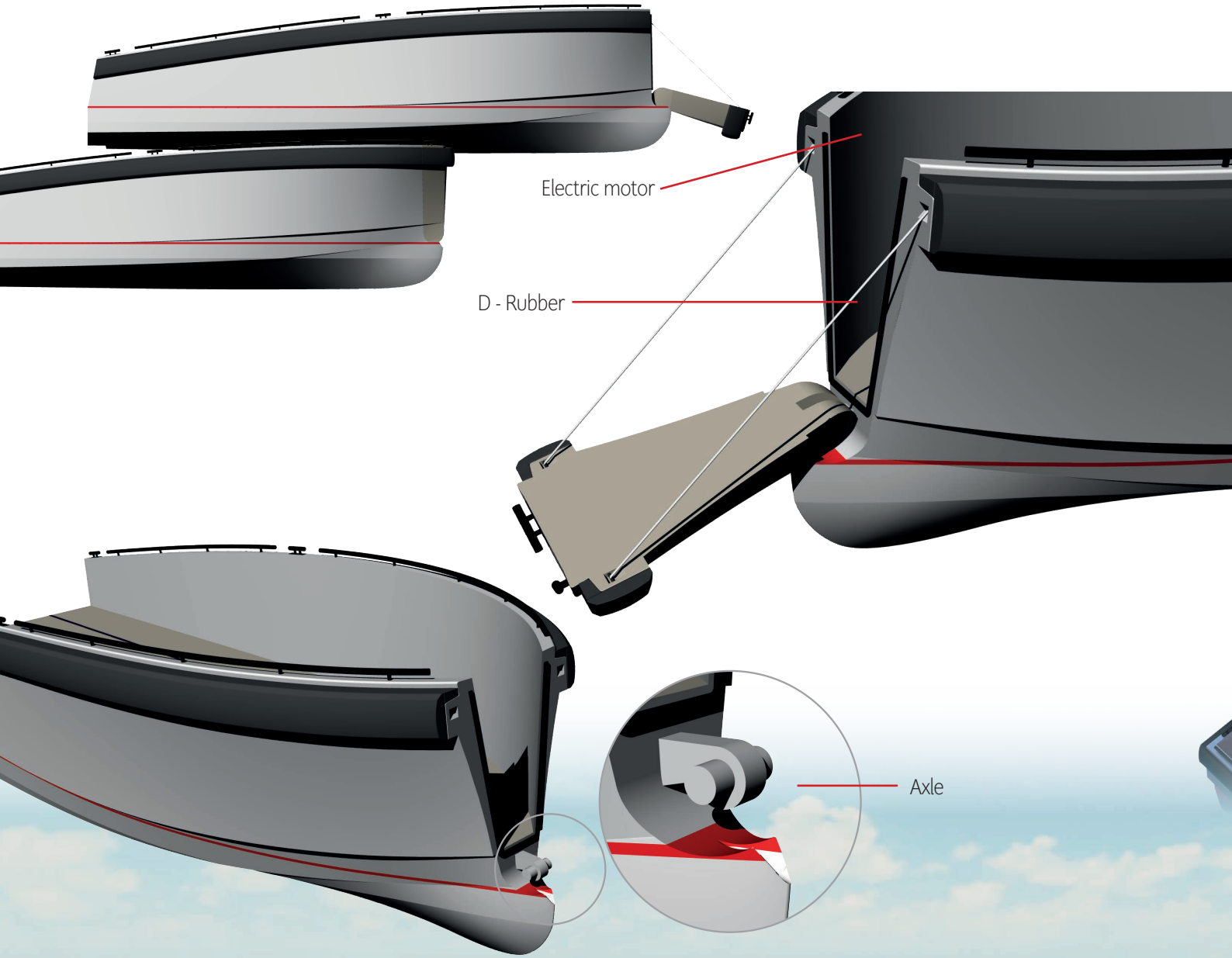
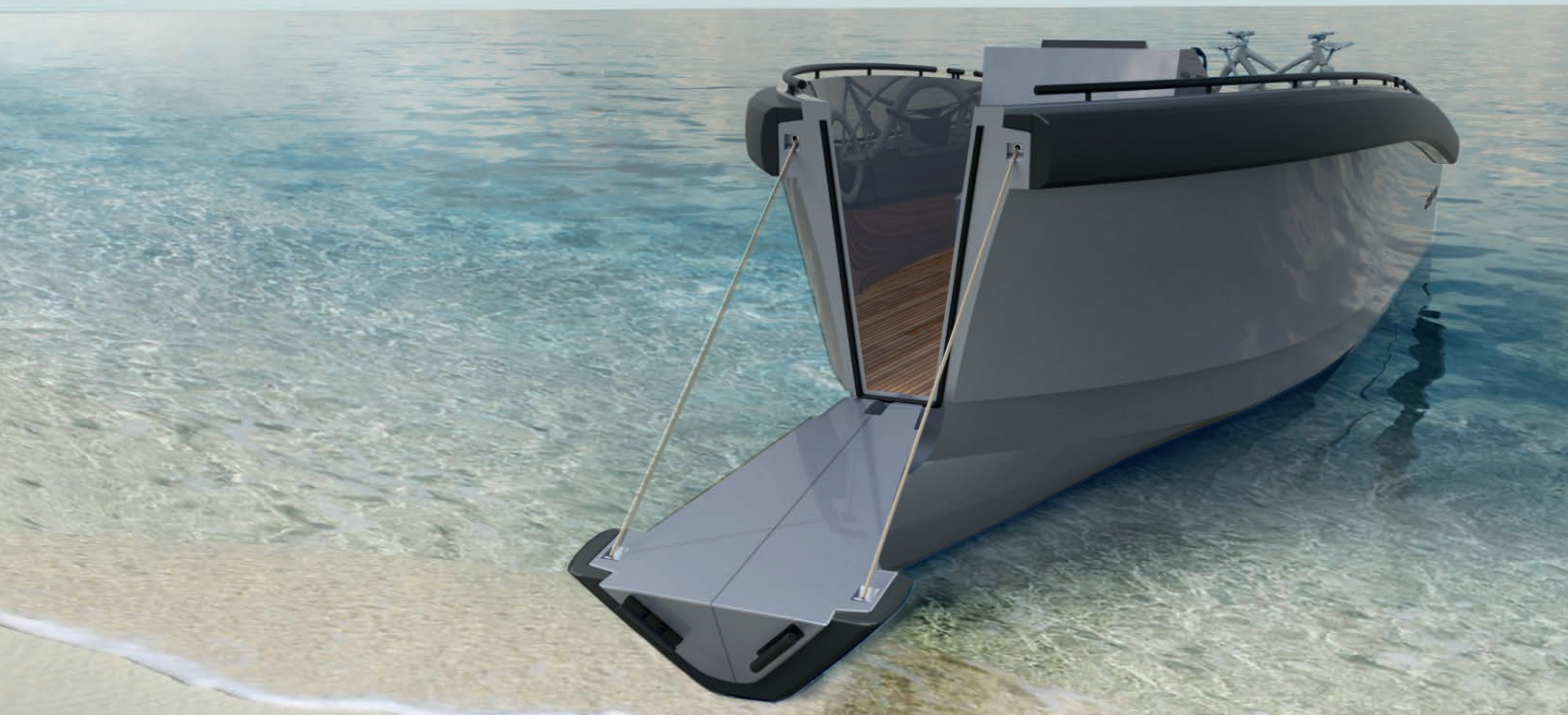


Figure 44: Front door



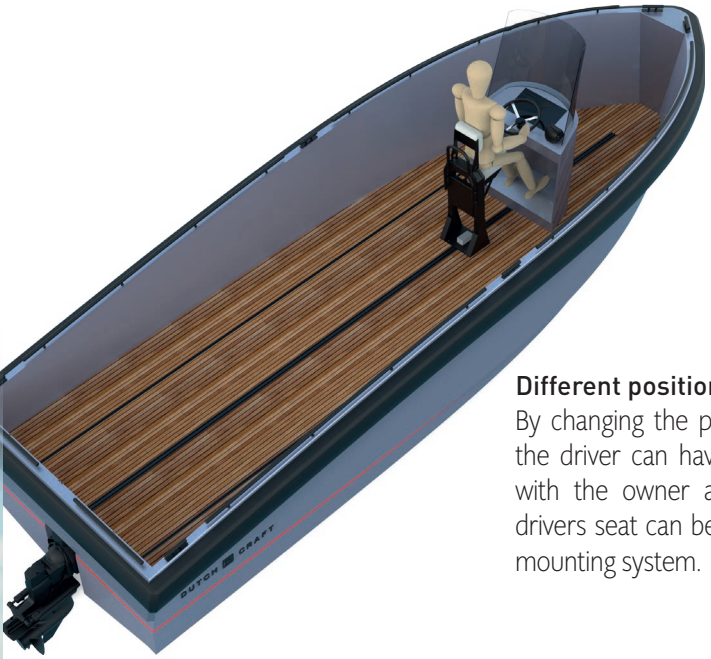


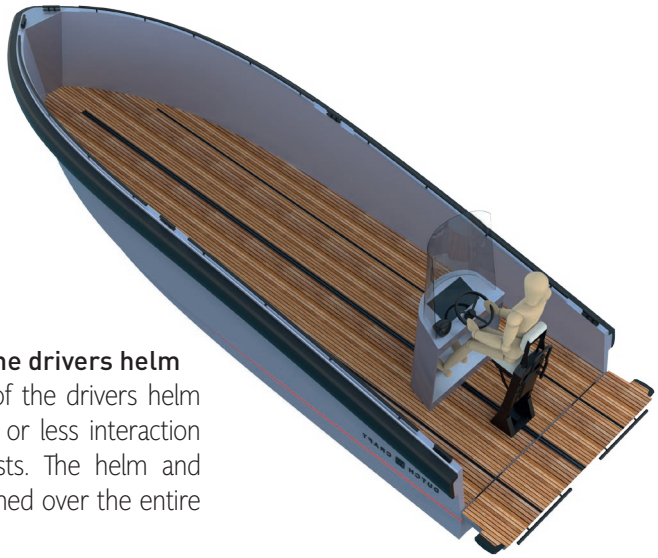
Beach landing solution

9.6 Conceptual proposal

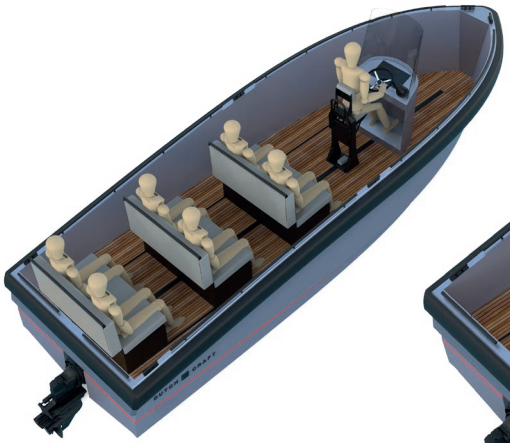
In this part the conceptual proposal is simulated according to the different activities the tender can support.

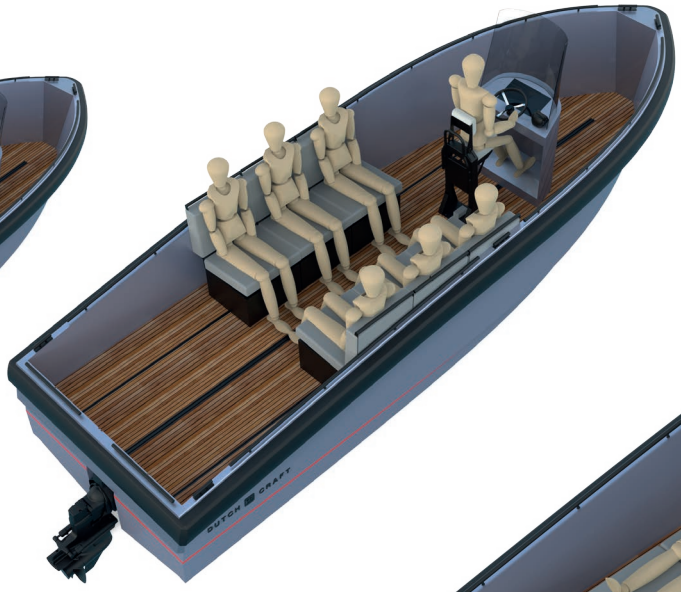
Cleaning
Because of the flat deck surface it is easy to clean the deck.

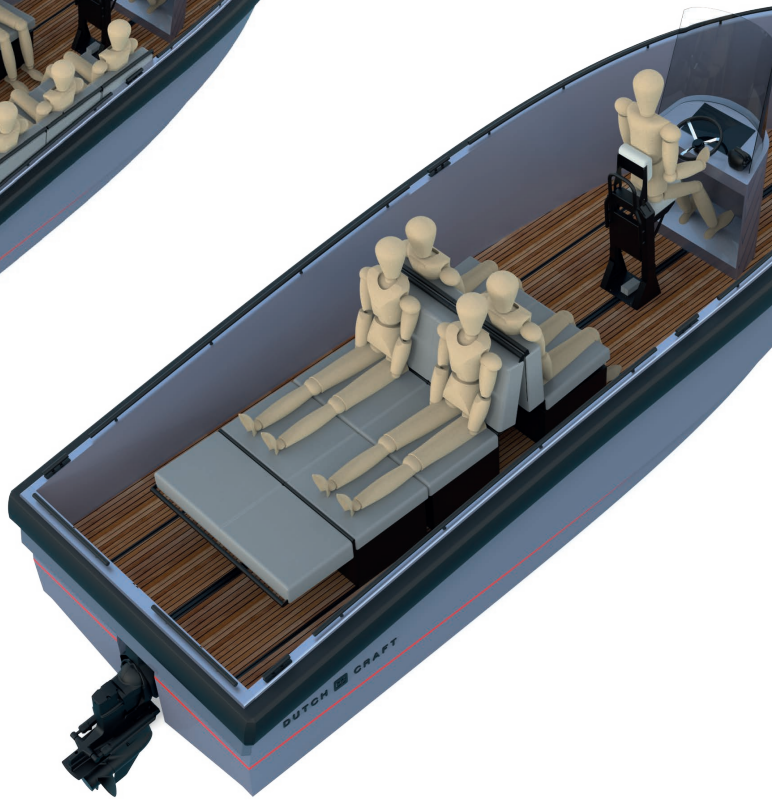




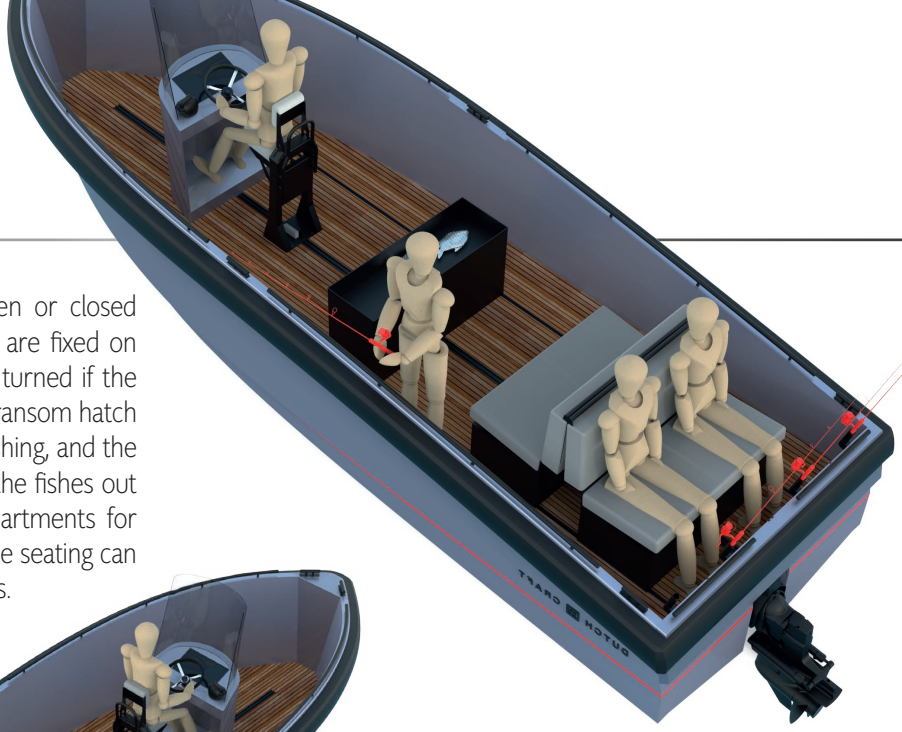
Different positions for the drivers helm
By changing the position of the drivers helm the driver can have more or less interaction with the owner and guests. The helm and drivers seat can be positioned over the entire mounting system.





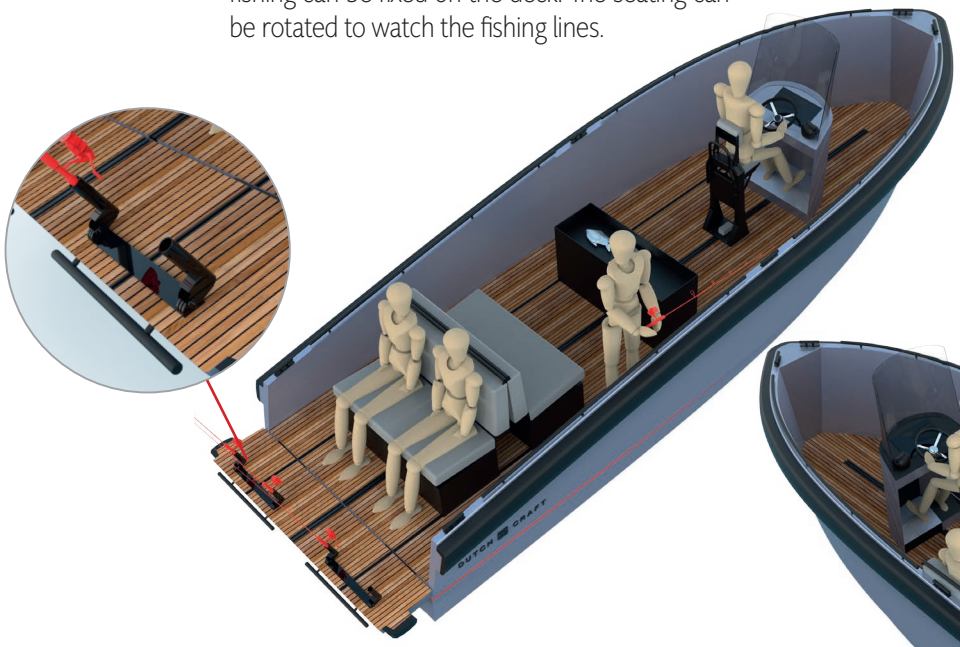


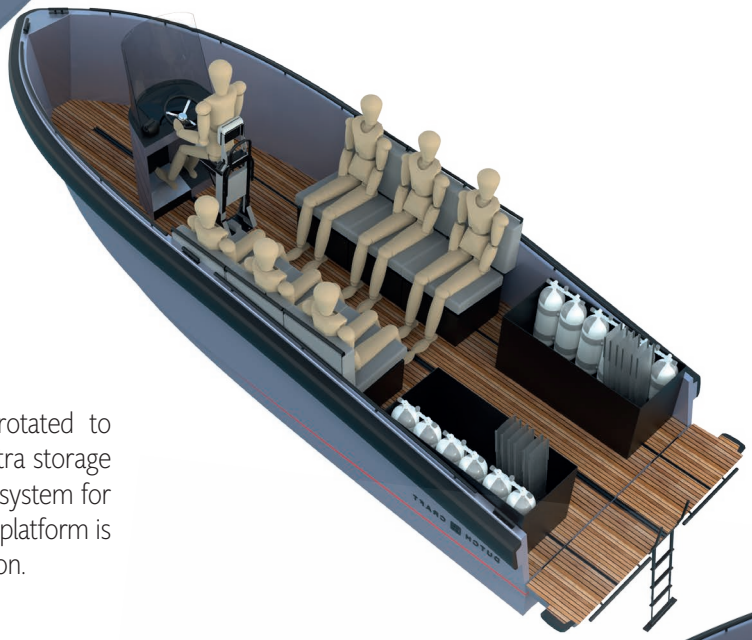
Ship to shore
The seating positions can be set as the users prefer and can be transformed into a sun-bed.



Fishing

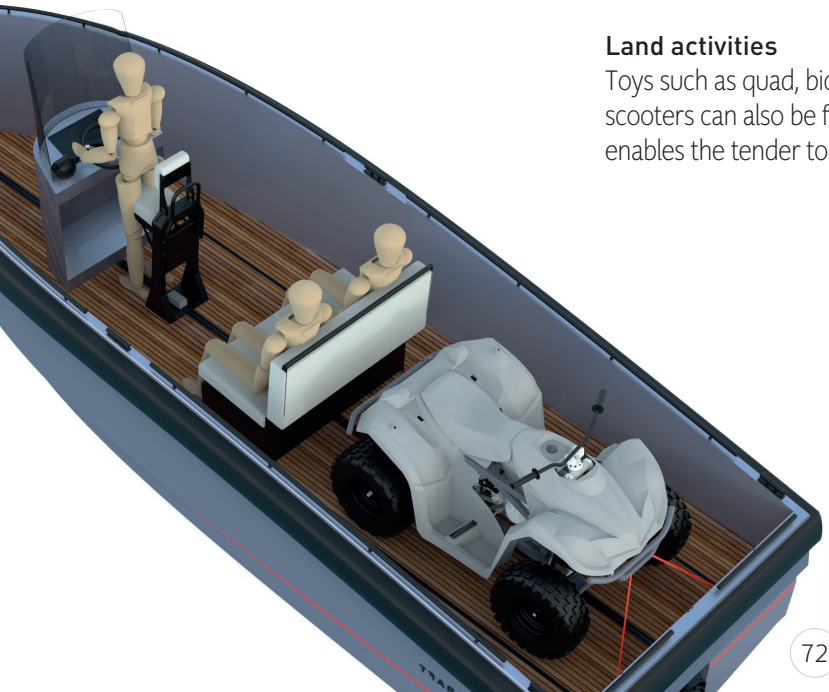
Fishing can be done with an open or closed transom hatch. The fishing blocks are fixed on the mounting system and can be turned if the hatch is open or closed. A closed transom hatch can provide extra support when fishing, and the open transom hatch helps to get the fishes out of the water. Extra storage compartments for fishing can be fixed on the deck. The seating can be rotated to watch the fishing lines.





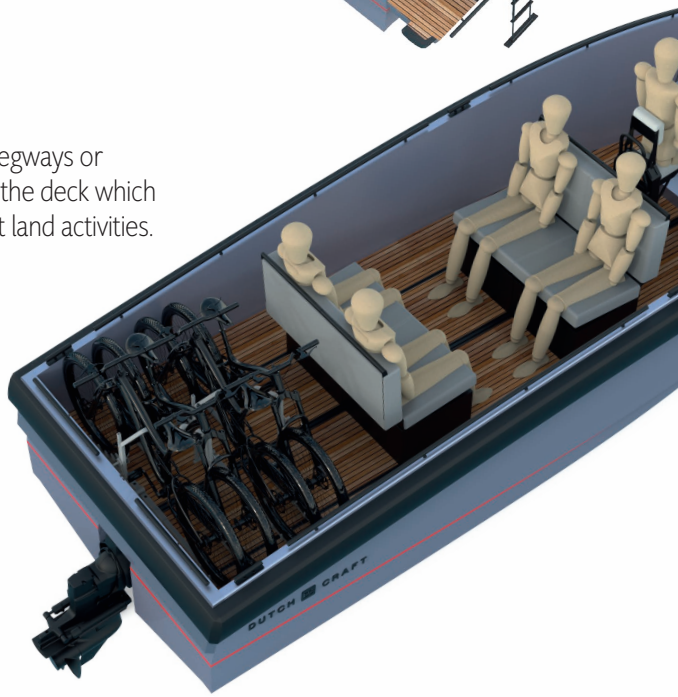
Diving

When diving the seating can be rotated to allow easier embarkation to dive . Extra storage boxes can be fixed on the mounting system for storage of the diving equipment. The platform is equipped with a ladder for embarkation.



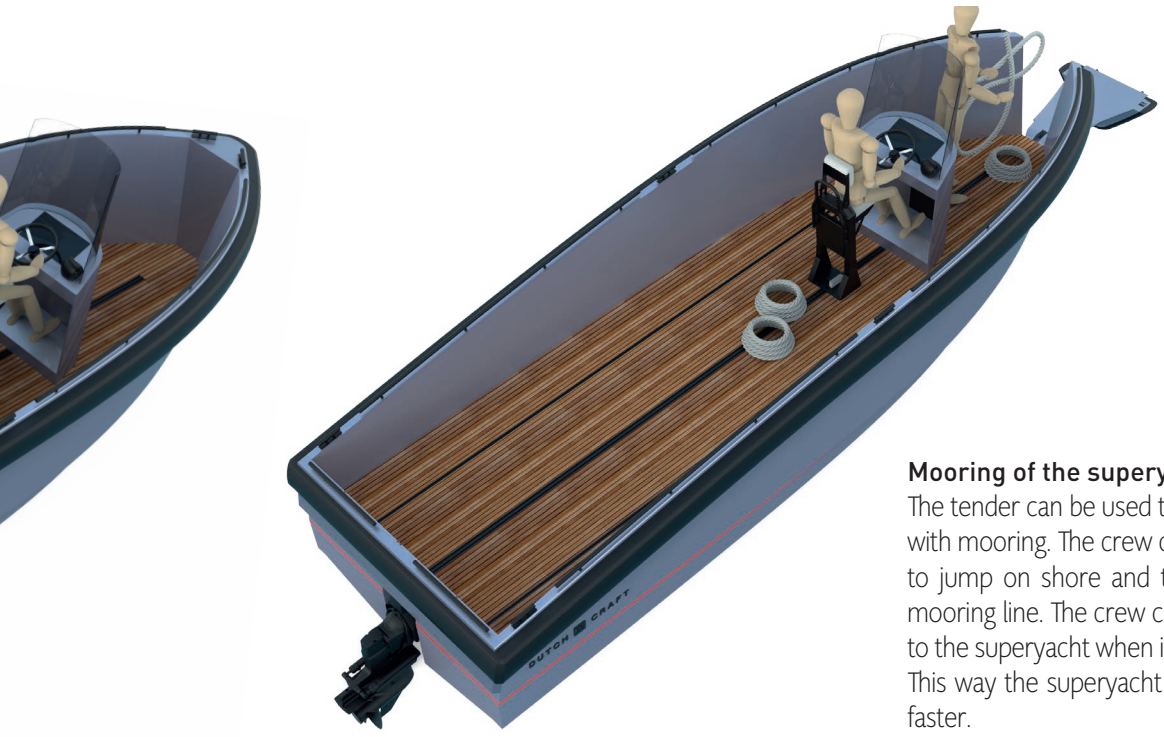
Land activities

Toys such as quad, bicycles, segways or scooters can also be fixed on the deck which enables the tender to support land activities.



Groceries/ garbage
The tender can be equipped with boxes that are fixed on the mounting system to transport garbage or groceries.

Storing/launching
The mounting system can also support storing and launching the tender. The tender can be lifted with a fixation on the mounting system. Because the tender is loaded differently for every activity, the lifting points can be adjusted to keep the tender balanced. The mounting system can also be used to fix the tender on the deck or in the tender garage.



Mooring of the superyacht
The tender can be used to help the superyacht with mooring. The crew can use the front door to jump on shore and to fix one end of the mooring line. The crew can pass the other end to the superyacht when it is reversing to shore. This way the superyacht can be docked much faster.

10. Evaluation

Dutchcraft 25 E-xtend

10.1 Conclusion

Drive-train arrangement

It is concluded that the transition to an electric drive-train for a tender creates new opportunities which Dutchcraft can use to enter the market successfully. The most important transition resulting from this project is the transformation of the shape of the deck due to the different electric drive-train configurations.

This transformation was also achieved for the hull of the 24,6-feet Dutchcraft and created an entire flat and empty deck. This deck enables to apply four mounting rails over the whole length of the tender. These rails creates the opportunity to fix an enumerable amount of arrangements such as moving passenger seats, driver seats, the driver helm, toys, fishing hooks or extra storage lockers on the deck. This modularity, changes the CODP to "buy 1" of the supply chain. This allows to link a specific customer in a later stage of the process, therefore, the customer has more influence on the customization of the product.

It is concluded that the conceptual proposal presented in this thesis, offers all activities (Figure 45) that came out of the research except water-skiing due to the performance. Currently, there are no other electric boats that offer such an extensive range of activities thus this is a unique market opportunity for Dutchcraft. This all-embracing concept allows the superyacht to have fewer tenders on board and accordingly save space on board for toys.

Brand / Activity	Boesch	Electric boat co.	Frauscher	Hickley Dasher	JP Ribs	Lillebror	Mylne	Q Yachts	Symphony boat	X Shore	DutchCraft 25 E-xtend
transport ship to shore	V	V	V	V	V	V	V	V	V	V	V
diving	V	V	V	V	V	V	V	V	X	V	V
fishing	X	X	X	X	X	X	X	X	X	X	V
beach landing	X	X	X	X	V	X	X	X	X	X	V
explore trip	X	X	X	X	X	X	X	X	X	V	V
water-skiing	X	X	X	X	X	X	X	X	X	X	X
transport groceries	V	V	V	V	V	V	V	V	V	V	V
transport garbage	V	V	V	V	V	V	V	V	V	V	V
mooring superyacht	V	V	V	V	V	V	V	V	V	V	V
cleaning the tender	V	V	V	V	V	V	V	V	V	V	V
emergency situation	V	V	V	V	V	V	V	V	V	V	V
charging the tender	V	V	V	V	V	V	V	V	V	V	V
storing the tender	V	V	V	V	V	V	V	V	V	V	V
launching the tender	V	V	V	V	V	V	V	V	V	V	V

Figure 45: Activities compared with the Dutchcraft 50 E-xtend

There is concluded that when the deck is maximal equipped with seats (6 seats + 2 driver seats) the users have enough legroom (675 mm) to sit comfortably for a trip that is maximal one hour.

Considering the 115.000 euro cost of the drive-train, it will be a challenge for Dutchcraft to build at a low budget and to make a profit when they want to offer a tender under 300.00 euro.

The tender has the following benefits:
- > 100 % electric tender which is quiet and requires low maintenance.
- > A tender with a length of 24,6-feet that can fit most superyachts between 130-feet and 300-feet.
- > A tender with one-hour full speed range.
- > A tender that can embark on the beach.

The tender has the following unique benefits:
- > A tender with a range that provides more than fourteen activities (Figure 44).
- > A tender that can be customized in a later stage of the supply chain because of the modularity.
- > A tender that has an innumerable amount of configuration (arrangements).
- > The purpose of the tender can be extended by buying extra equipment.
- > A tender that can change the privacy of the guest and owner by changing the position of the driver.
- > The tender that creates more space on the superyacht to store other toys.

10.2 Recommendations

Drive train arrangement

Because of the constant changing battery performance, it is recommended to keep following this emerging technology. This could result in reducing weight and increase storage space under the deck.

It is recommended to keep the electric drive-train circuit separated from other electrical systems because of the different voltages. Therefore, it is recommended to charge them separately. The drive-train should be in a divided water-proof room for safety reasons.

The capacity of the battery packs in the tender is now composted in such a way it can support all the activities resulting from the user research (one-hour full throttle). If the owner needs less range because the activities he or she desires are all short activities, Dutchcraft should offer smaller battery packs. This would have an essential influence on the price and weight of the tender and consequently will influence the displacement and the waterline; therefore a naval architect should help.

Activity arrangement

The seating of the Dutchcraft 50 could be improved by applying a 5° angle in the seat which provides more support under the legs and places the user more backwards to avoid to slide off the chair.

It is recommended to improve the design of the seating and driver helm because they do not have any luxury look and feel. Therefore, Dutchcraft could use the experience of the brand Zeelander.

Beach landing

The beach landing solution requires a further 1 to 1 scale simulations to test the moving principle on overlooked errors and a calculation for the strength of the hinge, ropes, and shape of the door.

10.3 Recommendations for further research

Naval architect
The first task before doing further detail engineering is to determent the exact dimensions of the hull by a naval architect. This way, the performance can be determined, and further detail engineering can be conducted.

Charging
Research into charging systems and charging possibilities on board of the superyacht for the electric tender was not conducted. To know the possibilities for charging the tender on board of the superyacht, it is recommended to do research into the accommodations on the superyacht.

Aesthetics
The project did not focus on the styling of the created components (seats, driver helm or storage boxes). The focus was on showing the possibilities that came with the transition of the electric drive-train. Therefore, it is recommended to restyle the components with a luxurious look and feel, and to match these with the exterior design.

Beach landing
A solution is found for the unique shape of the hull of Dutchcraft to embark on the beach. The solution shows a working principle that can work but has to be developed further into detail.

Carbon
To reduce weight, it is recommended to use carbon fiber for the construction of the hull. It is also recommended to apply carbon foilers to the hull to improve the performance of the tender.

Side embarkation
Side embarkation of the a tender was also a step that came out of the user research but was not developed during this thesis. Therefore, it is recommended to search for a solution that provides a comfortable and save side embarkation.

Spray-hood
Further research has to be done to find a solution to protect users from the sun. Probably, a spray-hood solution and it would be nice if it could be moved over the rails as well. The dimensions of the tender garage should be taken into account, so the tender fits.

Storage space
After the arrangement of the electric drive-train, there was no further investigation conducted on how many storage spaces there are exactly left under the deck. Therefore, the other small elements for the drive-train should be arranged, and the space that is left can be used as storage.

Dutchcraft 25 E-xtend

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Appendices

Appendix A: Portfolio specifications

Zeelander

	Z44	Z55	Z55 CORNICHE	Z66	Z68	Z164
LOA	13,52 m	17 m	17 m	20,12 m	20,5 m	49,9 m
BEAM	4 m	5 m	5 m	6 m	6 m	9.4 m
Pax	10 p	12 p	12 p	12 p	10 p	12 p + 10 crew
Weight	14.000 kg	24.000 kg		42 T	45 T	499 GT
Price from	€ 1.500.000	€ 2.245.000	€ 1.950.000	€ 3.295.000	€ Out of sale	€ 26.950.000
# produced	30	5 + 1 under construction	0	0	1	0

DutchCraft

DC50
15,89 m
5,06 m
12 p
22.000 kg
€ 645.000
Under construction

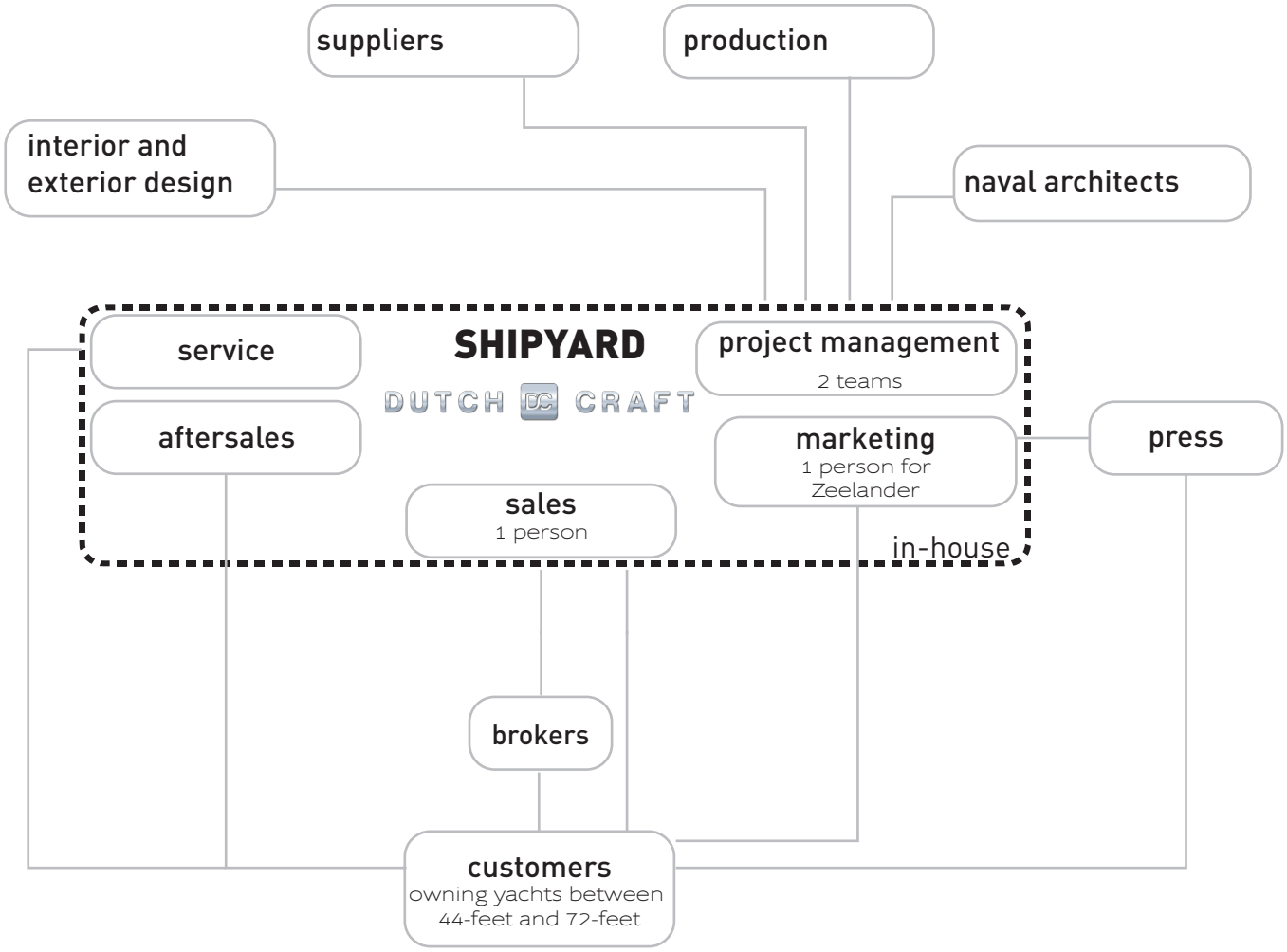
Zeelander has built three models the Z44, Z55, and Z68. Currently, they are constructing a Z72 model and are planning to develop a z55 Corniche. The Z164 model is ready for production, but the company will only start building when they have a customer.

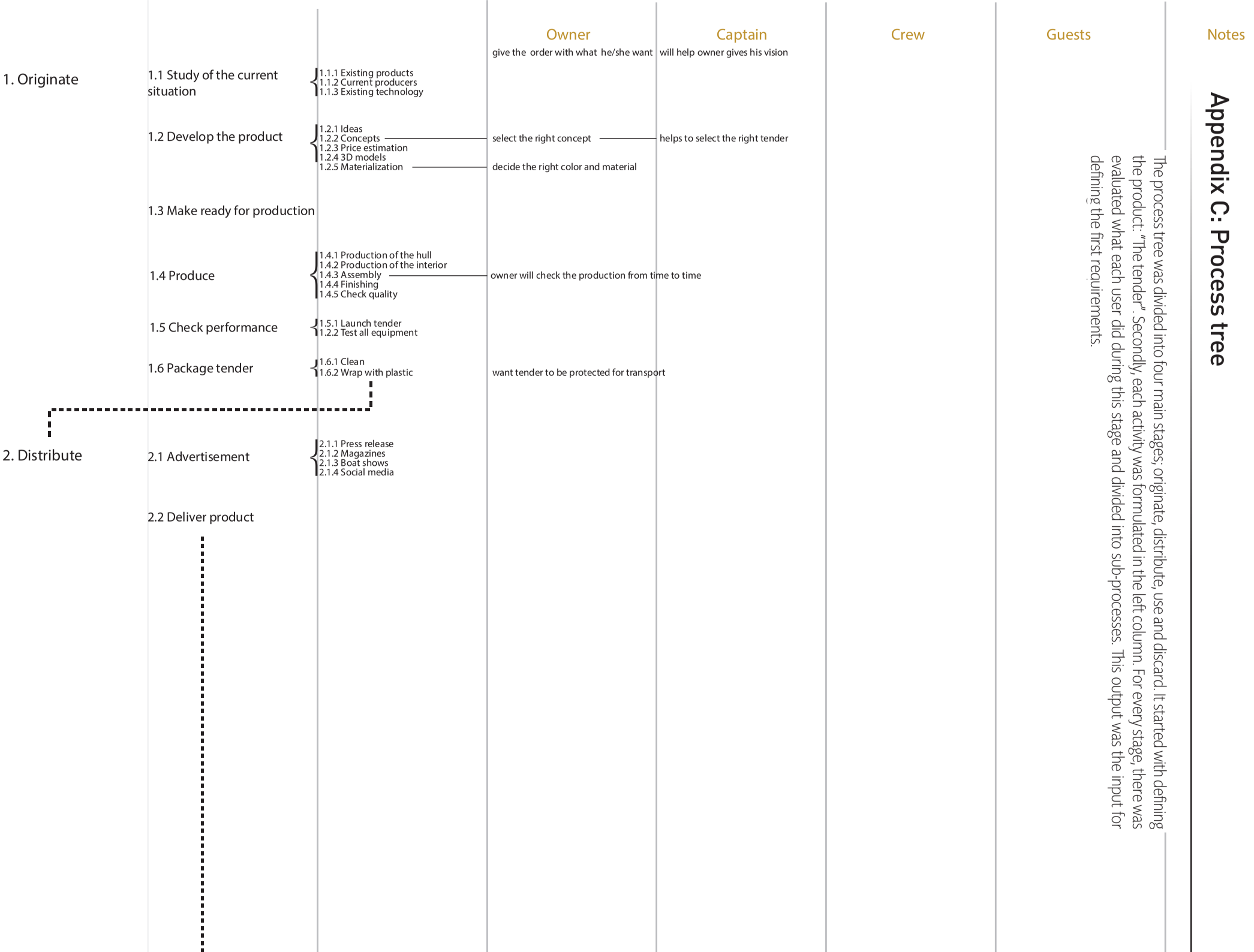
Built

Under construction

Appendix B: Resource map

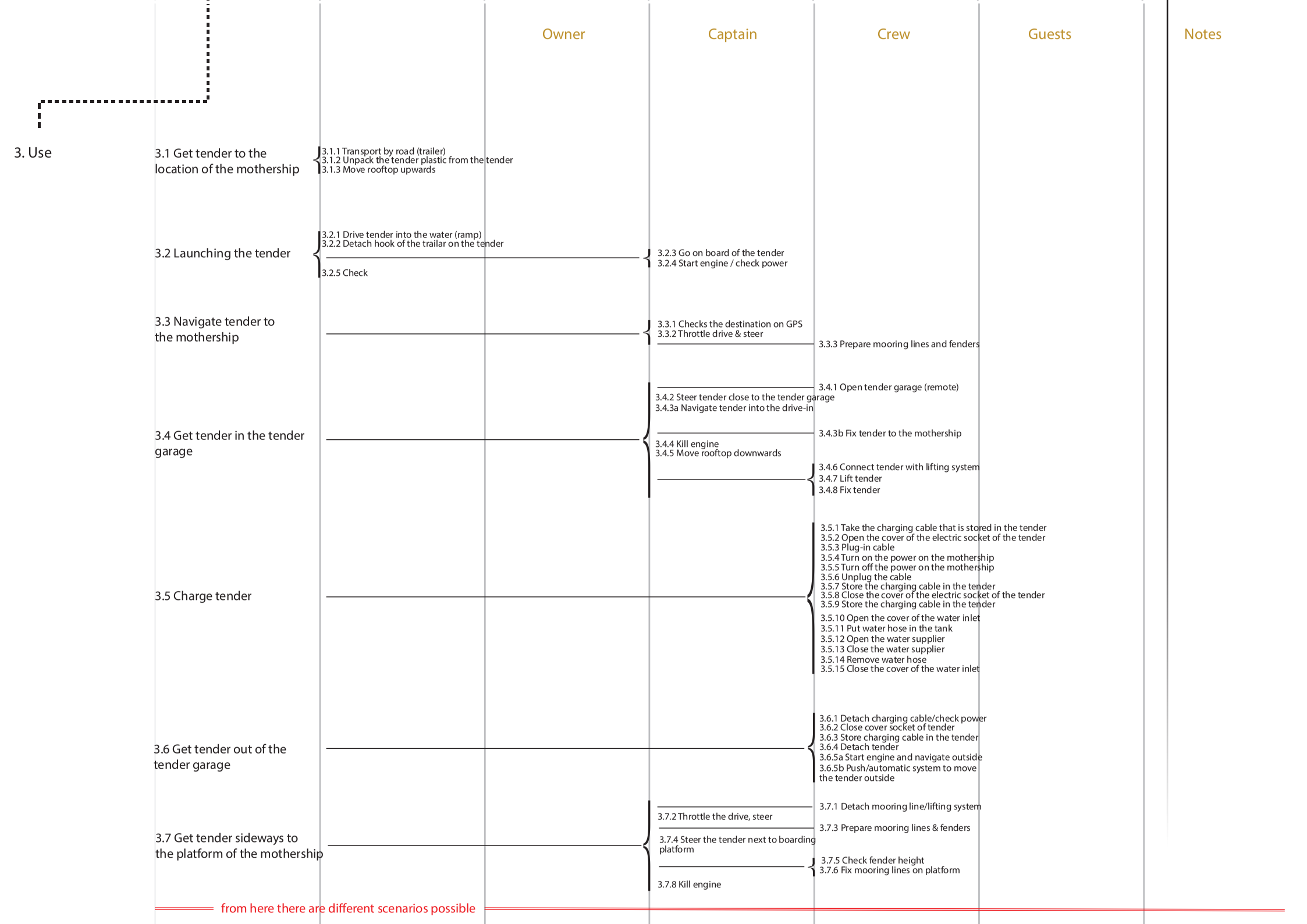
To create the overview an internal and external research was conducted to found all the resources of Dutchcraft and Zeelander. The overview shows the available resources the company currently has.





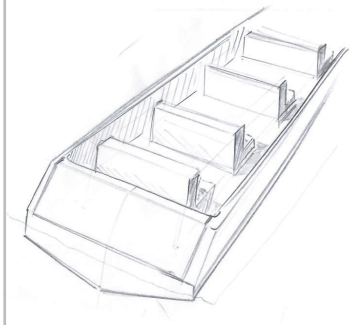
Appendix C: Process tree

The process tree was divided into four main stages; originate, distribute, use and discard. It started with defining the product: "The tender". Secondly, each activity was formulated in the left column. For every stage, there was evaluated what each user did during this stage and divided into sub-processes. This output was the input for defining the first requirements.


Owner
Captain
Crew
Guests
Notes
3. Use
3.1 Get tender to the location of the mothership
3.1.1 Transport by road (trailer)
3.1.2 Unpack the tender plastic from the tender
3.1.3 Move rooftop upwards
3.2 Launching the tender
3.2.1 Drive tender into the water (ramp)
3.2.2 Detach hook of the trailar on the tender
3.2.3 Go on board of the tender
3.2.4 Start engine / check power
3.2.5 Check
3.3 Navigate tender to the mothership
3.3.1 Checks the destination on GPS
3.3.2 Throttle drive & steer
3.3.3 Prepare mooring lines and fenders
3.4 Get tender in the tender garage
3.4.1 Open tender garage (remote)
3.4.2 Steer tender close to the tender garage
3.4.3a Navigate tender into the drive-in
3.4.3b Fix tender to the mothership
3.4.4 Kill engine
3.4.5 Move rooftop downwards
3.4.6 Connect tender with lifting system
3.4.7 Lift tender
3.4.8 Fix tender
3.5 Charge tender
3.5.1 Take the charging cable that is stored in the tender
3.5.2 Open the cover of the electric socket of the tender
3.5.3 Plug-in cable
3.5.4 Turn on the power on the mothership
3.5.5 Turn off the power on the mothership
3.5.6 Unplug the cable
3.5.7 Store the charging cable in the tender
3.5.8 Close the cover of the electric socket of the tender
3.5.9 Store the charging cable in the tender
3.5.10 Open the cover of the water inlet
3.5.11 Put water hose in the tank
3.5.12 Open the water supplier
3.5.13 Close the water supplier
3.5.14 Remove water hose
3.5.15 Close the cover of the water inlet
3.6 Get tender out of the tender garage
3.6.1 Detach charging cable/check power
3.6.2 Close cover socket of tender
3.6.3 Store charging cable in the tender
3.6.4 Detach tender
3.6.5a Start engine and navigate outside
3.6.5b Push/automatic system to move the tender outside
3.7 Get tender sideways to the platform of the mothership
3.7.1 Detach mooring line/lifting system
3.7.2 Throttle the drive, steer
3.7.3 Prepare mooring lines & fenders
3.7.4 Steer the tender next to boarding platform
3.7.5 Check fender height
3.7.6 Fix mooring lines on platform
3.7.8 Kill engine
from here there are different scenarios possible

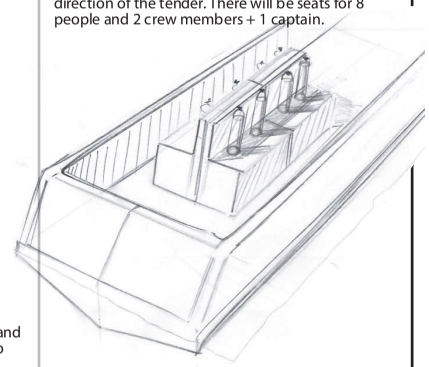
3.8 Picking up the owner or guests from shore

Owner	Captain	Crew	Guests	Notes
		3.8.0 Set the configuration of the tender to taxi mode.		The seating will be placed in transverse direction of the tender. There will be seats for 8 people and 2 crew members + 1 captain.
		3.8.1 Provide drinks and snacks		
	3.8.2 Start engine/ check power			
		3.8.3 Detach mooring lines		
	3.8.4 Throttle drive, steer			
		3.8.5 Store mooring lines and fenders		
	3.8.6 Navigate to shore / harbor			
		3.8.7 Prepare mooring lines and fenders 3.8.8 Take hook for mooring line		
	3.8.9 Backwards to shore			
		3.8.10 Grab mooring line with hook 3.8.11 Fix mooring line in frond of the tender 3.8.12 Fix mooring line to shore		
	3.8.13 Kill engine			
		3.8.14 Open swim platform and adjust height 3.8.15 Extend gangway 3.8.16 Extend rail 3.8.17 Release owner and guest from their luggage		
3.8.18 Get on board 3.8.19 Take a seat 3.8.20 Inspecting his / her tender			3.8.18 Get on board 3.8.19 Take a seat	
			3.8.21 First time, inspecting the tender	
		3.8.22 Storage luggage in dry storage locker 3.8.23 Pull in rail and gangway 3.8.24 Close swim platform		
	3.8.25 Start engine / check power			
		3.8.26 Detach mooring lines		
	3.8.27 Throttle drive, steer 3.8.28 Navigate to mothership (30min)			
		3.8.29 Store mooring lines and fenders 3.8.30 Offer drink/snacks		
		3.8.31 Prepare mooring lines & fenders		
	3.8.32 Steer tender next to boarding platform			
		3.8.33 Check fender height 3.8.34 Fix mooring lines on platform		
	3.8.35 Kill engine			
		3.8.36 Open side door		
3.8.37 Go on board of the mothership				
		3.8.38 Take luggage on board 3.8.40 Clean tender (8.13) 3.8.41 Store in garage (3.4) 3.8.42 Charge tender (3.5)		



3.9 Diving with owner or guests

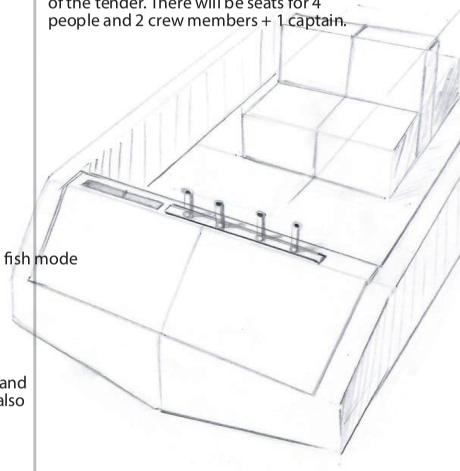
Owner	Captain	Crew	Guests	Notes
		3.9.0 Set the configuration of the tender to dive mode.		The seating will be placed in longitudinal direction of the tender. There will be seats for 8 people and 2 crew members + 1 captain.
		3.9.1 Put 8 diving bottles on board in the special bottles holders in the wet storage compartment 3.9.2 Put masks, snorkels, weight belts, dive suits, gloves Buoyancy Control Devices and flippers in the wet storage compartment of the tender 3.9.3 Close wet storage compartment 3.9.4 Provide towels and store them in a dry storage compartment		
	3.9.5 Start engine			
3.9.6 Get on board of the tender and wear swimming clothes, they also brought along dry clothes			3.9.6 Get on board of the tender and wear swimming clothes, they also brought along dry clothes	
3.9.7 Take a seat			3.9.7 Take a seat	
		3.9.8 Store the dry clothes in the dry storage compartment 3.9.9 Detach the mooring lines		
	3.9.10 Throttle drive, steer			If the tender goes to far, the system will give a signal to the captain so he knows if he goes further away from the mothership, he will not be able to get back to the mothership.
		3.9.11 Store the mooring lines and the fenders		
	3.9.12 Navigate to the diving location (30min)			
		3.9.13 Prepare the anchor		
	3.9.14 Look for a nice spot to drop the anchor			
		3.9.15 Drop the anchor		
	3.9.16 Kill engine			
3.9.17 Put on diving gear			3.9.17 Put on diving gear	
3.9.18 Sit to put flippers on			3.9.18 Sit to put flippers on	
3.9.19 Jump into the water			3.9.19 Jump into the water	During the dive, solar cells provide extra power
3.9.20 Come back to the surface			3.9.20 Come back to the surface	
		3.9.21 Placing swim ladder		
3.9.22 Hold on, on the swim platform			3.9.22 Hold on, on the swim platform	
3.9.23 Taking off flippers			3.9.23 Taking off flippers	
3.9.24 Handing over flippers to crew			3.9.24 Handing over flippers to crew	
		3.9.25 Receive flippers		
3.9.26 Come on board with the swim ladder			3.9.26 Come on board with the swim ladder	
3.9.27 Put out the diving gear			3.9.27 Put out the diving gear	
		3.9.28 Storage diving gear in wet storage compartment 3.9.29 Handing over the towels		
3.9.30 Take shower on the rear deck			3.9.30 Take shower on the rear deck	
3.9.31 Put on dry clothes			3.9.31 Put on dry clothes	
3.9.32 Take a seat			3.9.32 Take a seat	
		3.9.33 Offer drinks		
3.9.34 Come on board with the swim ladder			3.9.35 Come on board with the swim ladder	
3.9.35 Take shower on the rear deck			3.9.36 Take shower on the rear deck	
		3.9.36 Taking in the swim ladder		
	3.9.37 Start engine / Check power			
		3.9.38 Lift anchor		
	3.9.39 Throttle drive, steer 3.9.40 Navigate to mothership (30min)			
		3.9.41 Prepare mooring lines & fenders		
	3.9.42 Steer tender next to boarding platform			
		3.9.43 Check fender height 3.9.44 Fix mooring lines on platform		
	3.9.45 Kill engine			
		3.9.46 Open side door		
3.9.49 Go on board of the mothership			3.9.48 Go on board of the mothership	
		3.9.50 Unloading 3.9.51 Clean tender* (3.13)* 3.9.52 Store in the garage (3.4) * 3.9.53 Charge tender* (3.5)*		

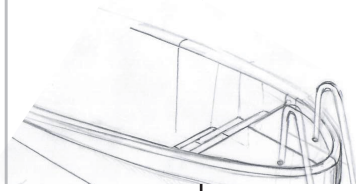


3.10 Fishing with owner or guests

Owner	Captain	Crew	Guests	Notes
		3.10.0 Set the configuration of the tender to fish mode		The seating will be placed in transverse direction of the tender. There will be seats for 4 people and 2 crew members + 1 captain.
		3.10.1 Attach fishing equipment on the provided holders reposition boat to fish mode		
		3.10.2 Put toolkit with fishing gear in the wet storage compartment		
		3.10.3 Provide snacks and drinks in the cooler		
		3.10.4 Provide towels and store them in a dry storage compartment		
		3.10.5 Provide icebox to store the fishes in the wet storage compartment		
	3.10.6 Start engine			
3.10.7 Get on board of the tender and are wear swimming clothes, they also brought along dry clothes			3.10.7 Get on board of the tender and are wear swimming clothes, they also brought along dry clothes	
3.10.8 Take a seat			3.10.8 Take a seat	
		3.10.9 Store the dry clothes in the dry storage compartment		
		3.10.10 Detach the mooring lines		
	3.10.11 Throttle drive, steer			
		3.10.12 Store the mooring lines and the fenders		
	3.10.13 Navigate to the fishing location (5min)			
		3.10.14 Prepare the fishing lines		
	3.10.15 Keep speed of the tender between 5 and 6 kts for 1-3 hours			
3.10.16 Throw out fishing lines			3.10.16 Throw out fishing lines	
3.10.17 Catch			3.10.17 Catch	
		3.10.18 Open icebox		
3.10.18 Put fish in icebox			3.10.19 Put fish in icebox	
		3.10.20 Close icebox		
3.10.21 Put fishing line back in provided holders			3.10.21 Put fishing line back in provided holders	
3.10.22 Wash hands with douche system (aft deck)			3.10.22 Wash hands with douche system (aft deck)	
3.10.23 Relax / take a seat			3.10.23 Relax / take a seat	
		3.10.24 Offer drinks		
	3.8.25 Navigate to mothership (30min)			
		3.8.26 Prepare mooring lines & fenders		
	3.9.27 Steer tender next to boarding platform			
		3.9.28 Check fender height		
		3.9.29 Fix mooring lines on platform		
	3.9.30 Kill engine			
		3.9.31 Open side door		
3.9.32 Go on board of the mothership			3.9.32 Go on board of the mothership	
		3.9.33 Unloading		
		3.8.34 Clean tender* (3.13)		
		3.8.35 Store in garage* (3.4)		
		3.8.36 Charge tender* (3.5)		

Owner	Captain	Crew	Guests	Notes
		3.11.0 Set the configuration of the tender to taxi mode		The seating will be placed in transverse direction of the tender. There will be seats for 8 people and 2 crew members + 1 captain.
		3.11.1 Put BBQ and gas bottle on board		
		3.11.2 Put toolkit for BBQ in the wet storage compartment		
		3.11.3 Provide snacks and drinks in the cooler		
		3.11.4 Provide towels and store them in a dry storage compartment		
		3.11.5 Provide cool box with meat, salad, ...		
		3.11.6 Provide cutlery, dishes and glasses store them and fix		
		3.11.7 Provide extra blankets store them in the dry storage compartment		
	3.11.8 Start engine			
		3.11.9 Close side door		
		3.11.10 Detach the mooring lines		
	3.11.11 Throttle drive, steer			
		3.11.12 Store the mooring lines and the fenders		
	3.11.13 Navigate to the beach (15min)			
	3.11.14 Approaching beach careful			
	3.11.15 Lift driver, to prevent the propeller from entering the bottom			





3.11 Beach landing / BBQ

3.11.16 Open front door
3.11.17 Take the swim ladder
3.11.18 Attach swimming ladder
3.11.19 Unload all equipment for BBQ
3.11.20 Prepare the BBQ
3.11.21 Detach swimming ladder
3.11.22 Close front door
3.11.23 Push tender back in the water

3.11.24 Start engine
3.11.25 Drop driver
3.11.26 Navigate to mothership (30min)

3.11.27 Prepare mooring lines & fenders

3.11.28 Steer tender next to boarding platform

3.11.29 Check fender height
3.11.30 Fix mooring lines on platform

3.11.31 Kill engine

3.11.32 Open side door

3.11.33 Step on board of the tender through the side door, they brought along personal belongings, extra sweater

3.9.34 Take a seat

3.11.35 Store personal belongings in the dry storage compartment
3.11.36 Close side door
3.11.37 Detach the mooring lines

3.11.38 Throttle drive, steer

3.11.39 Store the mooring lines and the fenders

3.11.40 Navigate to the beach (15min)
3.11.41 Approaching beach careful
3.11.42 Lift driver, to prevent the propeller from entering the bottom

3.11.43 Open front door
3.11.44 Take the swim ladder
3.11.45 Attach swimming ladder

3.11.46 Embark the tender via the swimming ladder

3.11.47 Have BQQ on the beach

3.11.48 Board the tender via the swimming ladder

3.11.47 Embark the tender via the swimming ladder
3.11.48 Have BBQ on the beach
3.11.49 Board the tender via the swimming ladder

3.11.49 Detach swimming ladder
3.11.50 Close front door
3.11.51 Push tender back in the water

3.11.52 Start engine
3.11.53 Drop driver
3.11.54 Navigate to mothership (30min)

3.8.55 Prepare mooring lines & fenders

3.9.56 Steer tender next to boarding platform

3.9.57 Check fender height
3.9.58 Fix mooring lines on platform

3.9.59 Kill engine

3.9.60 Open side door

3.9.61 Go on board of the mothership

3.9.61 Go on board of the mothership

3.11.62 Close side door
3.11.63 Detach the mooring lines

3.11.64 Throttle drive, steer

3.11.65 Store the mooring lines and the fenders

3.11.66 Navigate to the beach (15min)
3.11.67 Approaching beach careful
3.11.68 Lift driver, to prevent the propeller from entering the bottom

3.11.69 Open front door
3.11.70 Take the swim ladder
3.11.71 Attach swimming ladder
3.11.72 Load all equipment of BBQ
3.11.73 Push tender back in the water
3.11.74 Get on board via swimming ladder
3.11.75 Detach swimming ladder
3.11.76 Close front door

3.11.77 Start engine
3.11.78 Drop driver
3.11.79 Navigate to mothership (15min)

3.8.80 Prepare mooring lines & fenders

3.9.82 Steer tender next to boarding platform

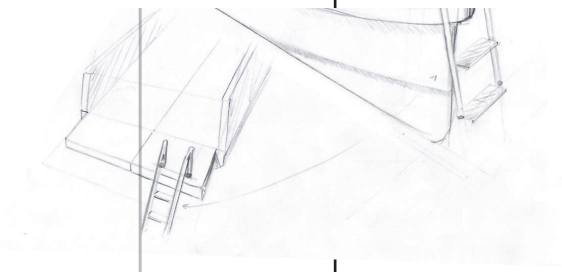
3.9.82 Check fender height
3.9.83 Fix mooring lines on platform

3.9.84 Kill engine

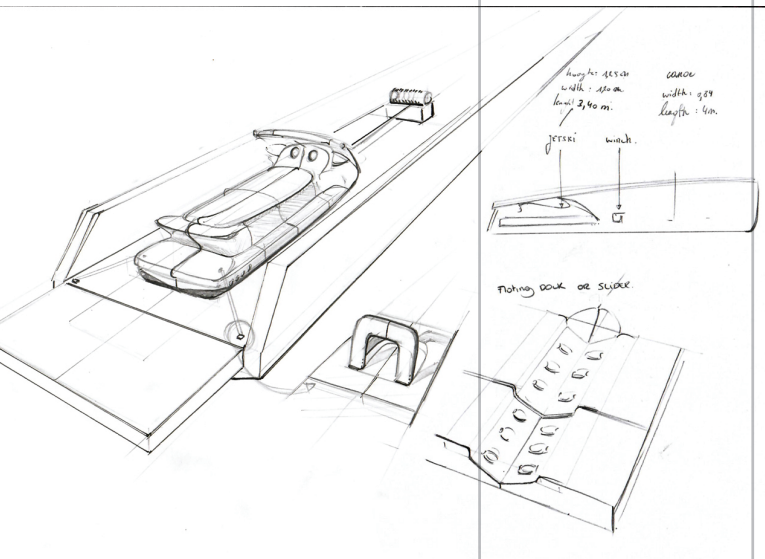
3.9.85 Open side door
3.9.86 Unload BQQ items
3.8.87 Clean tender* (3.13)

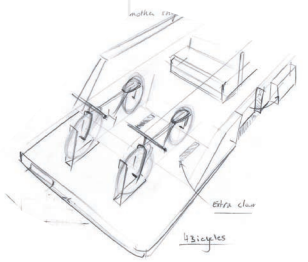
3.8.88 Store in garage* (3.4)

3.8.89 Charge tender* (3.5)



3.12 Explore trip
- Bicycles
- Jetski
- Canoes
- Windsurfing
- Quad
- Small sailing boat



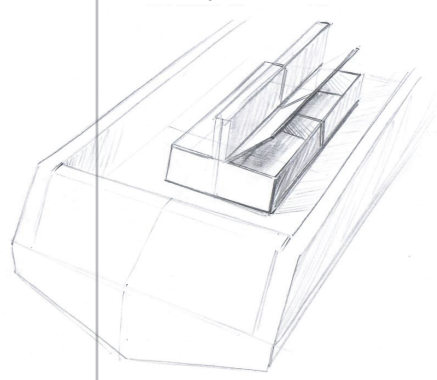
Owner	Captain	Crew	Guests	Notes
		3.12.0 Set the configuration of the tender to explore mode		The seating will be placed in transverse direction of the tender. There will be seats for 4 people and 2 crew members + 1 captain.
		3.12.1 Open side door 3.12.2 Open swim platform 3.12.3 Open bicycle clip 3.12.4 Board bicycles via side door on board in clip and fix 3.12.5 Provide snacks and drinks in the cooler 3.12.6 Provide towels and store them in a dry storage compartment		
	3.12.7 Start engine			
3.12.8 Go on aboard of the tender and brought a small backpack with personal to belong + sit down			3.12.8 Go on aboard of the tender and brought a small backpack with personal to belong + sit down	
		3.12.9 Store the backpacks in the dry storage compartment 3.12.10 Detach the mooring lines		
	3.12.11 Throttle drive, steer			For a longer trip, they should be an option for the owner to buy an generator that can extend the range
		3.12.12 Store the mooring lines and the fenders		
	3.12.13 Navigate to shore (60min)			
		3.12.14 Prepare mooring lines & fenders		
	3.12.15 Steer tender next to shore			
		3.12.16 Check fender height 3.12.17 Fix mooring lines		
	3.12.18 Kill engine			
		3.12.19 Open side door 3.12.20 Hand over bottle of cold water and snacks		
3.12.21 Embark the tender with backpack			3.12.21 Embark the tender with backpack	
		3.12.22 Open bicycle clip 3.12.23 Aboard Bicycles via side door 3.12.24 Close side door 3.12.25 Close swim platform		For transporting other toys the tender must be equipped with points on the deck where the toys can be secured.
	3.12.26 Start engine/ check power			
		3.12.27 Detach mooring lines		
	3.12.28 Throttle drive, steer			
		3.12.29 Store mooring lines and fenders		To lift bigger toys like the jet ski or small sailing boat a winch need to be used.
	3.12.30 Navigate to mothership			
		3.12.31 Prepare mooring lines and fenders 3.12.32 Take hook for mooring line 3.12.33 Charge tender* (3.5)		
	3.12.34 Start engine 3.12.35 Throttle drive, steer			
		3.12.36 Store the mooring lines and the fenders 3.12.37 Prepare mooring lines & fenders		
	3.12.38 Steer tender next to shore			
		3.12.39 Reload bicycles (dirty) 3.12.40 Offer cold drinks and snacks		
3.12.41 Disembark the tender with backpack (dirty)			3.12.41 Disembark the tender with backpack (dirty)	
	3.12.42 Start engine/ check power			
		3.12.43 Detach mooring lines		
	3.12.44 Navigate to mothership (15min)			
		3.12.45 Prepare mooring lines & fenders		
	3.12.46 Steer tender next to boarding platform			
		3.12.47 Check fender height 3.12.48 Fix mooring lines on platform		
	3.12.49 Kill engine			
		3.12.50 Open side door		
3.12.51 Go on board of the mothership			3.12.51 Go on board of the mothership	
		3.12.52 Clean tender (3.13)* + clean bicycles 3.12.53 Unload Bicycles 3.12.54 Store in garage* (3.4) 3.12.55 Charge tender* (3.5)		

3.13 Clean tender

3.13.1 Empty the waste bin
3.13.2 Use the water hose of the mothership with fresh water to remove the salt and other dirt
3.13.3 Desalt the mooring lines with fresh water
3.13.4 Ad soap and brush the deck and wet storage compartments
3.13.5 Brush the hull with soap
3.13.6 Use water hose to spray clean

The seating will be in moved around so the hole tender can be cleaned.

Figure1 : implementation

	Owner	Captain	Crew	Guests	Notes
3.14 Mooring the mothership in a bay			3.14.1 Drive tender into the water (ramp) 3.14.2 Detach hook of the trailer on the tender 3.14.3 Check power 3.14.4 Provide mooring lines of the mothership 3.14.5 Go on board of the tender and eject rooftop 3.14.6 Start the engine 3.14.7 Navigate to shore, rocks 3.14.8 Prepare mooring lines 3.14.9 Jump on shore with one end of the mooring line 3.14.10 Fix the end of the mooring line on the rocks 3.14.11 Navigate back to mothership 3.14.12 Hand over the other end to the mothership 3.14.13 Pick up the crew member 3.14.14 Navigate to shore, rocks 3.14.15 Jump on shore with one end of the mooring line 3.14.16 Fix the end of the mooring line on the rocks 3.14.17 Navigate back to mothership 3.14.18 Hand over the other end to the mothership 3.14.19 Pick up the crew member 3.14.20 Navigate to mothership 3.14.21 Prepare mooring lines & fenders 3.14.22 Fix mooring lines on platform 3.14.12 Kill engine 3.12.23 Cleaning (3.13)* the sand from shore		
3.15 Get the groceries on the mothership			**3.15.0 Set the configuration of the tender to supplier mode** 3.15.1 Start engine/ check power 3.15.2 Detach mooring lines 3.15.3 Throttle drive, steer 3.15.4 Store mooring lines and fenders 3.15.5 Navigate to shore / harbor (30min) 3.15.6 Prepare mooring lines and fenders 3.15.7 Take hook for mooring line 3.15.8 Backwards to shore 3.15.9 Grab mooring line with hook 3.15.10 Fix mooring line in front of the tender 3.15.11 Fix mooring line to shore aft deck 3.15.12 Kill engine 3.15.13 Open swim platform and adjust height 3.15.14 Extend gangway and rail 3.15.15 Aboard tender 3.15.16 Close gangway and rail (remote) 3.15.17 Close platform (remote) 3.15.18 Open swim platform and adjust height (remote) 3.15.19 Extend gangway and rail (remote) 3.15.20 Board groceries in dry and wet compartments 3.15.21Pull in rail and gangway 3.15.22 Close swim platform 3.15.23 Start engine/ Check power 3.15.24 Detach mooring lines 3.15.25Throttle drive, steer 3.15.26 Store mooring lines and fenders 3.15.27 Navigate to mothership (30min) 3.15.28 Steer tender next to boarding platform 3.15.29 Check fender height 3.15.30 Fix mooring lines on platform 3.15.31 Kill engine 3.15.32 Open side door 3.15.33 Disembark groceries		The seating will be placed in longitudinal direction of the tender. There will be seats for 8 people and 2 crew members. Seats will not be used. 
3.15 Repair the tender			3.16.1 Open tender garage (remote) 3.16.2 Steer tender close to the tender garage 3.16.3a Navigate tender into the drive-in 3.16.3b Fix tender to the mothership 3.16.4 Kill engine 3.16.5 Insert the rooftop 3.16.6 Connect tender with lifting system 3.16.7 Lift tender 3.16.8 Fix tender 3.16.9 Open tender 3.16.10 Replace broken parts 3.16.11 Close product		


Owner
Captain
Crew
Guests
Notes
4. Discard
4.1 Sell product second hand
4.1.1 Offer product online
4.1.2 Trade for new model at DutchCraft
4.2 Recycle materials
4.2.1 Battery packs
4.1.2 Electric components
4.1.3 Optical fiber

Appendix D: Requirements

1. Performance

1.1 Speed

1.1.1 The cruising speed of the tender should be under 30 knots.
1.1.2 The cruising speed of the tender through all-weather should be 25 knots.
1.1.3 The tender should be driven by an electric motor of 125 kW.

1.2 Battery

1.2.1 The battery must last at least one-hour full speed.
1.2.2 The battery must be purchased at late as possible in the production process.

1.3 Dimensions

1.3.1 The overall length including propulsion of the tender should be 7,5 meters or 24,6 foot.
1.3.2 The height of the tender should be under 2,5 meters.

1.4 Weight

1.4.1 The weight of the tender should be lower than 1.800 kg.
1.4.2 The weight of the components should be as light as possible.

1.5 Price

1.5.1 The selling price of the tender should be under 280.000 euro.

2. Usage

2.1 Drivers helm

2.1.1 The driver should have a 360• view when he/she is in a seating position.
2.1.2 The driver should be able to open the tender garage on board of the tender remotely.

2.2 Aboard and disembark the tender

2.2.1 The tender should have a side door to aboard or disembark the tender from the side.
2.2.2 The tender should have a rear door to aboard or disembark the tender at the back.
2.2.3 The tender should have a front door to aboard or disembark the tender at the front.
2.2.4 The tender should provide support when aboard or disembark the tender.

2.3 Transport luggage and guests

2.3.1 When going from shore to ship or ship to shore with the guests and their luggage, the tender should provide seating for six guests and two crew members.

2.4 Diving or swimming

2.4.1 When going on a dive trip the tender should provide seating for six guests, their diving equipment and two crew members.
2.4.2 The tender should have a swimming ladder.
2.4.3 The swimming ladder should be easy to climb with flippers.
2.4.4 The tender should have a small anchor that can be throw out and lift by a person.
2.4.5 The anchor should be heavy enough to hold the tender.
2.4.6 The tender should provide a smooth launch for a diver.
2.4.7 The tender should have a shower on the aft deck.
2.4.8 The tender should have a swim platform.
2.4.9 The tender should have a grab where the swimmers or divers can hold on when floating in the water.

2.5 Fishing

2.5.1 When going on a fish trip the tender should provide seating for four guests and two crew members.
2.5.2 The tender should have four holders to fix for fishing lines.
2.5.3 The tender should have a wet storage compartment for extra fishing gear.

2.5.4 The tender should have storage for ice to preserve the fish.
2.5.5 The tender should have storage for dry clothes.

2.6 BBQ trip/beach landing
2.6.1 When going on a BBQ trip the tender should provide seating for six guests and two crew members.
2.6.2 The tender should provide storage for the BBQ equipment.
2.6.3 The tender should have a storage for the BBQ toolkit, cool box, cutlery, dishes, glasses, extra blankets...
2.6.4 The tender should have a storage for six chairs
2.6.5 The tender should have a storage for one table
2.6.6 The tender should be able to board or disembark the users in the front of the tender when doing a beach landing.

3. Facilities
3.1 The tender should have a charging cable on board to charge the tender on shore.
3.2 The tender should have a water tank.
3.3 The tender should have an inlet to fill the water tank.
3.4 The tender should have a refrigerator to store drinks and snacks for the guests.
3.5 The tender should have a boat hook on board.
3.6 The tender should be able to transport two kayaks with a length of 3,65 meters and four guests on board.
3.7 The tender should be able to transport a jet ski.
3.8 The tender should be able to transport a small sailing boat.
3.9 The tender should be able to transport a quad.
3.10 The tender should have points to secure toys on the deck. The tender should be able to transport four bicycles and four guests
3.11 The water for the shower should be heated by the cooling water of the electric motor.
3.12 Storage
3.12.1 All wet storage compartments should be able to clean with a water hose.
3.12.2 The tender should have storage for five mooring lines.
3.12.3 The tender should have storage for a small umbrella anchor of eight kilograms.
3.12.4 The tender should have a waste bin for waste during a trim.
3.12.5 The tender should have storage for the electric charging cable.
3.12.6 The tender should have a place to store the boat hook.
3.12.7 The tender should have a dry storage compartment to store all personal belongings, towels,...
3.12.8 The tender should have a dry storage compartment to transport the groceries.
3.12.9 The tender should be able to store four garbage bags of 80 liters.
3.13 Mothership
3.13.1 The tender should fit the mothership.
3.13.2 All unused components of the tender should be able to be stored on the mothership.
3.13.3 The tender should be able to be lifted by the lifting system of the mothership.
3.13.4 The tender should be fixable into the mothership.
3.13.5 The should have a waterproof charging system that can connect with the mothership.
3.13.6 All systems on board of the tender should be able to supervise on the mothership.

4. Maintenance
4.1 The tender should be cleanable.
4.2 Tender must have a self-draining deck.
4.3 The tender should have a sweeper and can on board.
4.4 The tender should have a bucket on board.

5. Comfort
5.1 The tender should offer a dry trip when it rains.

5.2 The tender should provide protection for the sun.
5.3 Seating should provide comfortable accommodation for all guests.
5.4 Seating area should be positioned such that slamming and shocks from hitting waves are minimal.
5.5 The tender should have audio for the guests entertainment.
5.6 The tender should provide sharing spots for phones and tablets.

6. Appearance
6.1 The appearance of the tender should have the same design language as the 50 foot DutchCraft.

7. Safety
7.1 The tender offers support during for the users wherever they walk, stand or sit.
7.2 The tender should have lifejackets for all people on board.
7.3 The tender provides enough space to walk safely around.
7.4 Electric systems and powertrain should be 100% waterproof.
7.5 The tender should have a VHF on board.
7.6 The tender should have a GPS on board.
7.7 The tender should have an EHBO kit on board.
7.8 The tender should have two fire extinguishers on board and are easy to access.
7.9 The tender should have extra fenders to protect it hull from bumping against the pier or yacht.
7.10 The drivers helm should be powered with a different electric circuit then the powertrain.

Appendix E: List items

For every activity, there were made assumptions for how many passengers to board during the different activities and how long a specific activity would take. There was researched which items are needed for specific activities and what the dimensions are of the items (e.g., for diving; masks, gloves and, dive suits) Next, there was also made an overview with items that always have to be stored on board.

Activity	Seating		To store		Time full speed
transport ship to shore	6 Pax.	2 crew	bags	drink and snacks	40 min.
diving	6 Pax.	2 crew	diving items		60 min.
fishing	4 Pax.	2 crew	fishing items		20 min. + 4h (6kts)
beach landing	6 Pax.	2 crew	BBQ items		40 min.
explore trip	2-4 Pax.	2 crew	trip items		40 min.
water-skiing	4 Pax.	2 crew	water-ski items		120 min.
transport groceries	-	2 crew	groceries		40 min.
transport garbage	-	2 crew	garbage		40 min.
mooring superyacht	-	2 crew	mooring lines		20 min.
cleaning the tender	-	-	cleaning items		-
emergency situation	-	-	rescue items		-
charging the tender	-	-	charging items		-
storing the tender	-	-	-		-
launching the tender	-	-	-		-

item on board for certain activity

Store bags		
Hand luggage	6	67 x 46 x 25
Luggage	6	55 x 40 x 20

Store diving idems		
Mask	6	160 x 83 x 50
Snorkel	6	380 x 35 x 20
Weight belt	12	70 x 70 x 30
Dive suit	6	
Gloves	6	
BCD	6	500 x 400 x 200
Diving bottle	6	171 x 690
Dry clothes	6	

Mooring superyacht		
Mooring line mothership	2	50 m

Transport trip items		
Bicycle	4	16000 x 984 x 50
Kayak	2	3650 x 630 x 350
Small sailing boat	1	
	Boat	4200 x 1390 x 400
	Sail	

Store fishing items		
Fishing line	4	2400 x 30
Fish bait	1	500 x 300 x 100
Fish tank	1	1000 x 500 x 400
Dry clothes	4	

Store BBQ items		
BBQ	1	1041 x 1306 x 622
Gas bottle	1	Insite BBQ
Coolbox	1	400 x 240 x 280
Cutlery	6	
Dishes	6	
Glasses	6	
Blanket	8	

Water-ski		
Water-ski	2	
Water-ski pole	4	
Rope	1	
Windsurf	1	
	Board	2375 x 640 200
	Sail	
Quad	1	2147 x 1205 x 1292
Jet ski	1	3130 x 1130 x 1150

items always on board

Cleaning	
Sweeper and can	1
Bucket	1

Emergency	
EHBO kit	1
Fire extinguisher	2
Life jacket	8

Mooring tender	
Mooring line for tender	5
Fender	4
Gangway	1
Hook	1

Always on board			
Drive-train	1	Shower head	1
12 V Battery	1	Refrigerator	1
Radio system	1	Anchor	1
GPS	1	Swim platform	1
VHF	1	Lifting points	4
Remote tender garage	1	Waste bin	1
Charge socket	8	Fishline hole	4
Water tank	61 L	Captain seat	1
Water inlet	1	Charging cable	2
		Binocular	1
		Swimming ladder	1

Appendix F: Superyachts and their tender lengths

The data was collected form the source: www.yachtcharterfleet.com

NAME	Length [m]	Tender L1	Tender L2	Tender L3	Tender L4	Tender L5	Tender L6
Beachouse	40,00	5,00					
Ava	40,00	6,40					
Glaros	40,50	5,40	4,30				
Manifiq	40,50	6,00					
Allure A	40,53	4,20					
Alfa XII	40,54	4,50					
O'Rion	40,97	4,20					
Ocean Pearl	41,00	4,45					
Ocean Sapphire	41,00	5,00	3,50				
Ocean Emerald	41,00	5,00	3,51				
Liberdade	41,00	5,18					
Destination	41,00	5,90	3,10				
The Shadow	41,00	5,90					
LadyShip	41,04	5,00					
Legenda	41,10	5,00					
Ability	41,40	5,18					
Golden Horn	41,40	5,30					
Dragon	41,50	5,40					
Calisto	41,50	5,80	3,40				
Barents Sea	41,76	5,40	3,60				
This Is Us	41,83	4,30	3,80				
Billa	42,00	5,40					
Amz	42,00	5,75	3,00				
Angiamo	42,00	6,71	6,71				
Anda	42,00	7,00					
Idefix	42,40	5,50	3,50				
Diaima	42,50	5,18					
Labra Y	42,50	5,90	5,20				
Garmen Fontana	42,60	4,90					
H	42,60	5,80					
Mona Liza	42,67	2,13					
My Toy	42,67	5,40					
Ira	42,75	4,60					
Grayzone	42,90	7,00					
Integrity	42,98	6,10					
Go Yacht	43,00	6,00					
Philmi	43,25	5,60	3,50				
Lady J	43,28	4,27					
Far From It	43,28	5,70					
Baron Trenck	43,30	6,50	3,80				
Victoria	43,40	4,88					
L'Albatros	43,59	6,50					
Justa Delia	43,60	5,40					
Harmony III	43,60	6,00					
Dione Star	43,60	7,50	5,80	4,50			
Silver Wind	43,63	4,88					
Silver Dream	43,80	5,49	4,57				
Deep Blue II	43,80	6,00	4,20				
The Lady K	43,80	6,40					
Alaska of George Town	43,90	5,65					
G3	44,00	3,80					
Seakid	44,00	5,00	3,85				
Blue Vision	44,00	5,40	3,50				
Kijo	44,00	6,00					
Jems	44,00	6,50					
Ariete Primo	44,00	6,90					
Beluga	44,05	6,50					
Agram	44,17	6,50					
Hemisphere	44,20	4,50					
Relentless	44,20	5,18					
I Love This Boat	44,20	5,40	4,50				
Domani	44,20	6,00					
Muchos Mas	44,20	6,50					
Safari Explorer	44,20	6,71					
Balaju	44,50	4,50					

Costa Magna	44,50	4,50					
Lady L	44,60	2,60					
Berzinc	44,68	6,50	3,50				
San Bernardo	44,77	6,50	3,60				
Seastar	44,80	4,20					
Flying Dragon	44,80	5,18					
M3	44,81	5,49					
Tatiana	44,88	5,30					
Ipanemas	45,00	5,05	3,10				
Heureka	45,00	5,65					
Atlantic Goose	45,00	5,79	4,88				
Sea Dream	45,00	5,80	5,20				
Prometej	45,00	5,80	5,80				
Palmira	45,00	6,20					
Lady Rose	45,00	6,40	5,00				
Fathom	45,00	6,50	4,30				
Secret	45,00	6,71	4,80				
More	45,00	7,10					
Blush	45,00	7,32	5,49	3,96			
Big Fish	45,00	7,92	4,27				
Heritage	45,30	4,88	4,00				
My Eden	45,42	3,30					
Alila Purnama	45,60	4,90					
My Little Violet	45,60	5,18					
Vantage	45,69						
Attitude	45,72	5,18					
Silver Wave	45,72	6,00					
Ionian	45,73	6,10	4,88				
Ancallia	45,77	6,50	6,10				
Lisa IV	46,00	4,30					
Windrose of Amsteram	46,00	4,30					
Reve d'or	46,00	6,00	2,70				
Antara	46,00	6,00					
Sea Falcon II	46,00	6,71	6,71				
Scorpion	46,00	7,20	4,00				
Big Aron	46,00	9,75	7,01				
Golden Compass	46,02	5,79	3,66				
Avalon	46,02	5,79	4,27				
Cloud Atlas	46,02	6,25					
Allegria	46,33	6,40					
2 Ladies	46,35						
Arktos	46,40	4,30					
Stormborn	46,70	6,50					
Asya	46,70	6,80					
Roxane	46,80	6,50					
BG	46,90	9,80	5,50				
Usher	46,94	5,49	4,27				
Rhino	46,94	6,71	5,49				
Inspiration	47,00	5,49					
Liquid Sky	47,00	6,00	4,00				
Andromeda	47,00	6,00	5,00				
Lady Dee	47,00	6,10	4,60				
Sirocco	47,00	6,20	5,50	4			
El Duende	47,00	6,40	5,49				
Baasta	47,00	7,00					
Africa	47,00	7,50					
Asolare	47,20	4,80	4,20				
Arados	47,24	6,50					
One More	47,24	9,45	6,40				
Loon	47,24	10,67					
Rola	47,50	6,40	4,50				
Azzurra II	47,50	9,75	6,71				
Themis	47,55	11,28	5,49				
Lady Joy	47,85	4,57					
Never Enough	47,85	9,14	6,40				
Lady Ellen II	48,00	7,00	6,00				

Out	48,00	7,60	5,50	3,20			
Big Sky	48,00	10,36	6,60				
Polaris I	48,29	6,24					
Audacia	48,46	9,45	4,57				
Menorca	48,50	7,20	5,50				
Cyan	48,70	6,50	4,30				
Clarity	48,77	5,70					
Odessa	48,77	7,01	4,88	4,57			
Herculina	49,00	6,10	6,10				
Lady Ann Magee	49,00	6,10					
Glaze	49,00	6,40	3,96				
La Tania	49,00	6,50	5,50	5,49			
La Dea II	49,00	6,50	3,80				
Khalilah	49,00	7,00					
Reef Chief	49,00	10,36	6,50				
Ocean Club	49,07	5,48					
Teleost	49,07	6,40	5,20				
Mq2	49,13	7,50	7,10				
Nassima	49,20	6,70	4,80				
O'Ceanos	49,23	6,20	3,20				
Te Manu	49,38	9,45	4,27	3,66			
Zaliv III	49,60	5,40	4,30				
Casino Royale	49,68	7,32	4,57				
Blue 470	49,68	11,28	6,40				
Skake N Bake TBD	49,82	7,92	6,10				
Lumiere	49,89	6,00	4,50				
Air Yacht	49,90	5,60	4,30				
Alexandra	49,90	5,75	4,30				
Da Vinci	49,90	5,90					
Mariu	49,90	9,50	6,10	4,00			
Trending	49,99	5,49	4,27	4,30			
Platinum	49,99	8,00	4,20				
Victoria Del Mar	49,99	9,75	6,71				
Harmony	49,99	10,67	5,18				
Sheherzade	49,99	11,28	5,49				
Impromptu	49,99	11,88	6,70				
Amarula Sun	49,99	12,50	6,40				
She's	50,00	5,79	5,79				
Silver Lining	50,00	6,70	4,90				
Resilience	50,00	7,01					
Malahne	50,00	7,50	6,25				
Eleni	50,00	10,70	6,00	4,20			
Inception	50,00	11,58	7,62	4,50			
Hanikon	50,00	11,58	6,20				
Ouranos	50,00	14,00	5,30	3,60			
Broadwater	50,28	11,28	6,40				
Sapphire	50,40	7,50					
Ledgend	51,25	7,92	5,49				
My Falcon	51,80	6,40	5,00	5,00			
Lazy Z	51,82	5,79	5,49				
Victory	51,90	6,00	6,00				
La Mirage	52,00	6,00	5,50				
Vera	52,00	6,15	5,10				
Deja Too	52,00	7,20	6,20				
Maria	52,12	9,75	9,45				
Gegasus	52,25	5,60	4,60				
Deniki	52,30	5,80	5,50				
Lady Nag Nag	52,30	6,20	5,70				
Big Eagle	52,43	9,75	4,27				
O'Neiro	52,70	6,15	4,70				
Vixit	52,75	8,53	5,49				
Sunrise	52,80	7,50	7,00				
Rarity	53,00	7,00	5,10				
Mia Rama	53,54	6,20	4,70				
Nonni II	53,80	6,20					
Noble House	53,90	8,53	5,18				

Keri Lee II	53,95	9,75	6,71				
Seagull II	54,00	5,80	4,50				
Mishief	54,00	7,01	4,27				
Sovereign	54,00	9,75	6,40				
Starfire	54,1	10,97	4,57				
Talisman Maiton	54,20	6,20	5,00				
Maraya	54,20	7,50	7,50	4,50			
Chantal Ma Vie	54,56	9,45	7,32				
Sequil P	54,70	11,00	5,00	5,00			
Sea Huntress	54,86	8,84	5,79	3,66			
Lady Michelle	54,86	9,75	6,71	4,57			
Stargazer	54,90	7,92	5,79				
Ocean Paradise	55,00	6,20	4,20				
4You	55,00	6,25					
Kinta	55,00	6,40					
Lili	55,00	7,10	4,50				
Quite Essential	55,00	7,50	5,49				
Quinta Essentia	55,00	8,00	5,48				
Mustique	55,00	9,00	7,50				
Oceana	55,00	10,50					
Turquoise	55,40	7,50	7,50	4,80			
Illusion I	55,47	6,10	6,10				
Cynthia	55,50	6,40	3,66				
Insignia	55,60	5,64	4,24				
O'Natalina	56,00	5,20	3,40				
Bash	56,00	7,50	4,80				
Jaguar	56,00	10,00	4,57				
My Seanna	56,28	6,71					
Bad Girl	56,70	8,84	7,01	5,81			
Maserret II	57,00	7,10	6,90				
Lady Sara	57,00	11,89	7,01	3,96			
Lady Sheridan	57,90	11,20	7,30				
Skyfall	57,91	9,14	5,49				
Illusion V	58,00	9,50	7,50				
Unbridled	58,20	8,50	7,50				
Baraka	58,20	9,40	4,50				
Carpe Diem	58,23	7,00	6,70				
Magna Grecia	58,50	5,79	6,40	3,05			
Carpi I	58,55	6,70	7,10				
Idol	58,90	7,80	7,20				
Vicky	59,40	5,70	4,20				
Katina	60,00	6,56					
Light Holic	60,00	7,20	4,20				
Diamonds Are Forever	60,00	7,32	4,27				
Formosa	60,00	8,00	5,70				
Excellence V	60,00	8,22	7,00				
Dream	60,00	9,75	6,70				
Andreas L	60,00	9,75	7,01				
Elysian	60,00	24,00	10,97	7,32			
Sarastar	60,20	7,50	7,50				
Mia Elise II	60,30	12,20	8,40				
Blue Moon	60,35	8,53	7,62				
Samadhi	60,96	9,00	7,00				
Calypso	61,00	6,70	7,30				
Lady Kathryn	61,00	7,01	7,01				
Katharine	61,30	12,00	6,00	5,78			
Esmeralda	61,50	7,00	6,70	5,00	4,25		
Sealyon	61,80	8,53	7,01				
Sarah	62,00	7,54	7,54				
Flag	62,00	8,23	7,92				
Mini Games	62,00	9,45	7,00	4,45			
Roma	62,00	10,20	7,20				
Virginian	62,25	6,40	6,20	5,00	4,50	3,00	
Sea Walk	62,30	7,40	6,30				
Apogee	62,50	7,00	5,79				
Baton Rouge	62,50	8,00	7,30	6,20			

Party Girl	62,50	11,30	7,50	6,40	4,50		
Lucky Lady	62,56	9,14	8,50				
Sokar	63,00	7,50	4,70	4,20			
11)11	63,00	8,00	6,00				
La Sultana	63,78	7,70					
Silver Angel	64,50	7,50	7,50				
Shemara	64,70	7,92	7,32				
Double Down	65,00	7,00					
Seanna	65,00	8,50	7,50				
Callisto	65,20	8,50	8,00				
Invictus	66,00	8,50	8,50				
Okto	66,40	7,50	5,50	6,65	3,90		
Icon	67,50	7,80	6,60				
Sycara V	68,16	9,44	7,00				
Lady S	68,50	9,14	9,12	4,00			
Suerte	69,30	7,40	7,40	4,00			
Joy	70,00	8,50	6,20	3,00			
Freedom	70,00	10,50	6,81				
Martha Ann	70,11	13,41	7,90	7,90			
Utopia	71,60	8,50	8,50	3,80			
Solo	72,00	7,50	7,50				
Elegant 007	72,40	6,00					
Coral Ocean	72,55	8,60	8,60	6,00	4,50		
Honor	72,64	10,00	7,01	-			
Titania	73,00	8,00	6,80				
Laurel	73,20	7,62	6,71	4,57			
Siren	73,50	12,00	7,50	5,00			
Magombo	73,55	11,58	7,50				
Cocoa Bean	74,00	8,24	7,62				
Cloud 9	74,00	9,45	6,10				
Anastasia	75,50	9,45	9,45	9,45	9,45	6,71	
Silver Fast	77,00	7,40	7,40				
Pagasus	78,00	10,67	6,10				
Pegasus VII	78,00	10,67	6,10				
Amaryllis	78,43	9,90	8,80	6,60			
Air	81,00	10,00	10,00				
Alfa Nero	81,27	8,00	8,00	6,00			
Romea	81,80	9,60	8,58	5,90			
O'mega	82,50	9,20	9,20	6,00	12,00		
Savannah	83,50	9,50	9,50	6,00			
O'ptasia	85,00	9,75	8,13	6,00	4,40		
Solandge	85,10	10,97	10,00	7,30	6,25		
Aquila	85,60	11,30	10,70	10,61			
Nirvana	88,50	11,00	11,00				
Phoenix 2	90,02	10,06	10,06	7,62			
Nero	90,10	9,50	7,39	5,20			
Moonlight 2	91,40	7,01	7,01				
Queen Miri	92,00	7,80	7,80	3,80			
Indian	95,00	8,10	8,10	4,30			
Kismet	95,20	33,00	8,84	5,80			
Serene	133,90	10,00	9,00	9,00	8,23	7,40	

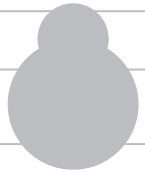
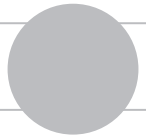
Electric boats

Brand	Type	Speed [kts]	Weight [kg]	Range [km]	Range [nm]	Length [m]	Length [ft]	Pax
Boesch	750 Portofino de luxe	25	2500	40	24,8548	6,2	20,34	8
Electric boat co.	Bruce 22 Open Utility	41	1088	65	40,38905	6,7	21,98	8
Frauscher	750 St. Tropez	21,6	1600	57	35,41809	7,52	24,67	9
Hickley Dasher	Dasher	23,5	2950	46	28,58302	8,60	28,21	8
JP ribs	JP Green	35	-	30	18,6411	8,5	27,89	8
Lillebror	LB 60	6,4	-	54	33,55398	5,9	19,36	10
Mylne	Mylne Bolt 18	30	750	18,5	11,495345	5,5	18,04	6
Q Yachts	Q30	15	1500	39,6	24,606252	9,3	30,51	8
Symphony boat	Six-1	18	953	55	34,17535	6,13	20,11	6
X Shore	3000	25	2200	64	39,76768	8	26,25	8

Combustion boats

Brand	Type	Speed [kts]	Weight [kg]	Range [km]	Range [nm]	Length [m]	Length [ft]	Pax
Boesch 625 sunski	750 Portofino de luxe	42	2500			7,50	24,61	8
Carbon craft	CC180	43	1290			5,63	18,47	10
Castoldi	Jet tender 25 (RIB)	41	2100			7,50	24,61	16
Chris Craft	Calypso 26	-	3040			8,08	26,51	8
Cockwell Owners tender	Sports and limousine tender	36	1800			7,00	22,97	10
Compass Tenders	TT Pestifer	40	2500			8,00	26,25	14
De Antonia yachts	D23 Tender	-	1300			7,00	22,97	8
De Antonia yachts	D28	38	2700			7,99	26,21	10
Foiler	Foiler	40	-			9,60	31,50	8
Iguana yachts	Iguana 29 (rupsbanden incl)	40	3000			9,25	30,35	8
Invictus	280 TT	38	2860			8,90	29,20	10
Isloep	Rapida 750	-	1450			7,50	24,61	12
LMC 650	LMC Open 650	32	1250			6,50	21,33	8
Nautica	Eastcraft 850	-	2100			8,5	27,89	-
Real life tender 750	RealLife 7.5	30	1400			7,50	24,61	9
Riva	Iseo	36	3750			8,24	27,03	6
Venandi luxury tenders	650	40	-			6,50	21,33	-
Venandi luxury tenders	900	35	-			9,00	29,53	-
Windy	Luxury limo tender	45	4497			7,92	25,98	10
X craft	Beachlander tender	43	2068			7,50	24,61	13
Xtender	Run-About	45	2200			8,00	26,25	10
Xtender	Concept	-	4500			10,00	32,81	12
Yachtwerft meyer	Semi-custom limousine	40	-			9,00	29,53	12
ZEE	ZEE 26 Tender	-	1350			7,80	25,59	9

	Strengths				
	Dutchcraft is strong in offering a multi-activity product.	The company does have in-house knowledge about electric drive-train technology.	Dutchcraft is able to deliver a product with a high quality to their potential customers.	Zeelander is strong in building with high-end finishing. (SWOT analysis of Zeelander, 2016)	The company offers more than semi-custom products.
Opportunities					
An electric tender that is able to do a beach landing.					
An electric tender with a length of 24,6-feet (7,5m).					
An electric tender for a selling price lower than 280.000 euro.					
An electric tender with a broader range of activities than the current competitors so superyacht can have less tenders on board.					
An electric tender that supports more land activities.					
Getting involved in a yacht project at the start of the project. So they can adjust the superyacht to the tender of DutchCraft and not the DutchCraft to the space of the superyacht.					
Flexible range of tenders with different lengths to serve even more superyachts.					
An electric tender that has more passengers capacity than eight.					
A limousine electric tender.					
Keep up with the changing technology of batteries. The battery capacity per volume is getting higher.					
Threats					
Current brands offering tenders with a combustion drive-train who offer a broader range of activities can make the switch easily to electric.					

	Dutchcraft is strong in designing at low costs.	The company is strong in detail engineering, management and assembling.	The company has a well-established network with suppliers that could help them out with the electric drive-train technology.	The company has no experience in 25-feet electric tenders.	The core competences are not hard to copy or to pursue by competitors.
Opportunities					
An electric tender that is able to do a beach landing.					
An electric tender with a length of 24,6-feet (7,5m).					
An electric tender for a selling price lower than 280.000 euro.					
An electric tender with a broader range of activities than the current competitors so superyacht can have less tenders on board.					
An electric tender that supports more land activities.					
Getting involved in a yacht project at the start of the project. So they can adjust the superyacht to the tender of DutchCraft and not the DutchCraft to the space of the superyacht.					
Flexible range of tenders with different lengths to serve even more superyachts.					
An electric tender that has more passengers capacity than eight.					
A limousine electric tender.					
Keep up with the changing technology of batteries. The battery capacity per volume is getting higher.					
Threats					
Current brands offering tenders with a combustion drive-train who offer a broader range of activities can make the switch easily to electric.					

	Weaknesses					
	The company sometimes builds without any customization what makes it hard to sell .	The company does not have enough employees to work out the project.	The company does not have enough space to built.	The company does not have enough marketing and sales teams to bring this product into the market.	The company does not have a naval architect in-house.	
Opportunities An electric tender that is able to do a beach landing.						
An electric tender with a length of 24,6-feet (7,5m).						
An electric tender for a selling price lower than 280.000 euro.						
An electric tender with a broader range of activities than the current competitors so superyacht can have less tenders on board.						
An electric tender that supports more land activities.						
Getting involved in a yacht project at the start of the project. So they can adjust the superyacht to the tender of DutchCraft and not the DutchCraft to the space of the superyacht.						
Flexible range of tenders with different lengths to serve even more superyachts.						
An electric tender that has more passengers capacity than eight.						
A limousine electric tender.						
Keep up with the changing technology of batteries. The battery capacity per volume is getting higher.						

Threats Current brands offering tenders with a combustion drive-train who offer a broader range of activities can make the switch easily to electric.					

Appendix I: Function evaluation of electric tender competitors

Lorem ipsum

Boesch

Electric		
E1	Audio system	■
E2	Refrigerator	
E3	Heading system	
E4	Lights	■
E5	Bilge pomp	■
E6	Navigation	
E7	Electric winch	
E8	Underwater lights	

score: 3

Sanitary		
W1	Shower on deck	
W2	Small bathroom	
W3	Water tank	
W4	Grey water tank	
W5	Toilet	
W6	Sink	

score: 0

Comfort		
C1	Cushion	■
C2	Side door	
C3	Bench	■
C4	Swimming ladder	
C5	Bed	
C6	Sundeck	■
C7	Table	
C8	Bow thruster	
C9	Storage space	■
C10	Swim deck	■

score: 5

Options		
O1	Teak deck	■
O2	Deck cover	
O3	Fishline hole	
O4	Support waterski	
O5	Pick up point to lift	

score: 1

Design		
D1	Foldable rear deck	
D2	Build-in fender holder	
D3	Wind screen	■
D4	Limousine	
D5	Stairs in the frond	
D6	Carbon hull	
D7	Fender strip	
D8	Moveable rooftop	

score: 1

Total score: 10

CANADIAN Electric Boat co.

Electric		
E1	Audio system	■
E2	Refrigerator	
E3	Heading system	
E4	Lights	■
E5	Bilge pomp	■
E6	Navigation	
E7	Electric winch	
E8	Underwater lights	■

score: 4

Sanitary		
W1	Shower on deck	
W2	Small bathroom	
W3	Water tank	
W4	Grey water tank	
W5	Toilet	
W6	Sink	

score: 0

Comfort		
C1	Cushion	■
C2	Side door	
C3	Bench	■
C4	Swimming ladder	■
C5	Bed	
C6	Sundeck	
C7	Table	■
C8	Bow thruster	
C9	Storage space	■
C10	Swim deck	■

score: 6

Options		
O1	Teak deck	■
O2	Deck cover	
O3	Fishline hole	
O4	Support waterski	■
O5	Pick up point to lift	

score: 2

Design		
D1	Foldable rear deck	
D2	Build-in fender holder	
D3	Wind screen	■
D4	Limousine	
D5	Stairs in the frond	
D6	Carbon hull	
D7	Fender strip	
D8	Moveable rooftop	

score: 1

Total score: 13

Frauscher

Electric		
E1	Audio system	■
E2	Refrigerator	■
E3	Heading system	
E4	Lights	■
E5	Bilge pomp	■
E6	Navigation	■
E7	Electric winch	
E8	Underwater lights	

score: 5

Sanitary		
W1	Shower on deck	■
W2	Small bathroom	
W3	Water tank	
W4	Grey water tank	■
W5	Toilet	
W6	Sink	

score: 2

Comfort		
C1	Cushion	■
C2	Side door	
C3	Bench	■
C4	Swimming ladder	■
C5	Bed	
C6	Sundeck	■
C7	Table	■
C8	Bow thruster	
C9	Storage space	■
C10	Swim deck	■

score: 7

Options		
O1	Teak deck	■
O2	Deck cover	
O3	Fishline hole	
O4	Support waterski	
O5	Pick up point to lift	

score: 1

Design		
D1	Foldable rear deck	
D2	Build-in fender holder	
D3	Wind screen	■
D4	Limousine	
D5	Stairs in the frond	
D6	Carbon hull	
D7	Fender strip	
D8	Moveable rooftop	

score: 1

HINCKLEY

Electric		
E1	Audio system	■
E2	Refrigerator	
E3	Heading system	
E4	Lights	■
E5	Bilge pomp	■
E6	Navigation	■
E7	Electric winch	
E8	Underwater lights	

score: 4

Sanitary		
W1	Shower on deck	
W2	Small bathroom	
W3	Water tank	
W4	Grey water tank	
W5	Toilet	
W6	Sink	

score: 0

Comfort		
C1	Cushion	■
C2	Side door	
C3	Bench	■
C4	Swimming ladder	
C5	Bed	
C6	Sundeck	■
C7	Table	
C8	Bow thruster	■
C9	Storage space	■
C10	Swim deck	■

score: 6

Options		
O1	Teak deck	■
O2	Deck cover	
O3	Fishline hole	
O4	Support waterski	
O5	Pick up point to lift	

score: 1

Design		
D1	Foldable rear deck	
D2	Build-in fender holder	
D3	Wind screen	■
D4	Limousine	
D5	Stairs in the frond	
D6	Carbon hull	
D7	Fender strip	
D8	Moveable rooftop	

score: 1

Total score: 12

JP RIBS

Electric		
E1	Audio system	■
E2	Refrigerator	
E3	Heading system	
E4	Lights	■
E5	Bilge pomp	■
E6	Navigation	■
E7	Electric winch	
E8	Underwater lights	

score: 4

Sanitary		
W1	Shower on deck	
W2	Small bathroom	
W3	Water tank	
W4	Grey water tank	
W5	Toilet	
W6	Sink	

score: 0

Comfort		
C1	Cushion	■
C2	Side door	
C3	Bench	■
C4	Swimming ladder	■
C5	Bed	
C6	Sundeck	
C7	Table	
C8	Bow thruster	
C9	Storage space	■
C10	Swim deck	■

score: 5

Options		
O1	Teak deck	■
O2	Deck cover	
O3	Fishline hole	
O4	Support waterski	
O5	Pick up point to lift	

score: 1

Design		
D1	Foldable rear deck	
D2	Build-in fender holder	
D3	Wind screen	■
D4	Limousine	
D5	Stairs in the frond	
D6	Carbon hull	
D7	Fender strip	■
D8	Moveable rooftop	

score: 2

Total score: 12

LILLEBROR

Electric		
E1	Audio system	■
E2	Refrigerator	
E3	Heading system	
E4	Lights	■
E5	Bilge pomp	■
E6	Navigation	
E7	Electric winch	
E8	Underwater lights	

score: 3

Sanitary		
W1	Shower on deck	
W2	Small bathroom	
W3	Water tank	
W4	Grey water tank	
W5	Toilet	
W6	Sink	

score: 0

Comfort		
C1	Cushion	■
C2	Side door	
C3	Bench	■
C4	Swimming ladder	
C5	Bed	
C6	Sundeck	
C7	Table	
C8	Bow thruster	
C9	Storage space	■
C10	Swim deck	■

score: 6

Options		
O1	Teak deck	■
O2	Deck cover	
O3	Fishline hole	
O4	Support waterski	
O5	Pick up point to lift	

score: 1

Design		
D1	Foldable rear deck	
D2	Build-in fender holder	
D3	Wind screen	
D4	Limousine	
D5	Stairs in the frond	
D6	Carbon hull	
D7	Fender strip	
D8	Moveable rooftop	

score: 0

Total score: 10

MYLNE CLASSIC YACHT DESIGN 1896

Electric		
E1	Audio system	
E2	Refrigerator	
E3	Heading system	
E4	Lights	■
E5	Bilge pomp	
E6	Navigation	
E7	Electric winch	
E8	Underwater lights	

score: 4

Sanitary		
W1	Shower on deck	
W2	Small bathroom	
W3	Water tank	
W4	Grey water tank	
W5	Toilet	
W6	Sink	

score: 0

Comfort		
C1	Cushion	■
C2	Side door	
C3	Bench	■
C4	Swimming ladder	
C5	Bed	
C6	Sundeck	
C7	Table	
C8	Bow thruster	
C9	Storage space	■
C10	Swim deck	■

score: 6

Options		
O1	Teak deck	■
O2	Deck cover	
O3	Fishline hole	
O4	Support waterski	
O5	Pick up point to lift	

score: 1

Design		
D1	Foldable rear deck	■
D2	Build-in fender holder	
D3	Wind screen	■
D4	Limousine	
D5	Stairs in the frond	
D6	Carbon hull	
D7	Fender strip	
D8	Moveable rooftop	

score: 1

Total score: 12

Q YACHTS

Electric		
E1	Audio system	■
E2	Refrigerator	
E3	Heading system	
E4	Lights	■
E5	Bilge pomp	■
E6	Navigation	■
E7	Electric winch	
E8	Underwater lights	■

score: 5

Sanitary		
W1	Shower on deck	■
W2	Small bathroom	■
W3	Water tank	■
W4	Grey water tank	■
W5	Toilet	■
W6	Sink	■

score: 6

Comfort		
C1	Cushion	■
C2	Side door	
C3	Bench	■
C4	Swimming ladder	■
C5	Bed	
C6	Sundeck	■
C7	Table	■
C8	Bow thruster	
C9	Storage space	■
C10	Swim deck	■

score: 6

Options		
O1	Teak deck	■
O2	Deck cover	
O3	Fishline hole	
O4	Support waterski	
O5	Pick up point to lift	

score: 1

Design		
D1	Foldable rear deck	
D2	Build-in fender holder	
D3	Wind screen	■
D4	Limousine	
D5	Stairs in the frond	
D6	Carbon hull	
D7	Fender strip	
D8	Moveable rooftop	

score: 1

Total score: 19

Electric		
E1	Audio system	
E2	Refrigerator	
E3	Heading system	
E4	Lights	■
E5	Bilge pomp	
E6	Navigation	
E7	Electric winch	
E8	Underwater lights	

score: 1

Sanitary		
W1	Shower on deck	
W2	Small bathroom	
W3	Water tank	
W4	Grey water tank	
W5	Toilet	
W6	Sink	

score: 0

Comfort		
C1	Cushion	■
C2	Side door	
C3	Bench	■
C4	Swimming ladder	
C5	Bed	
C6	Sundeck	
C7	Table	
C8	Bow thruster	
C9	Storage space	■
C10	Swim deck	

score: 3

Options		
O1	Teak deck	■
O2	Deck cover	
O3	Fishline hole	
O4	Support waterski	
O5	Pick up point to lift	

score: 1

Design		
D1	Foldable rear deck	
D2	Build-in fender holder	
D3	Wind screen	
D4	Limousine	
D5	Stairs in the frond	
D6	Carbon hull	
D7	Fender strip	
D8	Moveable rooftop	

score: 0

Total score: 5

X SHORE

Electric		
E1	Audio system	
E2	Refrigerator	
E3	Heading system	
E4	Lights	■
E5	Bilge pomp	■
E6	Navigation	■
E7	Electric winch	
E8	Underwater lights	

score: 3

Sanitary		
W1	Shower on deck	
W2	Small bathroom	
W3	Water tank	
W4	Grey water tank	
W5	Toilet	
W6	Sink	

score: 0

Comfort		
C1	Cushion	
C2	Side door	
C3	Bench	■
C4	Swimming ladder	
C5	Bed	
C6	Sundeck	
C7	Table	■
C8	Bow thruster	
C9	Storage space	■
C10	Swim deck	■

score: 4

Options		
O1	Teak deck	■
O2	Deck cover	
O3	Fishline hole	
O4	Support waterski	
O5	Pick up point to lift	

score: 1

Design		
D1	Foldable rear deck	
D2	Build-in fender holder	
D3	Wind screen	■
D4	Limousine	
D5	Stairs in the frond	■
D6	Carbon hull	
D7	Fender strip	
D8	Moveable rooftop	

score: 2

Total score: 10

Brands			Volvo	MerCruiser	MerCruiser	MerCruiser	MerCruiser	Konrad	Konrad	Konrad	Yanmar	Yanmar
												
Type				Bravo one	Bravo two	Bravo three	Alpha one	Konrad 520	Konrad 540	Konrad560	ZT350	ZT370
Max power	**kW**			321	321	321	186					150-370
Max rotation	**rpm**		until 6000	4400-5400	4400-5400	4400-5400	4400-5200				4000	4500
Dry weight	**kg**			57	62	67	38	85	69	75,7	112 (incl prop)	113 (incl prop
				€ 10.490,70	€ 10.806,00	€ 10.806,00	€ 4.016,00					7139 (INCL)

Appendix K: Electric motors

Brands		Brusa	Brusa	Brusa	AVID	AVID	AVID
Picture							
Type		HSM1-6.17.12	HSM1-10.18.13	HSM1-10.18.22	AF130	AF140	AF230
Power	kW	70	93	145	64	94	128
Max Power	kW	156/185	156/185	200	140	220	280
Torque	Nm	130	165	270	145	260	290
Max Torque	Nm	220/320	305/385	460	350	600	700
Nominal Speed	rpm	4200	4900	4400	-	-	-
Speed	rpm	12000	13000	12000	8000	5000	8000
Mass	kg	51,5	51	76	30,5	42,5	57,5
Cooling		Water	Water	Water	Water	Water	Water
Price	€		(-+)20.000 incl inverter	€ 34.000,00	€ 7.765,00	€ 10.200,00	€ 13.970,00
Voltage	V	300	300-450	300-450	UP to 800	UP to 800	UP to 800
Hours	1,5	105	139,5	217,5	96	141	192

	Piktronik	Piktronik	Piktronik	Arka	Arka	UQM	UQM	UQM
								
PMSM50	PMSM100	PMSM125	PMS150	PMSP82	PMSP108	PP135	PP135(HS)	HD220
50	100	125	150	82	108	80	100	120
	-	-	-	-	-	135	135	220
	318	332	422	356	469	320	320	350
	-	-	-	-	-	-	-	700
3000	3000	3600	3400	2200	2200	7700	-	-
	-	-	-	-	-	10000	10000	6000
	94	94	120	156	208			
	Water	Water	Water	Water	Water	Water	Water	Water
€ 19.953,00	€ 35.500,00	€ 36.700,00	-	-	-	-	-	20K (incl inverter and cables)
	249	290	260	560	469	270-425	360-550	250-440
Prijs is inclusief alle componanten!!								
	150	187,5	225	123	162	120	150	180

UQM	ELCO	Oceanvolt	WEG	WEG	TM4	TM4	EV Drive
							
HD250	EP-1000	AXC	W22	W50	SUMO MD HV1500	SUMO MD HV3000	EVD110HV
180	42.5	40	37-500	185-900	100	235	80
250	-		-	-	162	140	110
520	-		-	-	680	1065	160
900	-		-	-	1590	3255	195
5500	1500		-	-	-	-	6500
5500	1800		6000	5000	3250	3000	8500
	-		-	-	180	212	43 (8kg controller)
Water	-		TEBC-BLOWER	TEBC-BLOWER	Water-Glycol	Water-Glycol	Water-Glycol
	-	-	-	-	-	-	13.940 (incl inverter)
600	12		360-690	390-6600	<750	<750	320-360
270	#WAARDE!	60	#WAARDE!	#WAARDE!	150	352,5	120

EV Drive	EV Drive	Hybrid ship solution	Bosch	Brammo	TEMA	VISEDO
						
EVD110HV	EVD130LV	DST2-260	SMG180/120	GVM		PowerDisk
80	80	20,8-170	80kW	29		150
110	130-135	-	-	42		
160	170	150	200			
253	250	450	-	90		
6500	4500	1250	-	4200		
8500	5000	4840	-	9000		
44 (11kg controller)	45 (11kg controller)	-	32	16		
Water-Glycol	Water-Glycol	-		Water-Glycol		
13.940 (incl inverter)	15980 (incl inverter)	-				
602-750	348-360	-		48-450		
120	120	#WAARDE!	#WAARDE!	43,5	0	225

AMPEX	Siemens	Siemens
		
	Sivetec MRI	Sivetec MRS
	30 to 250	31 to 250
	350	350
	20000	15000
	Water-Glycol	Water-Glycol

Appendix L: Proposal drive-train

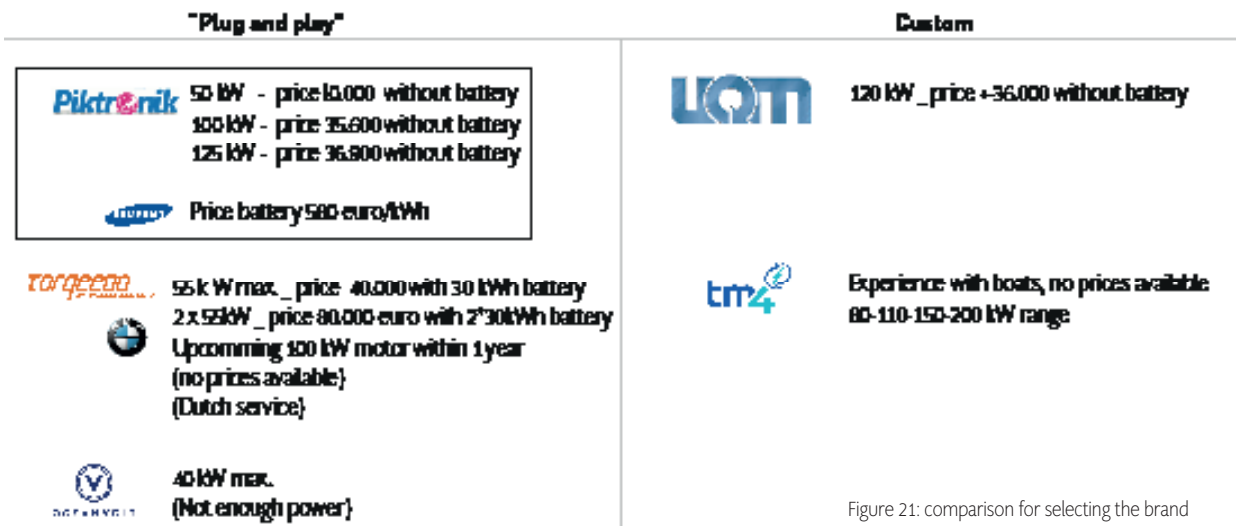


Figure 21: comparison for selecting the brand

Piktronik
POWER FOR RELIABILITY

DRIVE UNIT

125kW shaft motor – 432V unit – shaft power for Lithium Manganese battery technology (Version B)

Piktronik d.o.o.	quantity	e-components
	1 pc	SAC51-96 to 510V controller
	1 pc	Display GD2 (9-18V)
	6 m	Wire harness (C60D6V7)
	1 pc	KOP10-50020 (500V / 20A) charger
	1 pc	Control unit for KOP10
	1 pc	KOP100-12V / 8A charger for board battery and NAC-plugs
	1 pc	DC-DC converter: KOP270-600V
	1 pc 1 pc	KOP-PROT battery protection device with LCD-Display (to supervise the lithium battery, driving and charging electronics) KOP-PROT wire harness (12V, Type: P00300091, 6 m long)
	6 pcs	BPROT90T module (for analysis of the lithium battery)
	1 pc	KOP-Alarm with 2 pcs water sensors and 1 pc smoke detector
	1 pc	User manual SAC51

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Piktronik
POWER FOR RELIABILITY

DRIVE UNIT

Kopriva Elektronik GmbH	quantity	e-motor
	1 pc	Shaft motor PMSM 125kW with 3600 RPM (rotation per minute) (water-cooled) (PMSM = permanent magnet synchronous motor) consisting of: • 1 x Motor temperature sensor cable (2-pole) • 4 x Retaining feet • 1 x Water pump 12V / 14 l/min • 2 x Axle flange • 1 x Shaft flange
	4 m	Hose ½“ (spiral coiled tube, Ø 14 mm)
	6 pcs	Hose clips
	2 pcs	Switch disconnector with box (400A / 1000V/DC)
	1 pc	Distribution box for cooling pump 12V with fan control (**Blower**)
	1 pc	Box: HV2 module, 2 x main contactors and **BLOWER**
	1 pc	Electronic single lever control with neutral interlock – Dual-Die Hall sensor based (including connection cable)
	1 pc	Starter lock (1-pole) with 1 pc key (nr.: 001)
	1 pc	LSS-Box (**3-phase**) each with 3 x 20A circuit breakers inclusive relay and deactivation protection for charger

Total price (net) for the drive unit (without lithium battery):	**40.850,00 -10% = 36.765,00 €**

Available on request:

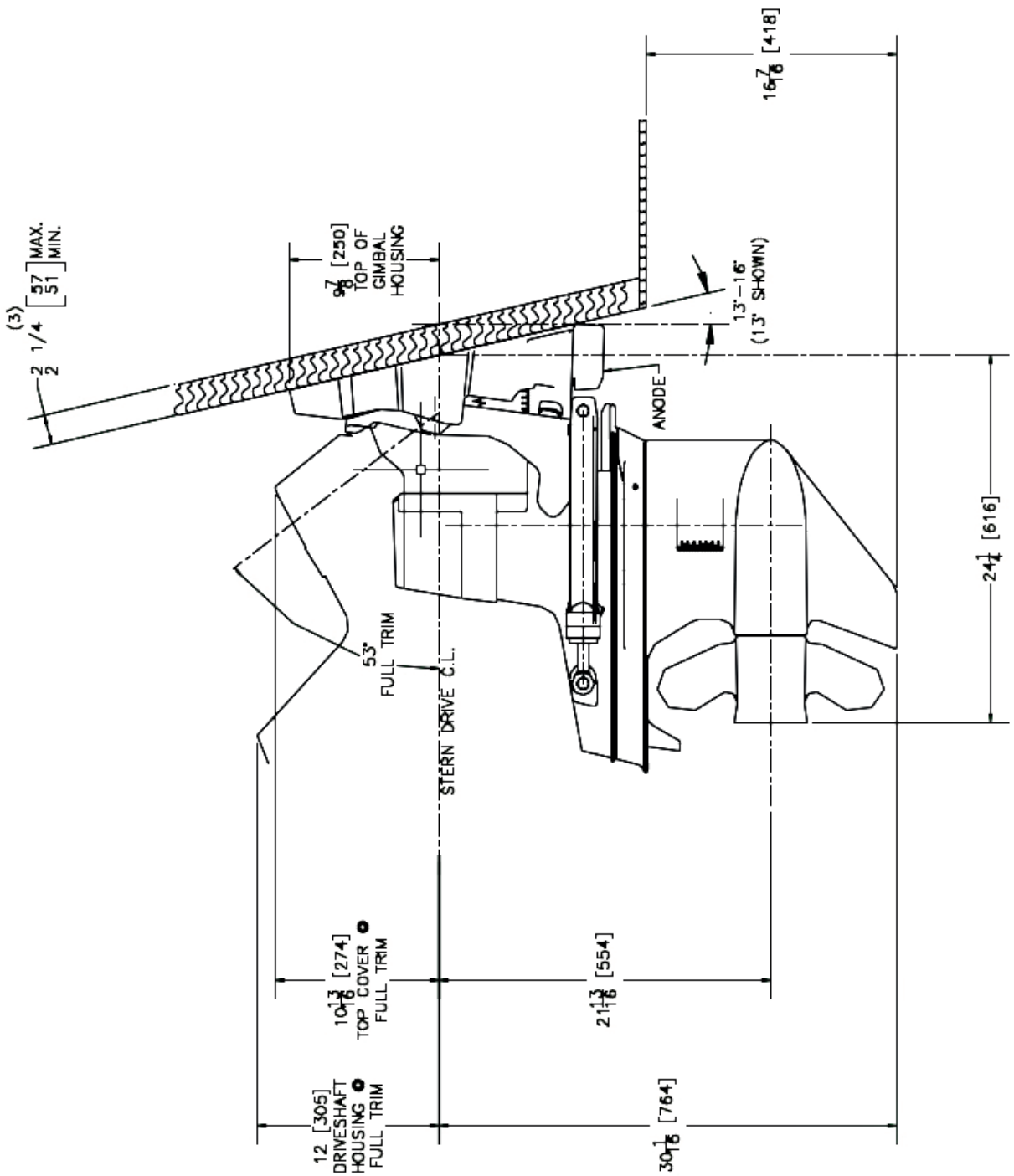
Lithium Manganese Battery

Regarding battery unit for this drive unit I can offer you the following versions:

Size	Dimensions (l x b x h in mm)	Cell	Versions	Calculation	kWh
6 pcs	500 x 410 x 290	SAMSUNG	**20S/72P**	$6 * \frac{(20S * 3.6V = 72V) * (72P * 2.9Ah = 208.8Ah)}{1000}$	**90.2**
6 pcs	500 x 410 x 370		**20S/80P**	$6 * \frac{(20S * 3.6V = 72V) * (80P * 2.9Ah = 232Ah)}{1000}$	**100.2**
			20S/88P	$6 * \frac{(20S * 3.6V = 72V) * (88P * 2.9Ah = 255.2Ah)}{1000}$	**110.2**
			20S/90P	$6 * \frac{(20S * 3.6V = 72V) * (90P * 2.9Ah = 261Ah)}{1000}$	**112.7**
			20S/100P	$6 * \frac{(20S * 3.6V = 72V) * (100P * 2.9Ah = 290Ah)}{1000}$	**125.2**

Price for 1kWh:	**€ 580,00**

Appendix N: Sterndrive Mercury Alpha one



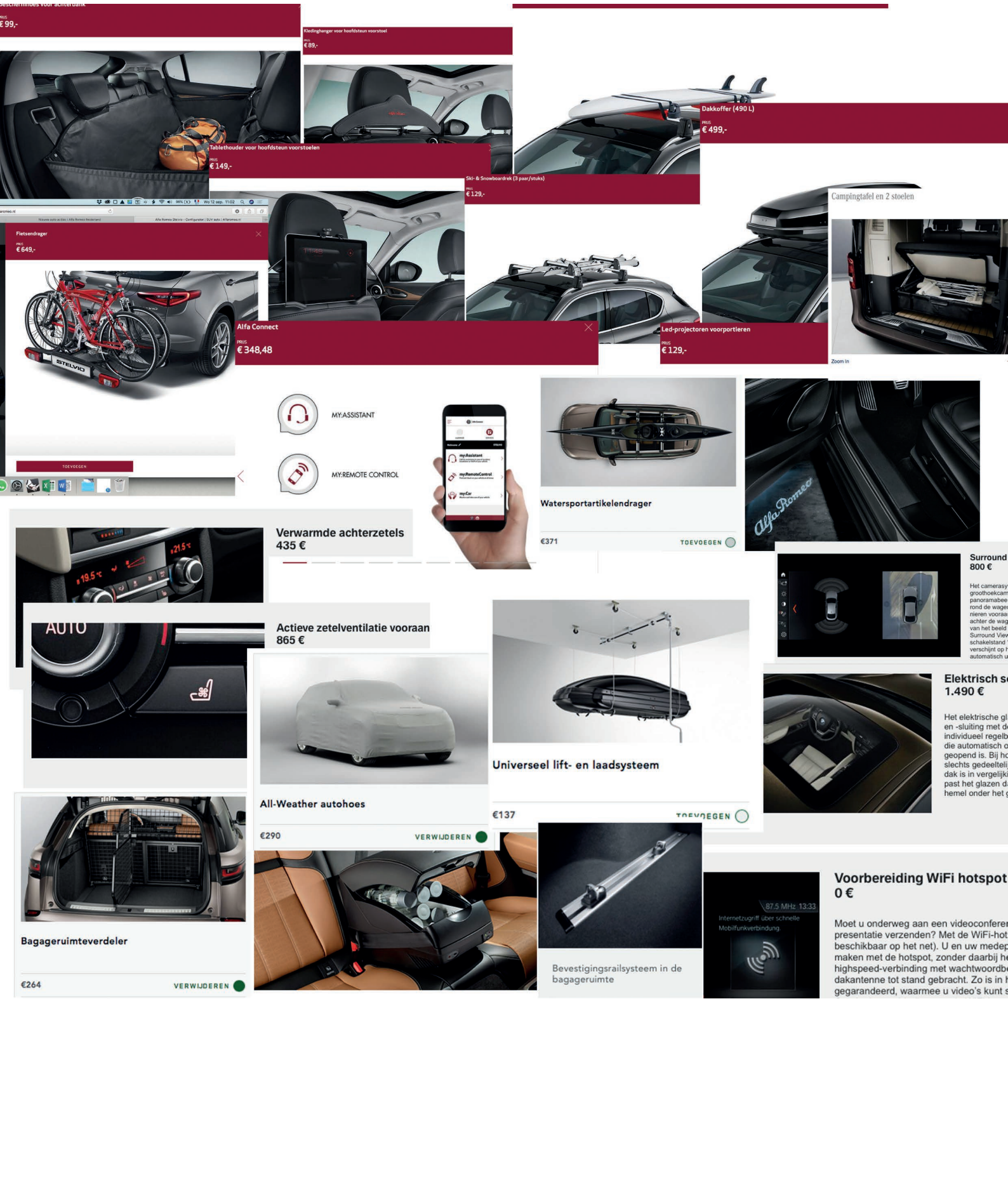
Appendix 0: Morphological chart

Before setting up a morphological chart each sub-function was described as a 'how can you...'. These sub-functions are results from the process tree and can be founded in the left column. For each problem the solutions that were founded during the ideation were clustered and can be found next to each problem. Three lines were drawn within the different solutions and formed three different idea direction.

Stearing/ control	Remote	STEARING Wheel	Autonomous				
H2 seat people comfortable	Bench	BED	HANGMOCK	CRANK	STANDING/Sitting		
H2 eleminate seating	Folding	Extendable	Hanging	Moveable			
Where 2 sit?	FRONT	BACK	LEFT	RIGHT	MIDDEL.		
H2 fixate	STATIC/Fixed	SCREW	MAGNET	RAIL.	CLICK		
Where 2 board and abaord	Frond	BACK	LEFT	RIGHT	MIDDEL.		
H2 move a door	Hinge END	Role	Rotate MID	Folding	Rail		

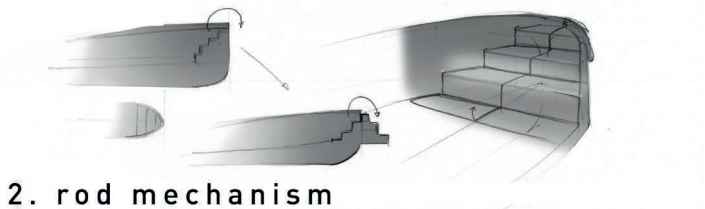
H2 transport a bicycle?	HOLE	RACK	HOOK				
H2 transport a kayak?	RAIL	Pull	TRAILOR	Hook	Extend Beam		
H2 transport a quad?	TRAILOR	ON DECK	ON Roof	On side			
H2 transport smelling goods	IN DECK	ON DECK	IN Box AIR TIGHT	TRAILOR.			
H2 transport BBQ equipment	Box	SPECIAL MADE Box					
H2 create extra storage	STAIR	Box	Side	TRAILOR	Roof box	INside components	
H2 fix a fishing line	HolE (fixed)	RAIL.	SCREW	Holder			
Where 2 store luggage	TRAILOR	ON Roof	DASHBOARD	ON DECK	IN DECK	SEATING	Side

Appendix P: Extra inspiration input

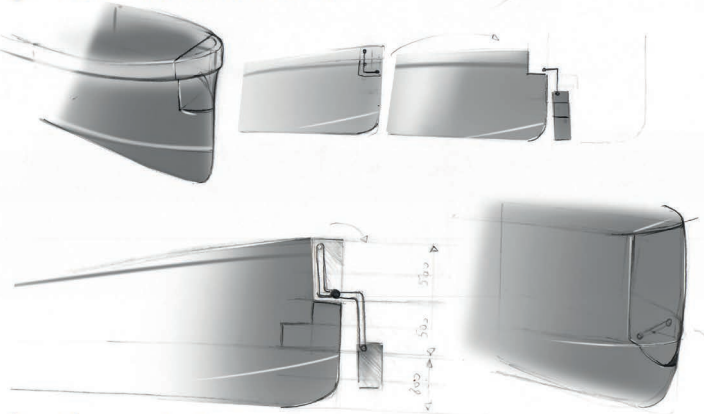


Appendix Q: Beach door solutions

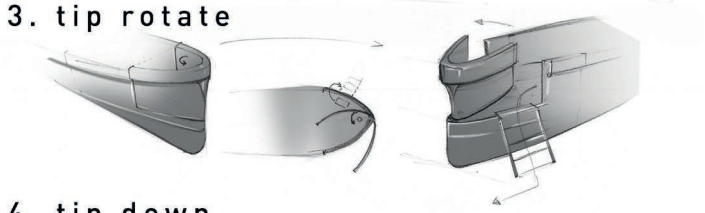
1. fixed stairs



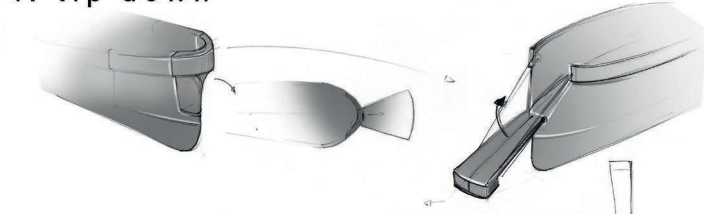
2. rod mechanism



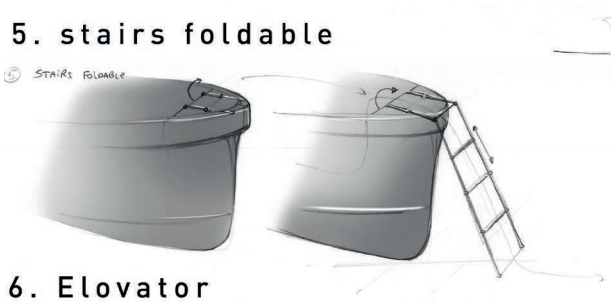
3. tip rotate



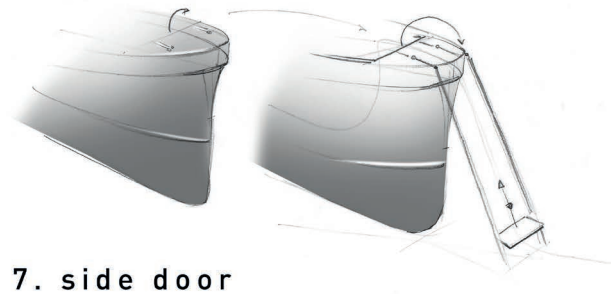
4. tip down



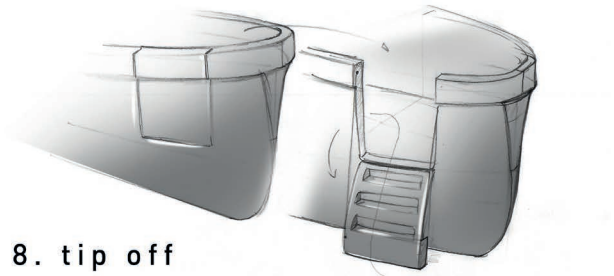
5. stairs foldable



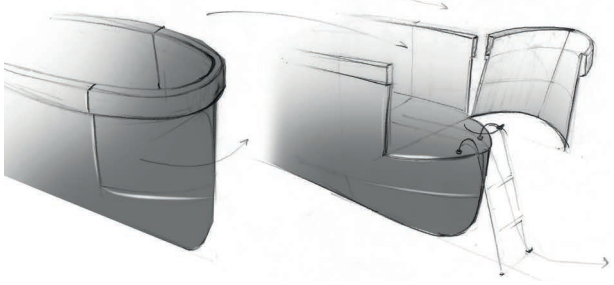
6. Elovator



7. side door



8. tip off



Appendix R: Beach door evaluation