Voyage

Exploring interfaces for autonomous maritime systems

Diploma project by Thomas Wang Johannesen

The Oslo School of Architecture and Design / Spring 2020

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FIELD

Interaction design

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ABSTRACT

Norway has a long history in the maritime sector and is one of the worlds leading innovators in the field of robotics and automation.

Maritime industries are complex workplaces were human and environmental safety is critical. Research shows that interfaces used in these workplaces are often lacking in consistency, causing unnecessary confusion and potentially dangerous situations.

In this project I am exploring new digital solutions and interfaces for autonomous maritime systems within the field of marine research. I believe that by democratising technology and sharing information is key to making our oceans safer, cleaner and more productive.

I hope that by presenting these concepts I can bring something valuable to the table in a othervise engineer-oriented industry.

1 BACKGROUND

MOTIVATION

When finding a topic for my diploma project at AHO, I knew that I wanted to work with something related to the ocean.
I grew up on an island on the south coast of Norway and have always been fascinated by the life under the surface as well as spending every summer along the coast in boats, fishing, and swimming. My dad even built a boat for me in our garage when I was 14, making the islands and rivers accessible to explore.

Sustainable oceans is something I am really passionate about, but since my childhood I have witnessed how human activities are affecting the oceans.

Fish have disappeared and hostile species are talking over the habitat of others. There is hardly any cod left in Skagerrak and the delicious blue mussels we used to pick on any beach are no longer there.

If we can apply our new technology and knowledge with good intentions and a bit of care we could possibly create lovable futures for humans and livable futures for the creatures in our oceans.

In my first diploma project draft I was intending to work with the topic of conservation and visualising ocean data, but after being introduced to the work of Ocean Industries Concept Lab at AHO, I decided to pursue a slightly different direction, originally proposed to them by one of their collaborators, the shipbuilder VARD;

to scientifically explore how a control center for autonomous ships would work.

By doing some quick desktop research I realised that this is a field which is in constant development, from large maritime industry actors, to DIY projects by researchers and activists. I wanted to know more about the subject and how design might be used to make better tools for people in ocean related industries.

MISSION

My mission in this diploma project is to explore and visualise scenarios and interfaces with a focus on user centered design solutions in the field of autonomy in maritime systems.

This is a complex and high risk task in a domain that requires a great deal of insight and technical understanding, while focusing on clear and consistent information visualization.

I wanted my end result to be explorative but feasible.

Since this is a student project I have an opportunity to challenge the status quo of current rules and regulations. Many of the current systems today are based on old standards, some dating back to times before computers were common. Therefore I am building on existing research and development for the OpenBridge project by Ocean Industries Concept Lab.

GOALS

EXPLORATIVE BUT FEASIBLE DELIVERY

A SCALABLE SOLUTION FOR THE FUTURE

CHALLENGE THE STATUS QUO

COMPLY WITH OPENBRIDGE GUIDELINES

DELIVERY

My final delivery in this project are screen interfaces for a **modular fleet control and data management tool for Unmanned Surface Vessels** using the OpenBridge design guidelines.

In other words; a software built for operators and researchers for planning and executing unmanned missions at sea, as well as analysis and sharing of the data collected. This software could be used in a multiscreen setup at a fixed shore control centre or as a scaled down mobile version for field work.

LIMITATIONS

Because of the time limits of the project, the complexity of the context, and the I consider my proposal as a work in progress. More time and user testing would be needed to properly evaluate the project and to implement functions that I haven't had the time to explore.

TOOLS & METHODS

In this diploma project I used several tools and methods learned through my 5 years at AHO, like semistructured interviews, field research, sketching, paper prototyping, scenario mapping and gigamapping. Digital prototypes were built using Sketch, Illustrator, Principle, FramerX and MapBox Studio for interactive maps.

OPAR Framework

One helpful tool was the OPAR Framework, developed by AHO's Etienne Gernez in his thesis "Connecting Ship Operation and Architecture in Ship Design Processes".
The research explores how Human Centered Design methods can be introduced to the ship design process. The targeted users of the framework are ship designers and other stakeholders of a design process. The framework consists of a two-dimensional matrix with four parts and four connections between each part. The vertical dimension of the matrix defines what relates to ship operation and what relates to ship architecture, as follows:

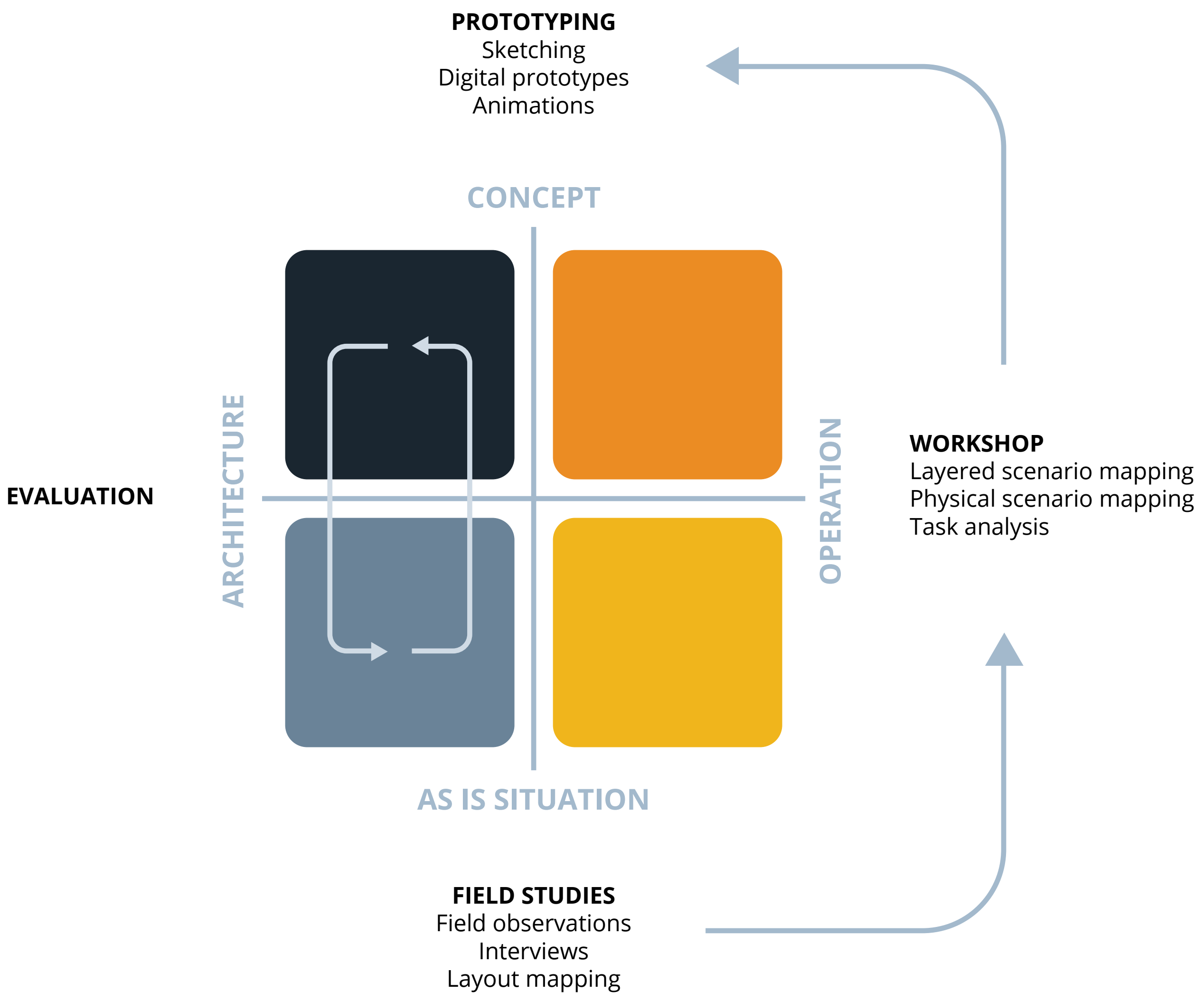
1) ARCHITECTURE is technology-centric and describes what systems are in place or are considered in the design process; and

2) OPERATION is human-centric and describes how the users of the ship might interact with the ship systems

1) AS IS SITUATION: as it exists now, as described by current best practices; and

2) CONCEPT: as it could be, should be, or ought to be.

Source: E. Gernez - Connecting Ship Operation and Architecture in Ship Design Processes (2019)



COLLABORATOR

Ocean Industries Concept Lab is my collaborator and with Kjetil Nordby as a second supervisor I have access to their network of industry partners in this project. They recently unveiled the OpenBridge Design System, which aims to realize consistent user interfaces across all ship systems. This is a project in continous development, and by actively using the design system I get to test and contribute with feedback and redesigned elements for a different use case.

> ***Since their startup in 2011, OICL has been a research group committed to develop knowledge that support user centered innovation processes in the maritime domain. Ocean Industries Concept Lab (OICL) is located at Institute of Design at AHO. The group is rooted in design practices such as industrial, interaction, graphic and service design and carries out projects in close collaboration with leading industry actors.***

> ***Digital innovation has a tremendous impact on the Ocean Industries. However, the rapid change enabled by digital innovation, have in many cases made people the bottleneck for new innovation. In short there is a gap between digital innovation in the maritime industries and people's ability to use these solutions safely and efficiently in practice. We argue the industry has to change approach to human centered innovation in order to take advantage of digitization and new enabling technologies for safer and more efficient workplaces.***
>
> Source: medium.com/ocean-industries-concept-lab

INITIAL BRIEF

> *We would like to have scientific backing on the design of a control centre for autonomous ships. It can be on land or aboard a mothership. There are many “star wars” inspired concepts online, but I doubt that there is much science behind it.*
>
> *We wish to focus on how a centre like this should be designed to sustain the situation awareness for the operators who might control 2-3-4 ships at once.*
>
> Ove Bjørneseth
> Vice President
> Vard Electro AS

With Ocean Industries Concept Lab as my collaborator, I chose to interpret this brief as an invitation rather than an assignment, where I could create my own project with a focus on exploration.

SCOPE

Autonomous maritime systems is a field which is in constant development, from large industriy actors, to DIY and research projects.
While there are many actors in the industry researching and developing systems for autonomous vessels, I noticed that many of these systems are intended for remote operating of larger ships like tankers and cargo ships.
While this is certainly an interesting topic I chose to limit my project to smaller Unmanned Surface Vessels (USV).

In areas like ocean mapping, research and routine tasks, fleets of smaller autonomous vessels can really make a difference.

AUV

1-2m

Kongsberg Hugin

Credit: Kongsberg Maritime

Wind/Solar driven USVs

1-2m

Saildrone

Credit: Erik Helland Urke

Small electric USVs

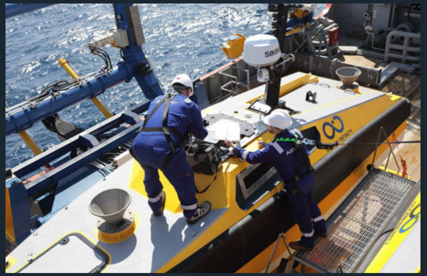
1-2m

Maritime Robotics Otter

Credit: Maritime Robotics

Long range USVs

2-8m



Ocean Infinity Seaworker

Credit: Ocean Infinity

Passenger transport

20-50m

Ballstad ferry concept

Credit: Tora Arctander

Cargo ships

100m +

Kongsberg Yara Birkeland

Credit: Kongsberg Maritime

USE CASES

The ocean presents a difficult, dangerous, and harsh environment in which to operate, especially over long durations.
USV's, can help people in a range or purposes, depending on the sensors and payload fitted.
Ranging from detailed ocean observations, data collection and oceanography to rescue and survey operations for the offshore industry.

Ocean conservation

FISH & MARINE MAMMAL MONITORING

ROUTINE WATER MEASUREMENTS

SEABED MAPPING

OCEANOGRAPHY

HYDROGRAPHY

OIL SPILL CLEANUP

Offshore industries

SEABED MAPPING

RESCUE OPERATIONS

OFFSHORE SURVEY

HARBOUR SECURITY

CONNECTION WITH AUVS & ROVERS

USE CASE STUDY

One of Ocean Industries Concept Lab's industry partner is Maritime Robotics. Located in norway's technological capital Trondheim, they are one of the leading developers of Unmanned Surface Vehicles (USV) and has customers all around the world. They have done extensive testing of autonomous guidance and collision avoidance systems in collaboration with Kongsberg and NTNU.

I wanted to know how they control and monitor these USVs, who uses them and for what purpose. I got introduced to them later in he project after the 1st midterm presentation.

In march I had a online group meeting, where I presented my project and we discussed their USVs, their software, usecases and possible improvements in their software. I will come back to this in the insight phase of the report. My intention was not to redesign their existing software, but rather to explore new interfaces that could be used with their and USVs and other similar ones.

Because of the Corona restrictions I was never able to travel to Trondheim to acually see their systems in real life. However I was able to have a meet again at the end of the semester with software engineer Henrik Lenes to discuss my project.

MARITIME ROBOTICS

"We believe that the future of maritime operations is unmanned and that innovation in automation will drive industry standards and continually broaden operational possibilities".

Source: https://www.maritimerobotics.com

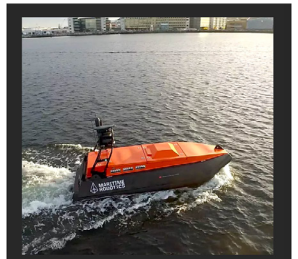
Maritime Robotics USVs:

Unmanned Surface Vehicle

OTTER

The Otter Unmanned Surface Vehicle (USV) is an easily deployable and portable USV, which provides a cost-effective turn-key solution for bathymetric surveys in sheltered waters.

USV

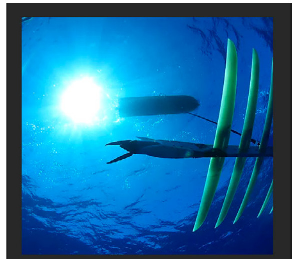


Unmanned Surface Vehicle

MARINER

The Mariner Unmanned Surface Vehicle (USV) is a multipurpose unmanned vehicle for offshore and coastal applications.

USV



Unmanned Surface Vehicle

WAVE GLIDER

The Liquid Robotics Wave Glider Unmanned Surface Vehicle (USV) is a vehicle powered by waves and solar energy that allows organizations to build networks of sensors to monitor ocean activity.

USV

EVALUATION

As spring of 2020 came and went we were all heavily inhibited by the Corona pandemic. In a nation in lock-down it is hard to accomplish interviews, workshops and proper user testing to evaluate the project. Being forced to work from home partly in quarantine also impacted the workflow and progress of my diploma, making it a lot less linear process.

However, I was able to meet potential users early in the project before any restrictions were enforced. My three field trips to Kystverkets Lostjeneste, Brevik VTS Station and Havforskningsinstituttet provided valuable insight into the context early on.

During restrictions I had the oppurtunity to have fruitful discussions and evaluate remotely with a handful of experts with a wide spectrum of knowledge. They were able to give be detailed feedback on proto-types through online Miro boards and Zoom meetings. Thank you!

I think the Corona lockdown situation has proved that working remotely is challenging, but certainly possible. Wether it's teaching, work meetings or remote controlling boats, with the right solutions and wire-less connection alot can be achieved. Diploma students and staff at AHO have become Zoom experts, and have collectively been rigorous testers of the technology through this period.

Kjetil Nordby

as second supervisor with extensive knowledge of maritime sectors and a keen eye for details.

Jesper Egemar, Steven Mallam and Jon Olav Eikenes

also from Ocean Industries Concept Lab with a broad range of expertise.

Henrik Lenes

Software engineer at Maritime Robotics

Kristoffer Husøy

Designer at Cognite with background from similar high risk, high complexity situations.

Caterina Forno Rios

Designer at EGGS, with expertise from earlier offshore and maritime projects including control of autonomous under-water vehicles.

Mosse Sjaastad

As supervisor and teacher with a sharp mind and incredible range of knowledge.

2

INSIGHT

The design process is not a linear one, it is a messy business. Things didn't decessarily happen in the order I am presenting. Here I will present some of the main insight and findings from my research and field studies.

AUTONOMY?

Autonomous means "self-governing" and autonomous control implies satisfactory performance under significant uncertainties in the environment and the ability to compensate for system failures without external intervention. (Antsaklis, Panos J.; Passino, Kevin M.; Wang, S.J. 1991)

There are great advances made in the innovation of driverless vehicles, and driving assistance is becoming more and more common in cars. However, the amount of sensory input needed on the road is far more complex than on the water or in the air. Most airliners today take off, land and fly almost interily on its own, having pilots as a backup in case of unforeseen events and for taxing on the ground. All airline traffic is also controlled by air traffic control centres at each airport, keeping the number of surprises to a minimum.

In space exploration, the need for robots with autonomous capabilities have been put to the test for decades. Because of the extreme challenges related to communication with machines longer and longer distances direct control and human interaction and decision making is increasingly difficult. Mars rovers like Curiosity does most of its daily operation autonomously, while humans back on earth decide which areas to go and explore based on the data sent back through daily satellite communication.

With higher level of monitoring and control of the invironment, the entities within it can operate with a higher level of autonomy given todays technology.
Advancement in AI and machine learning will most likely make it possible to have fully autonomous cars within a few years.

According to SEA International there are 5 levels of autonomy (LoA). In short terms they are described as follows:

L0 No autonomy
L1 Assistance
L2 AI is driving, human is monitoring
L3 Humans is there to take control if needed
L4 AI does the driving, humans can go to sleep
L5 Full autonomy, humans are free to do other things

Source: "Automated Driving – Levels of Driving Automation are Defined in New SAE International Standard J3016

Modes of operation

According to the report "Autonomy Levels for Unmanned Systems (ALFUS) Framework", four different modes of operation are defined:

Fully autonomous:

A mode of operation of an UMS (Unmanned System) wherein the UMS is expected to accomplish its mission, within a defined scope, without human intervention. Note that a team of UMSs may be fully autonomous while the individual team members may not be due to the needs to coordinate during the execution of team missions.

Semi-autonomous:

A mode of operation of a UMS wherein the human operator and/or the UMS plan(s) and conduct(s) a mission and requires various levels of HRI (Human Robot Interaction).

Teleoperation:

A mode of operation of a UMS wherein the human operator, using video feedback and/or other sensory feedback, either directly controls the actuators or assigns incremental goals, waypoints in mobility situations, on a continuous basis, from off the vehicle and via a tethered or radio linked control device. In this mode, the UMS may take limited initiative in reaching the assigned incremental goals.

Remote control:

A mode of operation of a UMS wherein the human operator, without benefit of video or other sensory feedback, directly controls the actuators of the UMS on a continuous basis, from off the vehicle and via a tethered or radio linked control device using visual line-ofsight cue. In this mode, the UMS takes no initiative and relies on continuous or nearly continuous input from the user.

Source: Hui-Min Huang, Kerry Pavek, James Albus, and Elena Messina "Autonomy levels for unmanned systems.
https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=822679

INDUSTRY ACTORS

During my initial research I found a number of industry actors within the field of autonomous maritime systems. Several of them develop their own interfaces, that are mentioned later in the report. Instead of giving detailed information every actor I have found out there, I will provide a short list with links to their websites :

MARITIME ROBOTICS : SMALL USV, WAVEGLIDER, SOFTWARE

LIQUID ROBOTICS : WAVEGLIDER SOLAR POWERED USV

SAILDRONE : WIND POWERED OCEAN DRONES

ASV L3 HARRIS : USV CONTROL SYSTEMS

OCEAN INFINITY : USV & MISSION PLANNING SOFTWARE

SEA-MACHINES : AUTONOMY CONVERSION SYSTEMS

KRAKEN ROBOTICS : AUV & SCANNING SYSTEMS

WAM-V MARINE : SMALL SCALE USV

ENABLE-S3 : SHORE-BASED-BRIDGE SYSTEMS

KONGSBERG MARITIME : AUTONOMOUS SHIPPING

NTNU AMOS : CENTRE FOR AUTONOMOUS MARINE SYSTEMS

AUTOSEA : MARITIME ROBOTICS, NTNU, DNV GL AND KONSGBERG

ROLLS ROYCE : CONTROL CENTRE CONCEPTS AND AUTONOMY

WHY AUTONOMY?

The interest in autonomous ships is growing rapidly, and both industrial players and researchers claim it could be the next shipping revolution. Autonomous ships can provide brand new business opportunities for shipbuilders, equipment suppliers and shipowners. They are less expensive to operate, they require high technology skills and new and tighter cooperation structures between the players. This gives the Norwegian maritime cluster a unique opportunity to take a leading international position in development and commercialising of these ideas.

The development of new technology for automation of ship operations will also create opportunities to improve the safety and operation of existing ships. In the short run, this will be the main market.

- Ørnulf Jan Rødseth (Sintef, 2016)
https://www.sintef.no/en/latest-news/autonomous-vessels-may-become-major-priority-in-no/

Operational safety:

Between 75% and 96% of maritime-related accidents are caused by human error, according to a study by Allianz. Introducing fully-autonomous and semi-autonomous vessels may help reduce the number of shipping-related accidents, as employee fatigue and personal judgement failures are reduced. As 90% of global trade takes place by ocean, this could markedly improve safety across the global trade supply chain.

Reduction in crew costs:

As on-board crews are reduced, shipping carriers will no longer need to pay their salaries, insurance, or on-board provisions. Crew-related expenses can account for up to 30% of a voyage's total cost. This means unmanned or lightly-manned vessels could save money for shipping carriers, and ultimately for those shipping goods, in the long run.

Energy efficiency:

The Yara Birkeland, is expected to be the first fully-electric, and zero-emission vessel. As shipping vessels account for 3% of global carbon-dioxide emissions, the adoption of zero-emission ships could notably reduce pollution around the world.

Data collection:

The global trade supply chain is becoming increasingly connected, digital, and data-driven. Startups and corporates are digitizing the shipping process and seeking to optimize logistics. Autonomous ships will be well-equipped to further promote supply chain visibility by collecting voyage-related data through their autonomous systems. This data can be used by supply chain partners to communicate the status of certain shipments, or further optimize shipping routes based on factors like sea conditions.

Source: https://www.cbinsights.com/research/autonomous-shipping-trends/

Hierarchical Task Analysis and collision avoidance

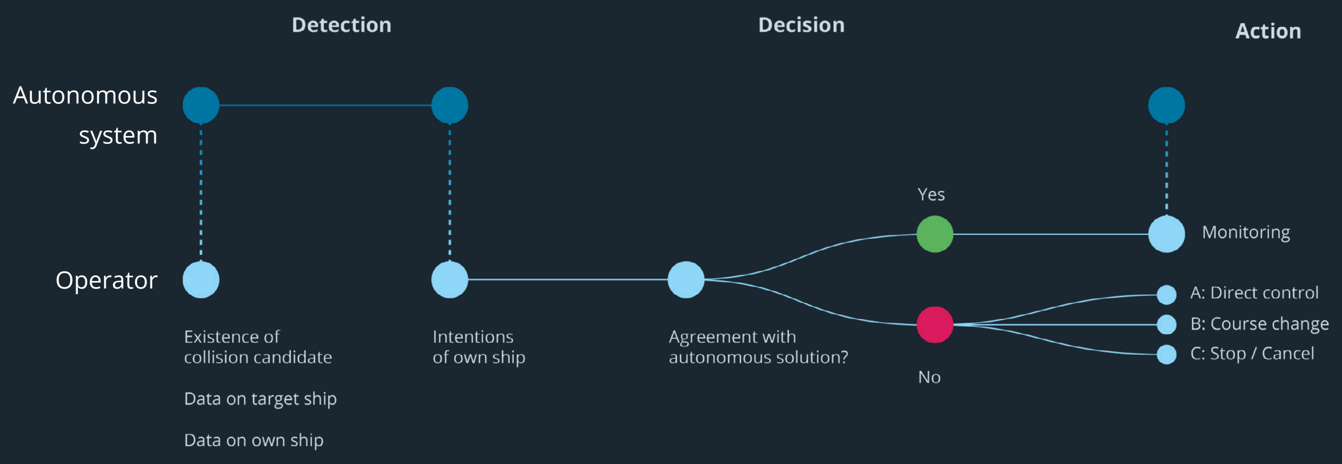
Although recent developments in autonomous ships projects introduce the concept of a fully autonomous operation, the use of some level of autonomy is not new to modern ships operations. For example, modern ships with dynamic positioning (DP) systems have control functionalities that may be characterized as autonomous (Utne et al., 2017).

“a system’s or sub-sys- tem’s own ability of integrated sensing, perceiving, analyzing, com- municating, planning, decision-making, and acting, to achieve its goals as assigned by its human operator(s) through designed human-machine interface (HMI)”
(Ramos, Mosleh, Utne, 2019)

The purpose of the analysis is to identify and discuss expected human actions during a collision accident with an autonomous ship, and how important these may be to safety even with a high autonomy level. We assumed thus the higher autonomy level to be achieved in the near future – constrained autonomy – with a possibility of changing LoA (Level of Autonomy) if necessary. Operators working in a control center onshore then con- stantly monitor the ship, and it is possible for the operators working onshore to contact/be contacted by the manned target ship
The crew needs data about the au- tonomous ships they are monitoring, the surrounding ships, and the en- vironmental conditions; and this data is crucial for most of the tasks they need to perform. The operator needs an adequate interface to avoid the errors of pressing a wrong button, or performing an action on the wrong ship, for example.
(Ramos, Mosleh, Utne, 2019)

Task analysis is the analysis of how a task is accomplished, including a detailed description of both manual and mental activities, task and element durations, task frequency, task allocation, task complexity, environmental conditions, necessary clothing and equipment, and any other unique factors involved in or required for one or more people to perform a given task
(Kirwan, B. and Ainsworth, L. (Eds.) (1992). *A guide to task analysis. Taylor and Francis.*

In this scenario the ship detects a collision candidate, it provides the operator with information on the target ship and own ship.
If the operator agrees with the future action presented by the autonomous system, the action is performed by the system and the operator monitors the action. If not the operator might choose to take over control, alter the course, or stop the mission.



This analysis indicates a minimum of interface elements needed in an interface for an autonomous system:

- Visual representation of risk and status
- Visual representation of future dangerous situations
- Detailed information about own ship and its environment
- Information about intended avoidance maneuver
- Tools for direct control of your own ship
- Information about other ships

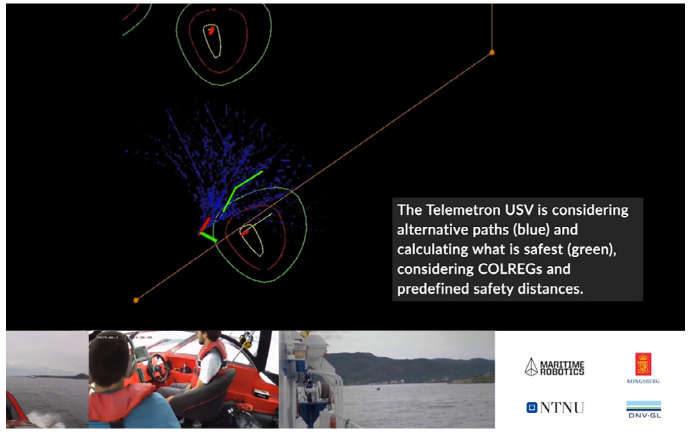
Collision avoidance tests in Trondheim fjord

The Autosea project (Sensor fusion and collision avoidance for autonomous surface vehicles) is a collaboration between NTNU, DNV-GL, Konsberg and Maritime Robotics. They have tested collision avoidance systems in several scenarios, proving it to be quite sturdy.

> *The main goal of the Autosea project is to develop methods for guidance and navigation of autonomous ships. A central component of this is collision avoidance. The Autosea project has demonstrated complete collision avoidance systems in full-scale experiments involving autonomous and semi-autonomous surface vehicles both in Trondheimsfjorden and in the Netherlands, with Maritime Robotics' Telemetron USV. The Telemetron is a 'converted' vessel, an originally manned vessel which has been adapted such that it can be run autonomously.*
>
> Source: https://www.maritimerobotics.com/post/field-demos-of-autonomous-collision-avoidance

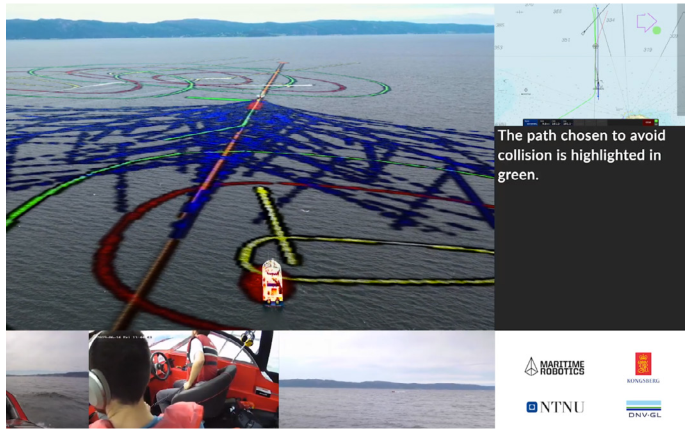
Scenario: Overtaking

The USV detects another boat on radar and plans an overtaking maneuver.



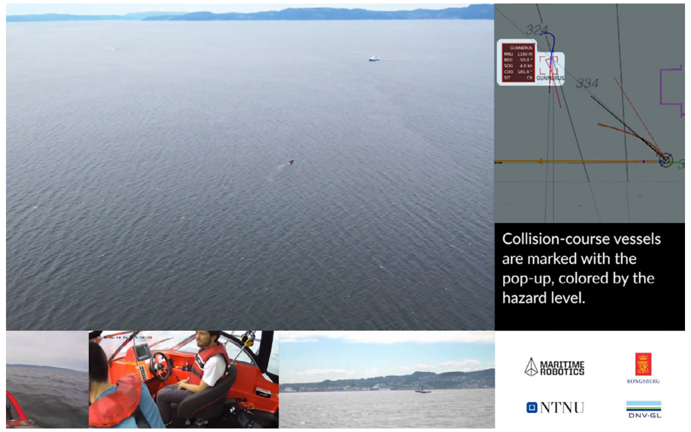
Scenario: Head-on

The USV is running autonomously and is on a collision course with another boat. The collision avoidance system choses an alternative path shown in green.



Scenario: Overtaking

The USV detects other vessels from AIS and plans a avoidance maneuver to avoid both vessels.



Photos: Maritime Robotics

NAVIGATING AT SEA

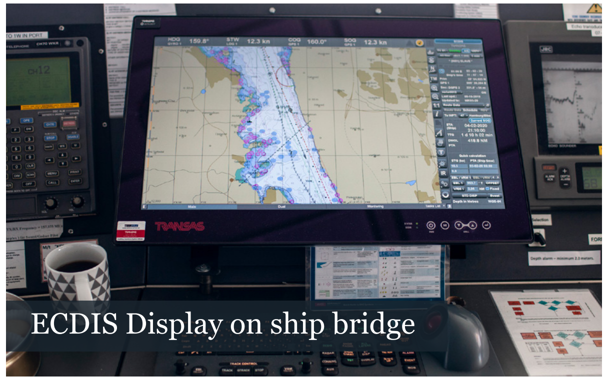
Unmanned Surface Vehicles (USV) run on a preplanned missions combined with sensory input to navigate, avoid obstacles and complete tasks while connected by wifi, cellular network or satellite to a shore based or offshore control system.
Due to the very low bandwith of sattelite connections, real time video feedback and direct control is difficult to achieve.
Within the range of wifi and 4G/5G, a certain degree of direct remote control and video monitoring is possible (such as commercially available drones. Further out to sea connection is typically achieved through commercial satellite networks like Iridium, which consist of 66 active satellites in low earth orbit.

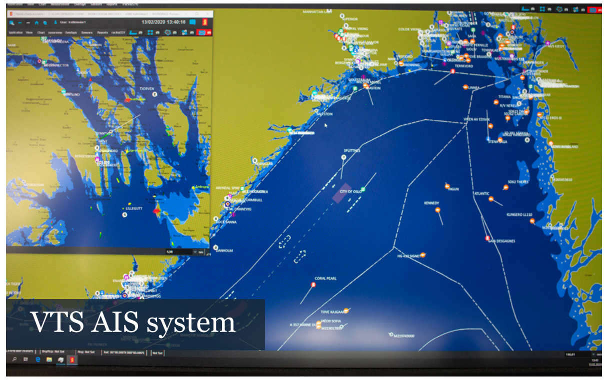
To detect other ships in the area USVs are usually fitted with Automatic Identification System (AIS) receivers in combination with radar or lidar.
AIS is an automatic tracking system that uses transponders on ships and is used by vessel traffic services (VTS). AIS information supplements marine radar, which continues to be the primary method of collision avoidance in ships.

AIS provides information such as unique identification, position, course, and speed, and is commonly displayed on a screen or an Electronic Chart Display and Information System (ECDIS). AIS is intended to assist a vessel's watchstanding officers and allow maritime authorities to track and monitor vessel movements. Vessels fitted with AIS transceivers can be tracked by AIS base stations located along coast lines or, when out of range of terrestrial networks, through a growing number of satellites that are fitted with special AIS receivers which are capable of deconflicting a large number of signatures.

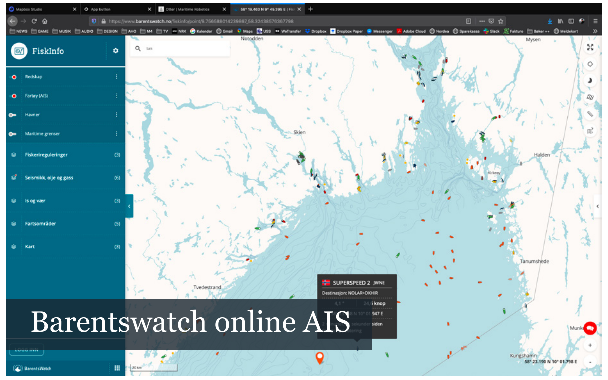
The International Maritime Organization's International Convention for the Safety of Life at Sea requires AIS to be fitted aboard international ships with 300 or more gross tonnage, and all passenger ships regardless of size.

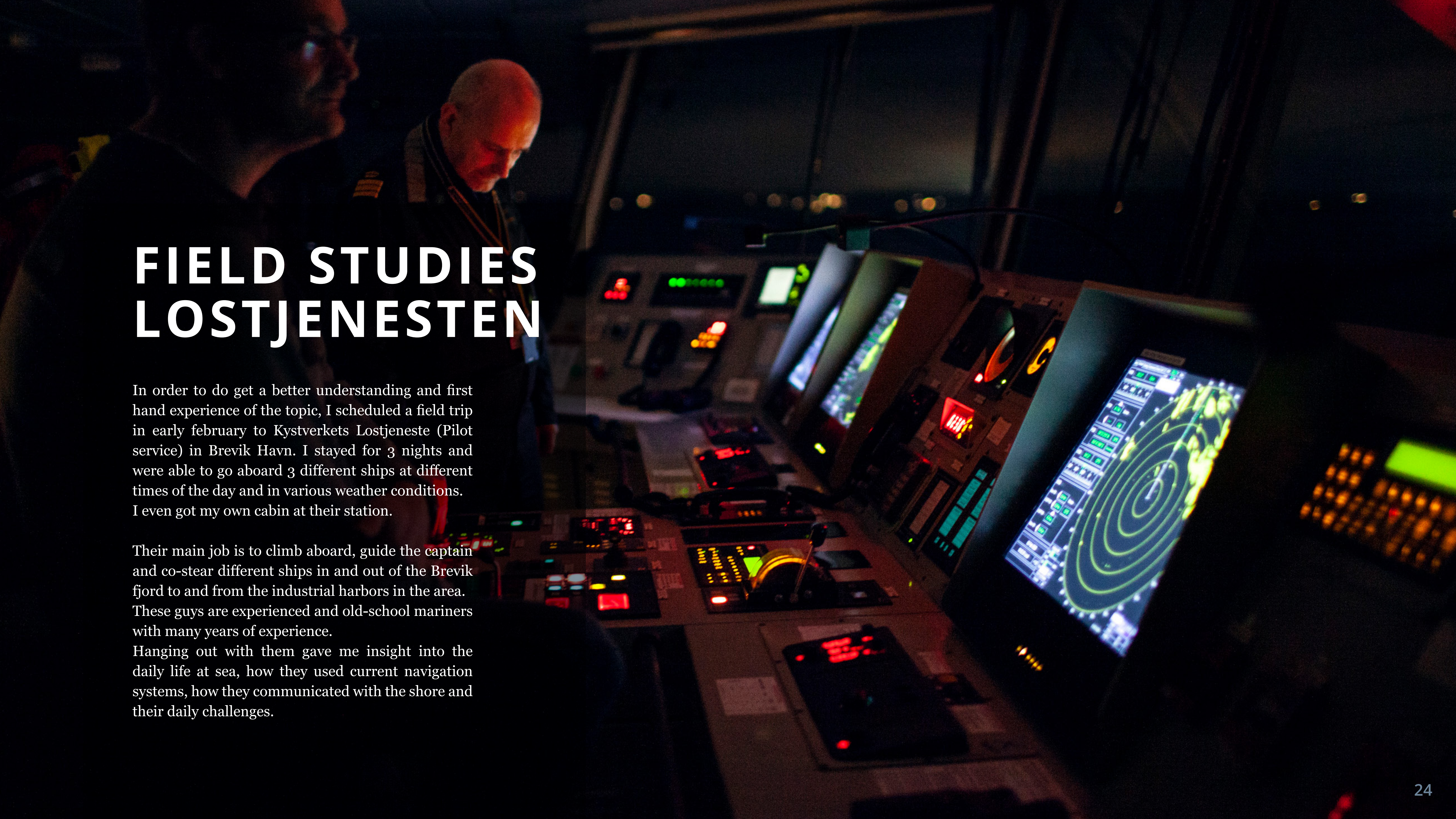
It is still unclear how the rules and regulations should consider unmanned vessels. Small USVs (like Maritime Robotics) does only have AIS receiver, while transceiver is optional.


ECDIS Display on ship bridge


VTS AIS system


SealQ iPad AIS


Barentswatch online AIS



FIELD STUDIES LOSTJENESTEN

In order to do get a better understanding and first hand experience of the topic, I scheduled a field trip in early february to Kystverkets Lostjeneste (Pilot service) in Brevik Havn. I stayed for 3 nights and were able to go aboard 3 different ships at different times of the day and in various weather conditions.
I even got my own cabin at their station.

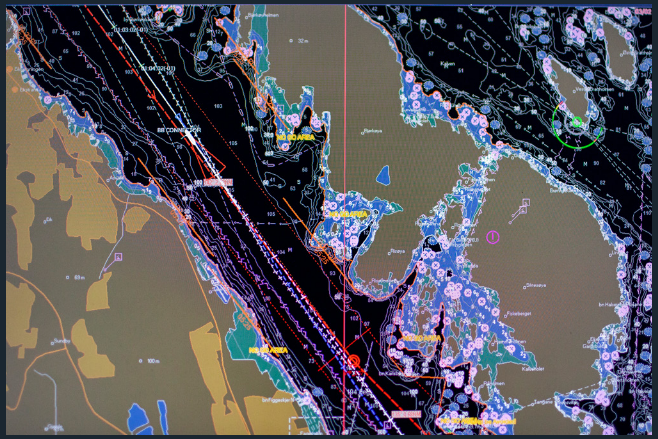
Their main job is to climb aboard, guide the captain and co-stear different ships in and out of the Brevik fjord to and from the industrial harbors in the area.
These guys are experienced and old-school mariners with many years of experience.
Hanging out with them gave me insight into the daily life at sea, how they used current navigation systems, how they communicated with the shore and their daily challenges.

Main takeaways from field studies

My project is not about fixing ship bridge designs. However it was key for the project to observe what instruments was in use, and how, communication between the pilot, the crew and the VTS station on land, and hear stories from the crew about some very close calls in the past. The workplace is relatable to what a Shore Conrol Centre could be, if you remove the visual contact...

"If it's too complicated, it's not good. When things get really hot, it's easy to make mistakes"

- Odd Jøran (Los at Kystverket)



1 Visual clutter and errors in systems

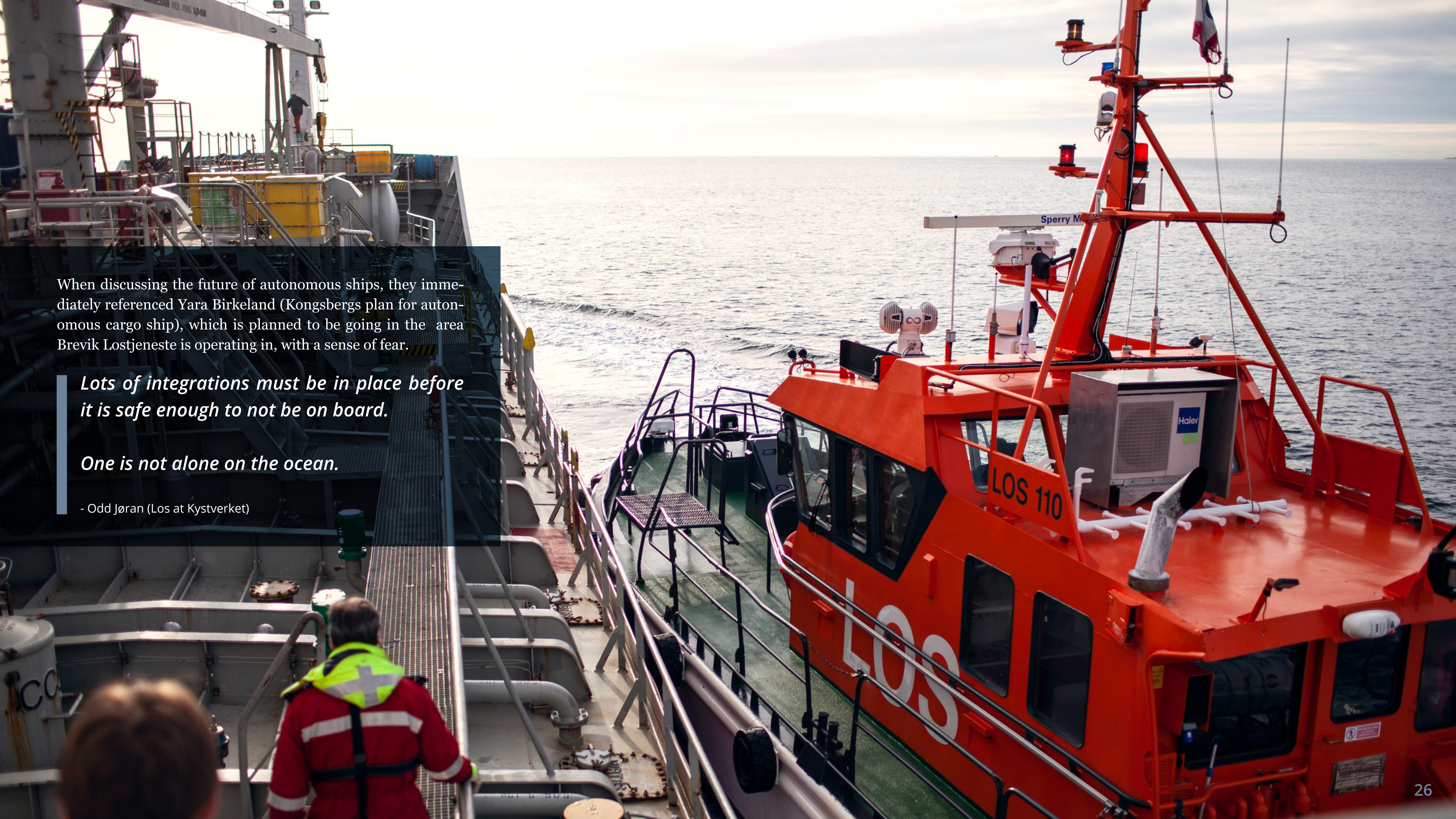
A well known problem on ship bridges, especially older ones is the lack of consistency in the equipment. Every manufacturer have their own way of doing things, resulting in systems that can cause confusion. The ECDIS was unusable at a critical narrow straight with the settings they used.

2 Visual contact & radar most important

Because they didn't trust many of the navigation systems on individual ships, and because they knew the area so well, they navigated mostly by recognising landmarks. That could be lights from a specific building, lights on bridges and towers and using radar as a tool when there was heavy fog

3 Alarms are ignored

Both visual and audio alarms were consequently ignored. There would be constant beeps from the ECDIS because we were too close to shore. It seemed like none of the crew were bothered, possibly because they trusted the pilot (Los) knowing the waters they were in. One pilot commented that there would be a "symphony of alarms" on some ships.



When discussing the future of autonomous ships, they immediately referenced Yara Birkeland (Kongsbergs plan for autonomous cargo ship), which is planned to be going in the area Brevik Lostjeneste is operating in, with a sense of fear.

> ***Lots of integrations must be in place before it is safe enough to not be on board.***
>
> ***One is not alone on the ocean.***
>
> - Odd Jøran (Los at Kystverket)

Situation awareness

Situation awareness is a constantly evolving picture of the environment.
Parallels can be drawn between what happens in a flight cockpit,a nuclear plant control room, behind the sticks of a submarine or at a Shore Control Center.

These are all complex and dynamic environments with similar challenges where too much information and high workloads can lead to human error. How will this work when you remove the visual connection from onboard a vessel?

History shows that such accidents occur frequently, impacting both human lives and the environment.
A more accurate term for these human errors would be design induced errors as they are outside the operator's control. Poorly designed systems lead to incomplete and faulty pictures of actual situations.

Situation Awareness is formally defined as a person's «perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future» This definition breaks down to three levels:

LEVEL 1 : PERCEPTION OF THE ELEMENTS IN THE ENVIRONMENT

LEVEL 2 : COMPREHENSION OF THE CURRENT SITUATION

LEVEL 3 : PROJECTION OF FUTURE STATES

In order to obtain an accurate mental picture for up to 10 vessels at any point during a captain's watch, a simplified operational approach based on a human/ship-autonomy symbiosis must be developed. There is reason to believe that the ships, with current and further developed technology, will be capable of determining the best route for themselves and make suggestions or inform their operators as changes and challenges occur.

Still, there is an important challenge regarding the amount of decision making being handled by the autonomous system. By letting the autonomy operate without human interference, the system is effectively handling a part of the overall workload but on the other hand, it is actively distorting the operator's mental picture by operating behind the curtains.

Source: E. Ottesen -Situation Awareness in Remote Operation of Autonomous Ships
Shore Control Center Guidelines

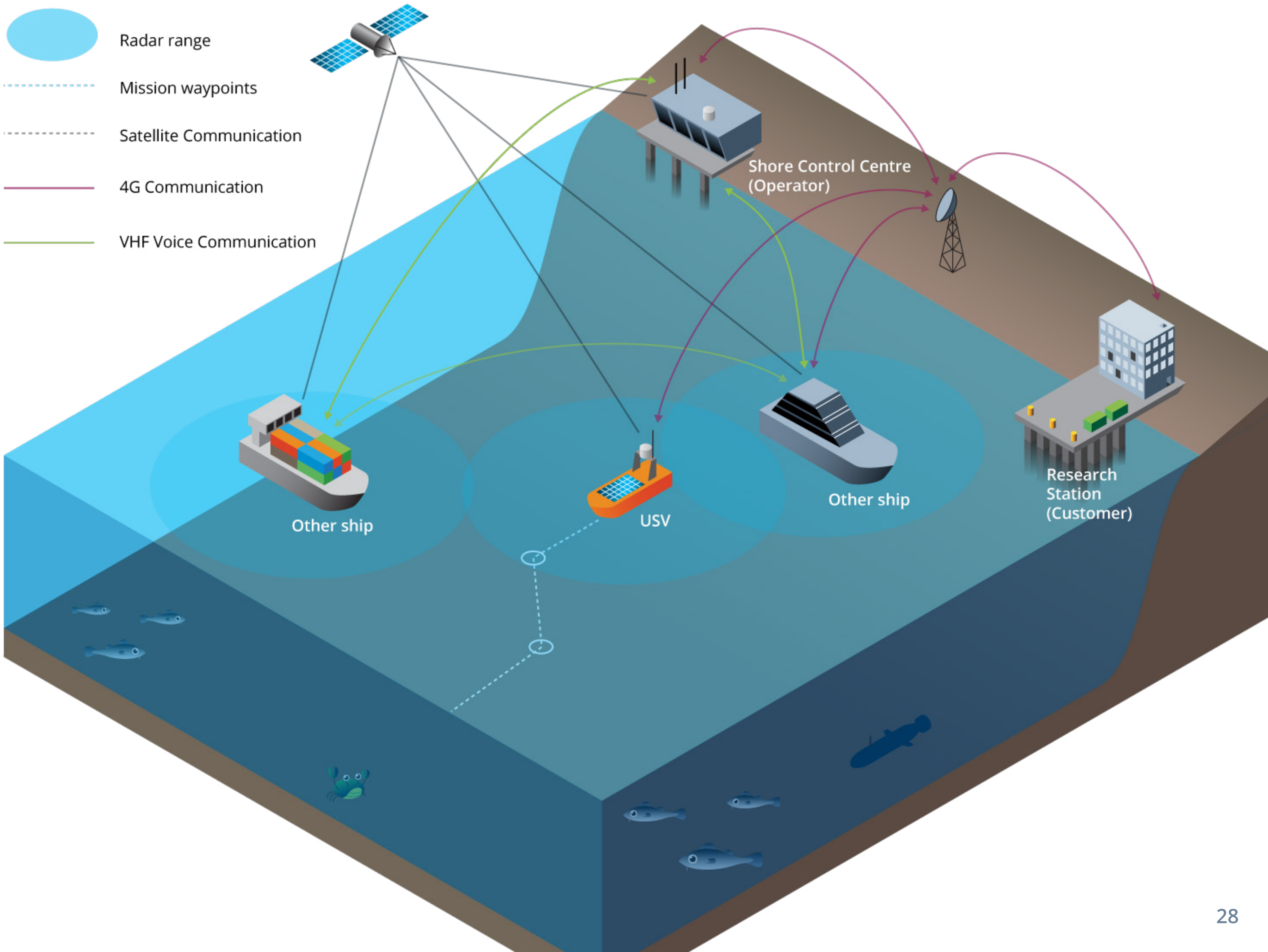
Communication

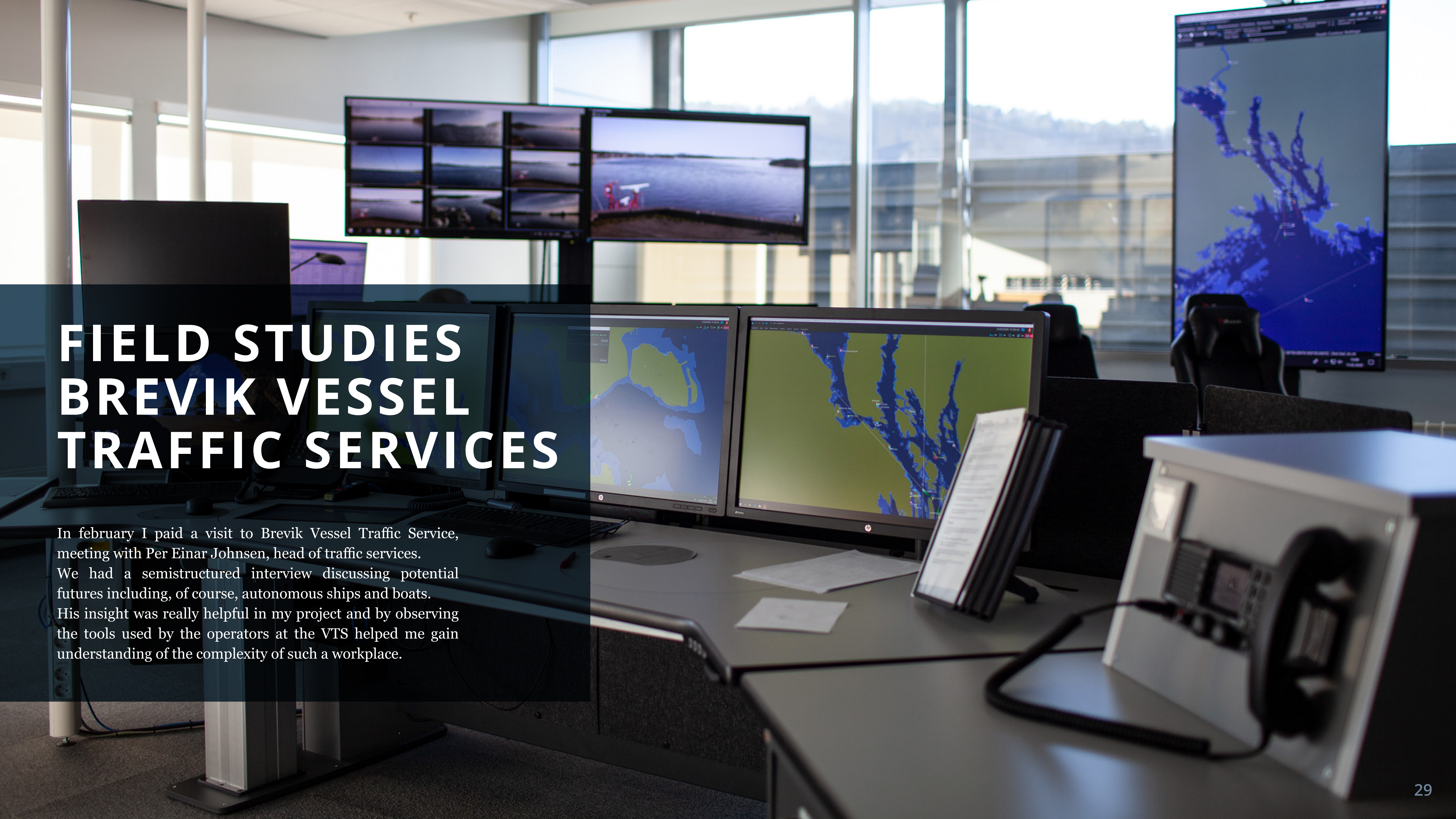
One of the common question regarding autonomus systems is: who do you call when there is no person aboard the boat? VHF communication is widely used for critical and everyday communication between ships and shore (or between aircrafts and air traffic control) to approve plans and actions and to call for help.

In an autonomous maritime system a simplified model of the communication flow would look something like this.

The operator in the Shore Control Centre (SCC) would be able to talk to other ships through VHF in case of emergency, then have control and feedback from USVs via satellite and/or 4G network. A critical scenario is losing all communication with the USV. With larger unmanned ships that could be fatal. With smaller USVs, it might not be as critical, but still pose a threat for other ships in the area.

While there are hundreds of scenarios that could play out, I have chosen to focus on a few potential scenarios that includes critical situations. How to give the operator enough situation awareness and overview of the situation without having alarms for every minor event.
Collision avoidance algorithms, and wireless connection architecture are not within the scope of my task although it is crucial for such a system to work.





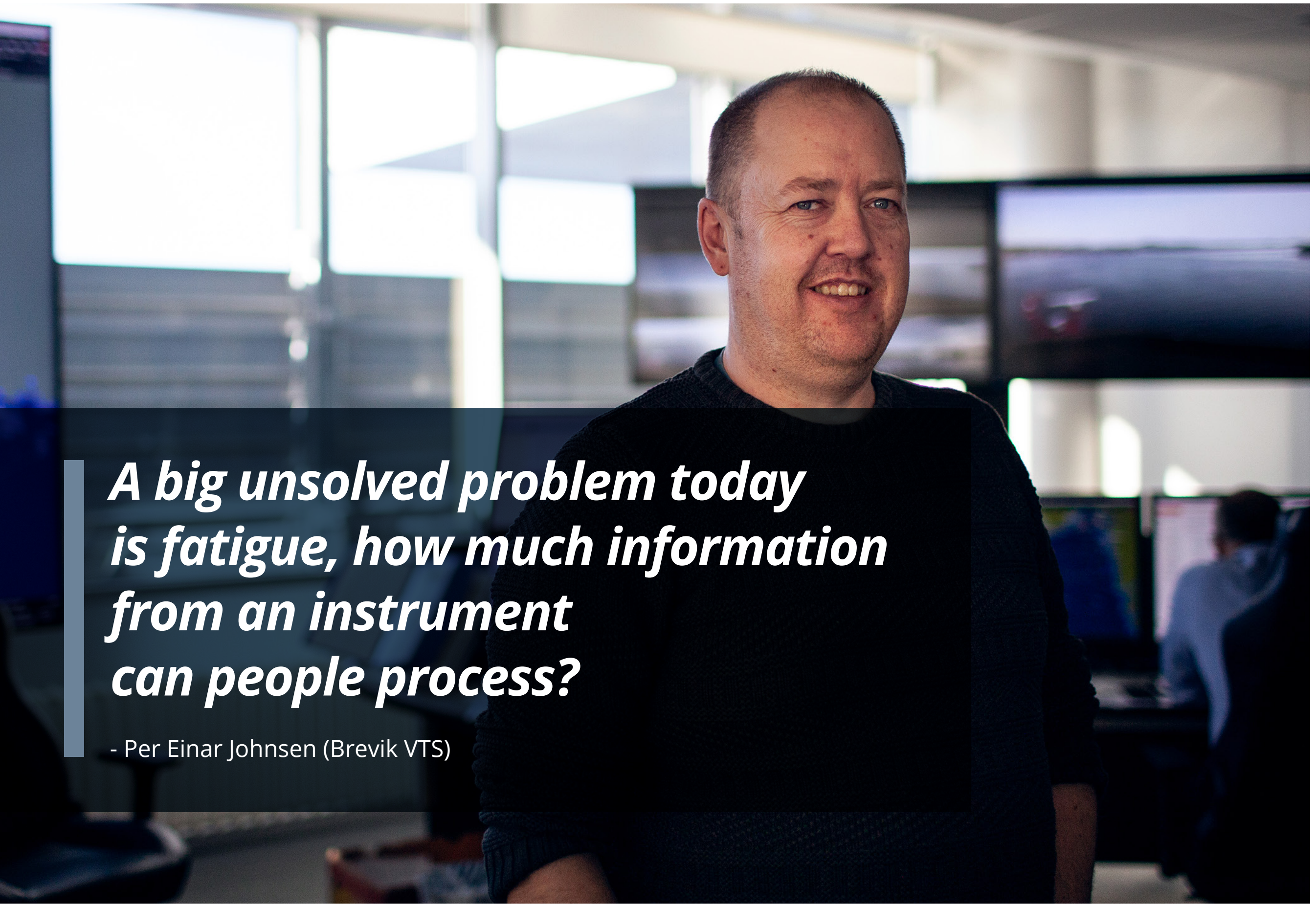
FIELD STUDIES BREVIK VESSEL TRAFFIC SERVICES

In february I paid a visit to Brevik Vessel Traffic Service, meeting with Per Einar Johnsen, head of traffic services.
We had a semistructured interview discussing potential futures including, of course, autonomous ships and boats.
His insight was really helpful in my project and by observing the tools used by the operators at the VTS helped me gain understanding of the complexity of such a workplace.

Main takeaways from interviews

A Vessel Traffic Service (VTS) is very similar to an Air Traffic Control tower. Their job is to have a complete overview of the current situation with what ships are allowed and not to enter or exit the Brevik fjord. They have daily dialogue with the pilots at Kystverkets Lostjeneste.

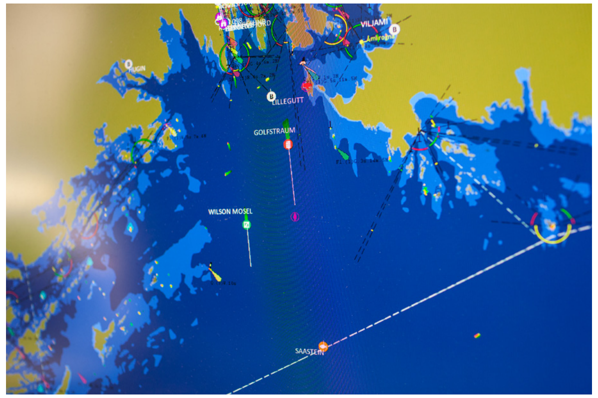
The workplace of a VTS station mas many similarities with a potential Shore Control Center. Both contexts involves situations awareness of complex and high risk situations.
The interfaces might also have many similarities, especially what involves monitoring and multitasking.



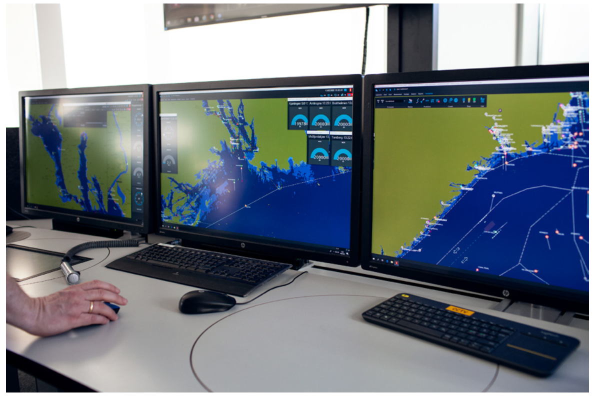
> ***A big unsolved problem today is fatigue, how much information from an instrument can people process?***
>
> - Per Einar Johnsen (Brevik VTS)

Systems used in a VTS

C-Scope is developed by Kongsberg and works similar to that of an ECDIS (Electronic Chart Display). All ships with AIS transceivers show up on the map with different icons and colors relating to the type of ship. In this image, the orange boat is a fishing vessel and has a fish symbol attached to it.
The lines of each ship symbol indicates velocity and direction.



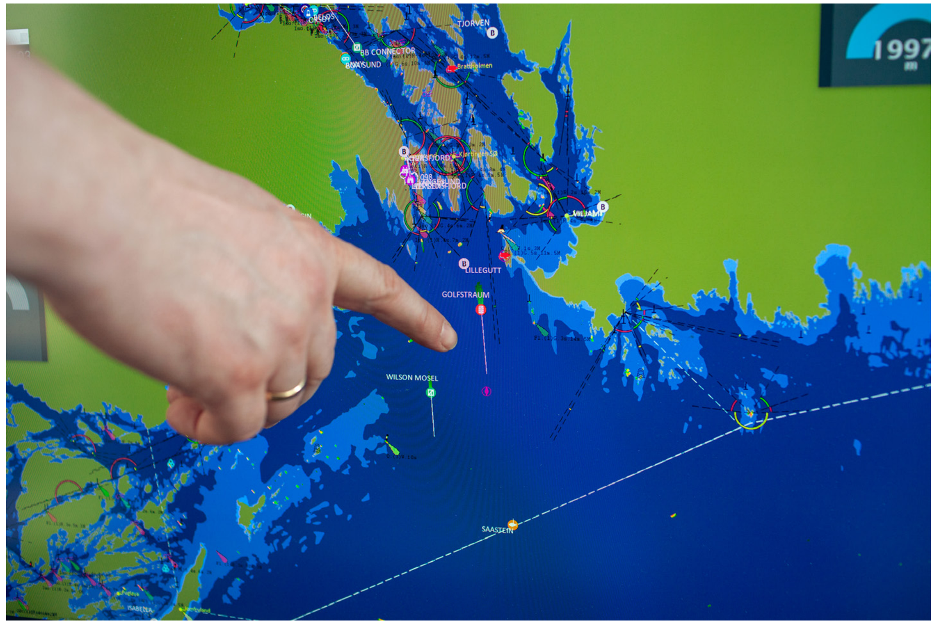
Three independent workstations include a multiscreen setup and two big screens used for a CCTV system with cameras placed along the shoreline.



The operators at the VTS has a maritime background and has to go through psychologic tests, a stresstest to see if they can handle challenges.

> ***It is important that we manage unmanned, autonomous and ordinary vessels equally. We must make sure there is equality between the different actors.***
>
> - Per Einar Johnsen (Brevik VTS)

Who you gonna call? When there's no one aboard the ship?



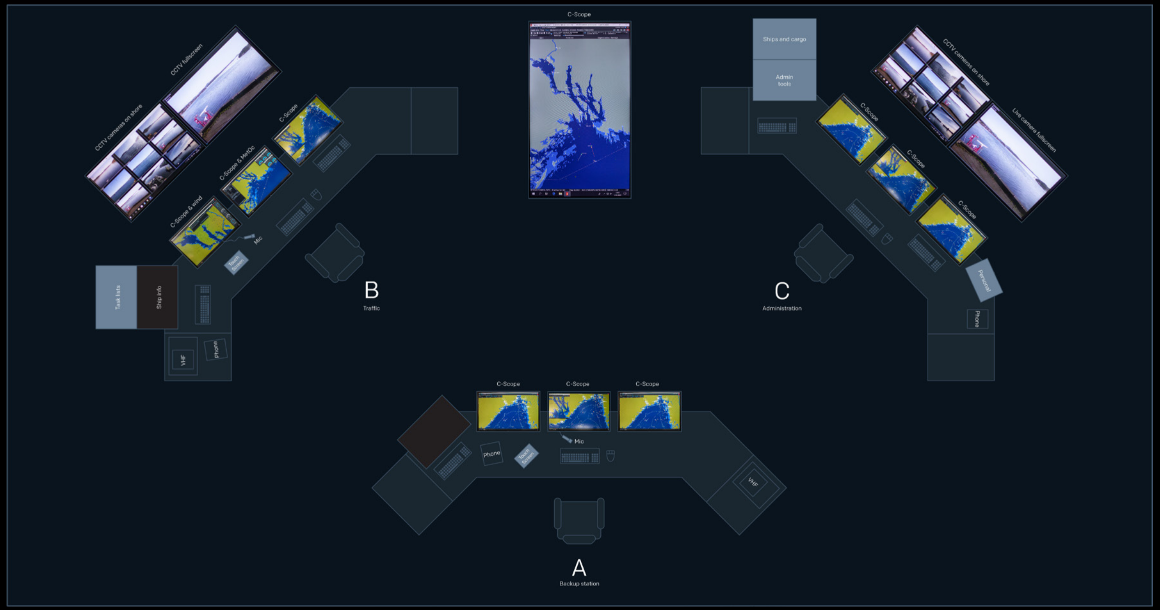
Control room layout mapping

After returning home from the 2 field trips I performed a layout mapping of the 3 different ship bridges to compare where the different instruments and controls were placed in relation to each other and the crew.

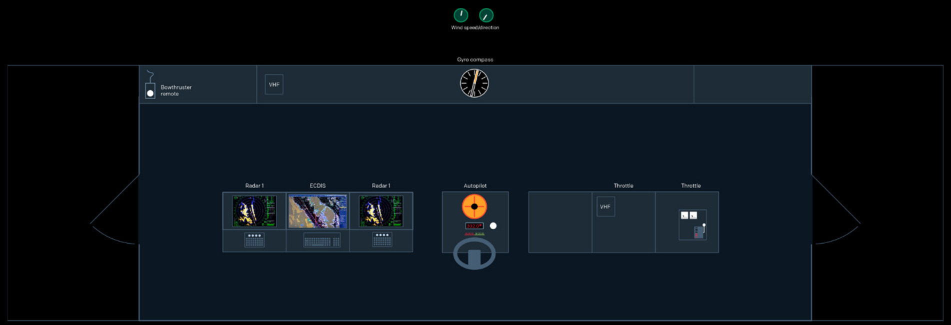
You can see how the bridge layout design has gradually evolved from a straight line into a double seated V section.

Below is the Control room at Brevik VTS, with its 3 individual control stations.

This, combined with other control room designs from the audio world inspired my final suggestion of a control room desk.



Brevik Vessel Traffic Services control room (2020)


Gas Galaxy, Phillipines (1997)


Key Bora, Gibraltar (2006)


Coral Patula, Netherland (2009)

Suggestion for Shore Control workstation Layout

AUTONOMY IN MARINE RESEARCH

Knowledge and data from our oceans are crucial for a sustainable future.
However, marine research and ocean mapping can be time consuming and expensive.
The gathering of objective data from our oceans over longer periods of time is key to understanding what is happening and what we can do about it.
Autonomous vehicles can carry sensors in ways that before have been too expensive or risky and offer a great advantage in repetitive and tedious work. Therefore the use of USVs in many areas of marine research makes total sense.

> ***Unmanned surface vessels could perform 10 times the amount of research missions at 1/10 of the price***
>
> - Asgeir Sørensen - Amos (Centre for Autonomous Marine Operations and Systems)
> Article: https://www.tu.no/artikler/droner-gjor-havforskningen-raskere-og-billigere/461091

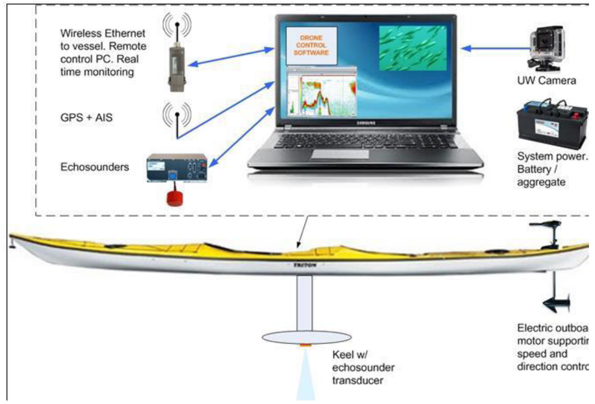
> ***Today with billions of devices on the network, the vast unexplored territory without that communication is the ocean. The ability of a fleet of dataaqcuiring ocean-going autonomous vehicles to give us a way to see this. Very important for science, very important for navies, but deeply important for all the rest of us. To really understand how the world is transforming.***
>
> - John Gage (former Vice President and Chief Research Officer, Sun Microsystems)
> Source: http://liquidrobotics.com

A selection of research projects

I think it is interesting to see what researchers and environmentalists are doing within the field of robotics. I have chosen a selection of projects that proves that there is unique innovation happening within marine research, and that there is a real need to develop user centered applications for other people than expert users with maritime or engineering background.

I have attached links to original articles and reports if you want to learn more about each case.

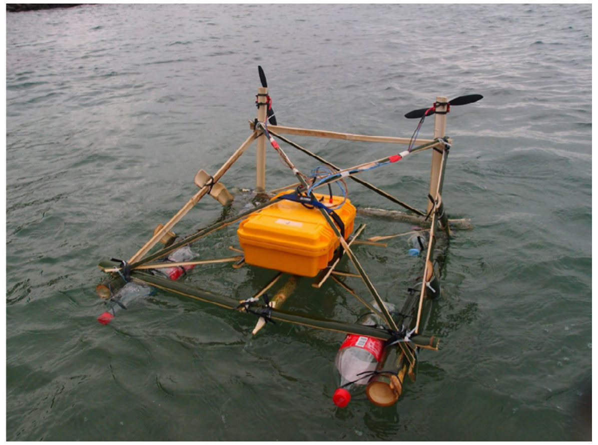
The kayakdrone



This is a project initiated and built by Espen Johnsen at Havforskningsinstituttet (Ocean research institute) in Bergen. It is (as the name implies) a battery powered drone built into a 7 meter oceangoing kayak. It is quiet and non intrusive so it can get closer to marine habitats without disturbing fish or birdlife. It has a underwater camera and echosounder to collect data and images. They use multiple individual software applications for guidance, recording video and for logging echosounder data.

Source: https://www.hi.no/hi/nyheter/2018/oktober/dronekajakk-med-elmotor-og-ekkolodd

Coral reef mapping robot by Cesar Jung Harada

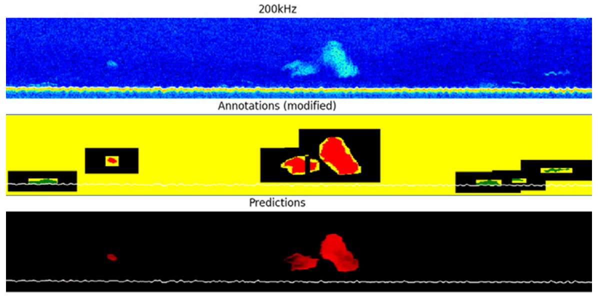


Cesar Jung Harada is a french-japanese environmentalist, entrepeneur and inventor who has done several innovative projects in the quest for cleaner oceans. His project of coral reef mapping robot uses off-the-shelf drone hardware and software (PixHawk) in combination with a laser quadrat (creating a frame of light on the surface) and underwater cameras to create color maps of coral reefs in shallow waters.

Source: https://www.researchgate.net/publication/337648583

Article: https://cesarjungharada.com/coral-reef-mapping-robot

Counting fish species with AI



Researchers at Havforskningsinstituttet (Norwegian ocean research institute) are testing deep convolutional neural networks to interpret echosounder images from research missions. They have trained the AI (Artificial Intelligence) with several years of echosounder images to count and identify different species of fish with surprising accuracy. Different fish species returns different frequency responses that can be read by the machine and give accurate numbers.

Source: https://doi.org/10.1093/icesjms/fsz235

Article: https://www.hi.no/hi/nyheter/2020/mai/her-finn-kunstig-intelligens-stimar-av-tobis-pa-ek-koloddbilda

Using Saildrones and AI

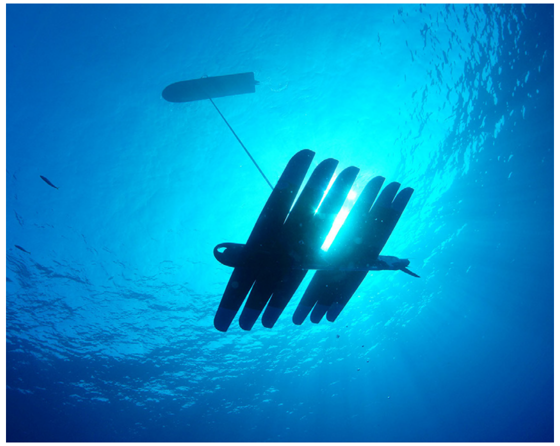
Havforskningsinstituttet are also testing the use combination of Saildrones and echosounder images fed through an AI to achieve more reliable data on fish stocks.

Source: https://www.tu.no/artikler/her-slippes-seildronene-som-skal-erstatte-forskningsfartoyer/463040?key=nlOegihC

Foto: Eirik Helland Urke

> *A solution like this is part of tomorrow's data collection. It is cheap, sustainable and scalable. The raw data is too big to be sent home by satellite. But if the vessels have an onboard AI system, that can interpret what they see, they could send the results back in realtime.*
>
> - Ronald Pedersen (Havforskningsinstituttet)

Tracking crabs in realtime to improve fishery management



A project collaboration between Liquid Robotics (who produces the Wave Glider USV), The Ocean Tracking Network and Canada's Department of Fisheries to tag and follow the yearly migration of snow crabs. Using a slow solar powered USV it can follow the movement of the crabs over long periods of time giving more detailed information than with traditional methods.

Article: https://www.liquid-robotics.com/customer-stories/tracking-crabs-in-real-time-to-improve-fishery-management/

> *We don't sell the vessels, we own and operate a fleet and sell the data. We develop the vessel and install the sensors. Today we deliver and deploy the vessels, send them out on missions and control the vessel, bring them back and calibrate the sensors. Our customers get the data in realtime, and there is no cost until the vessel is in the ocean at the location it should be. They don't want to own their own drones. They want to use the data.*
>
> - Richard Jenkins (Saildrone)
>
> Source: https://www.tu.no/artikler/her-slippes-seildronene-som-skal-erstatte-forskningsfartoyer/463040?key=nlOegihC

VISIT TO HAVFORSKNINGS INSTITUTTET

In february I scheduled a one day trip to the ocean research station in Hisøy, Arendal in order to talk to interview the guys there, see what kind of equipment they used and what their thoughts were on using autonomous vessels in marine their work.

Havforskningsinstituttet is one of the largest marine research institutions in Europe. They have four research stations around Norway and their main purpose is to be the leading knowledge provider for a sustainable management in marine ecosystems, and for the entire chain from ocean to food, including the marine environment, fishery management and for safe and healthy seafood.

They perform repeated measurements around the coast and has done so since 1919 using many of the same procedures.

At flødevigen I met with marinbiologist Sigurd Heiberg and section chief Petter Baardsen who gladly spent their afternoon talking to me and discussing challenges and oppurtunities within their field as well as interesting findings in their research.

They were the first to explain to me that cod has distinct personalities, some are introverts while other extroverts, making the extroverted fish more exposed to being caught. Over time this disturbes the fish stock leaving only introverted cod left in the ocean!

When discussing the potential of Unmanned Surface Vehicles they were immediately positive, knowing that several of their colleagues are already exploring this way of doing less tedious work.

Some of their routine measurements across Skagerrak missions include:
Nutrients, Oxygen, Salt, Temperature, Depth as well as visual observations using cameras.

To gather ocean data they use a combination of hi-tech instruments (Like automated gene sequencing of plancton) and "primitive" methods that just work like simple plastic tubes, gaffatape and old wooden boats.

> ***Much of the basis and what we spend most time on is mapping and surveillance.***
> ***There is a lot of routine gathering of data.***
>
> ***"These types of measurements is a basis that is done from all (research) boats. Temperature governs so much in nature, nutrients says something about primary production in the oceans, oxygen about how water is cycled in fjords etc. To have this automated, you would have laid "the golden egg".***
>
> - Sigurd Heiberg and Petter Baardsen (Havforskningsinstituttet)

Marine research workplaces

This is the typical workstation on the vessel G.M. Dannevig when doing a longer research mission in the field. This is not a glamorous workplace, and there might not be space for a fancy multiscreen setup in here. They have one separate computer for plotting waypoint to perform measurements for the upcoming mission using an older software called OLEX. The waypoints are transferred on an USB-key to the captain who then imports the waypoints into his ECDIS to plan the actual mission.

The OLEX interface with points to perform measurements are marked as small yellow squares. They are almost invisible against the intense yellow color of land.

Down below is the waterlab where routine measurements are taken by lowering a device holding an array of tubes that opens at different depths. The tubes collect water samples from the different depths and are analysed for nutrients, pH level, salinity and oxygen levels within 24 hours.

Printed plans and notetaking is still a common way to work.

A research team from HI is expensive.
To have automated processes, data collection and more effective routine missions is time and cost saving, and for much of the data collection to be as objective as possible. We'd rather not have peoples subjective ways of doing things.

Therefore it is ideal to use autonomous robots...

- Sigurd Heiberg (Havforskningsinstituttet)

The right tools for the right job. big is not always better. A lot of the research that I have done in the coast, in the fjords, doesn't work with the big ships.

- Sigurd Heiberg (Havforskningsinstituttet)

After my tour of the workplaces and discussions with Sigurd and Petter I realized that there is a potential in making their workflow more seamless. The time they spend every year doing routine measurements could possibly be done more efficiently and cheaper by using USVs. Many of the sensors used to analyse water samples are small and could fit into a "submersible sample collector" already used on Maritime Robotics' Otter USV. In addition they could collect more data by using the AI fish counting technology. Digital geographical map plotters is also a tool they have been using for years.


G.M. DANNEVIG
ARENDAL
MARIN

INTERFACES

My project is about exploring interfaces for autonomous maritime systems. To me that meant looking beyond what is commonly used in maritimes sector. I had already seen ship bridge interfaces in action. By collecting workspaces and screens used for navigation and other complex control systems, I could extract elements and compare, find similarities and oddities that may or may not be suitable for my situation.

On the next pages I will go through some of the ones I found most interesting.

2001 - a space odyssey

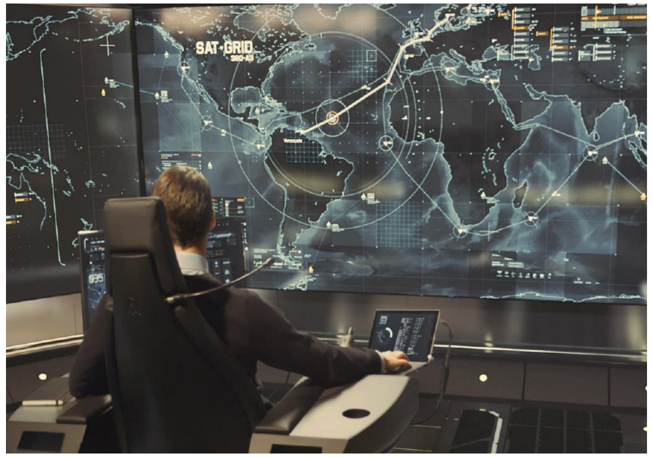
This film is a huge inspiration and a visionary production design and interfaces by Stanley Kubrick and Anthony Masters.
However cool and awesome, this was not the direction I needed to go with my interfaces. Although similar, my work was not intended for space.

Minority report

This gesture based interface often pops up as an example of the future of interaction design. It works impressive on film, but using your arms to point on a vertical surface is actually quite straining for more than a few minutes. Try holdig your arms in the air for the rest of this report, you'll see what I mean.

Oblivion drone control

In this film a fleet of drones are controlled from this huge flat touch-screen. Again, it works well on film but ergonomically, maybe not. I haven't tested it but it seems unnatural to look down on a flat surface and the risk of accidentally touching the wrong button is definitely present.

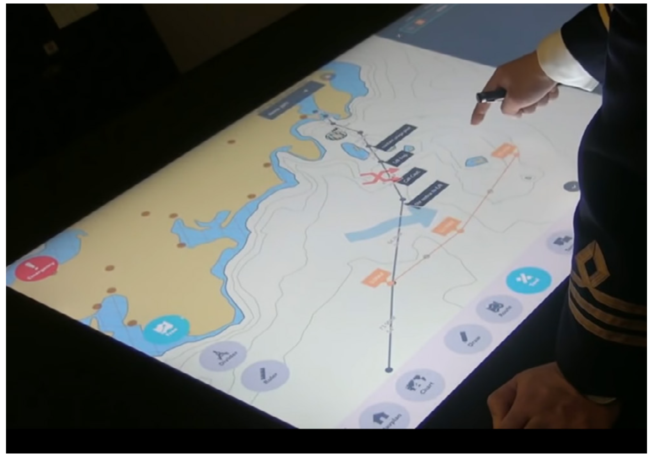


Rolls Royce SCC concept

This is a Shore Control Centre which looks concept which suffers from the same complexity of many film interfaces. In a control room situation

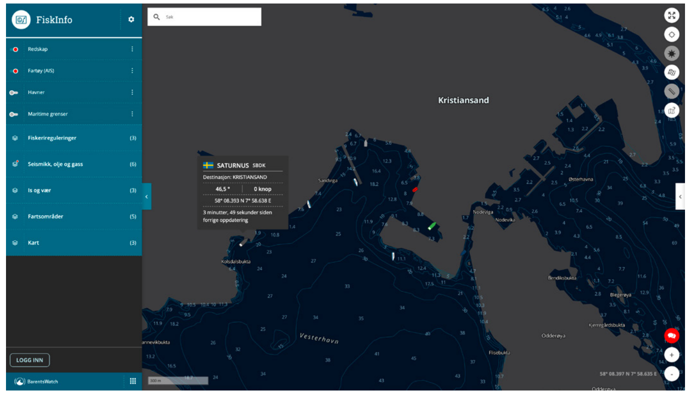
British Royal Navy concept

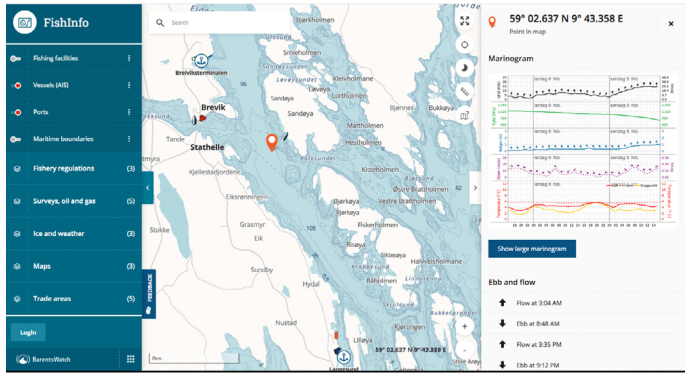
This concept has obviously been inspired by the transparent touch screens of Minority Report. It seems suitable for collaboration setting, like a whiteboard-type interface. Again we have strain on the arms. There is a reason why people are still using keyboards, and laptops are shaped they are.



NeCST concept

This concept is a flat touch screen interface for route planning, like traditional ECDIS and is probably meant to be included in a ship bridge setup.



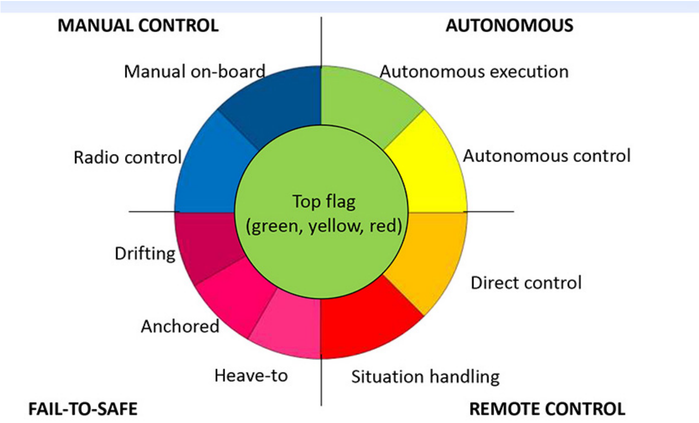


Barentswatch - fiskinfo

This is a well thought through website for displaying ship locations and fishing equipment in realtime.
It has a dark and bright palette and quick and easy info directly from AIS on each vessel you hover. It has the most maps I have seen in any interface like this.

You can even plot in your own routes and get a timeline view of waves and weather forecast for your voyage.

source: barentswatch.no/fiskinfo

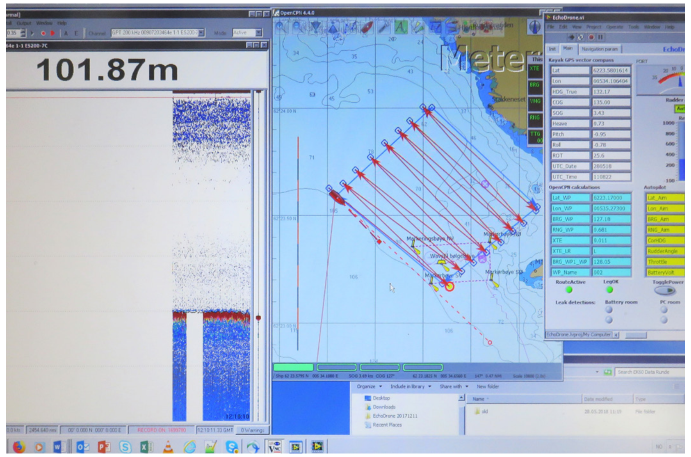


MUNIN SCC concept

A reseach project by Chalmers and Kongsberg often referred to in the report “Situation Awareness in Remote Operation of Autonomous Ships” A.E. Ottesen (2009).

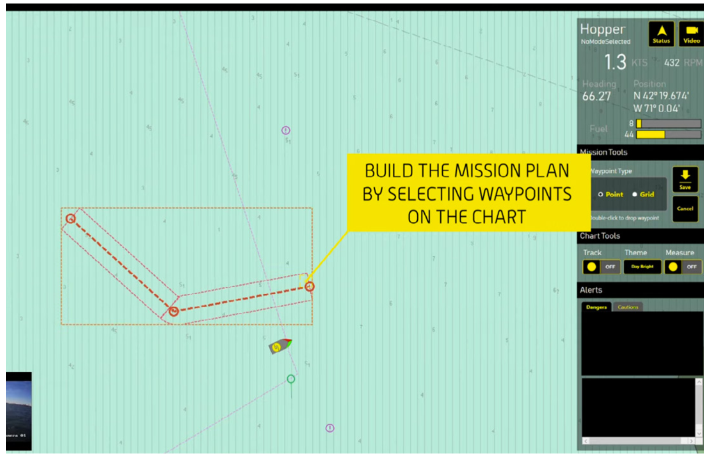
Some interesting theories are the practical use of timelines for missions, and specific color codes for modes of operation. This is intended for cargo ships and requires a setup of 7 screens.

Source: unmanned-ship.org



SIMRAD Drone software

This is the software used for the DIY project kayakdrone. It looks like something out of Windows 95, but the combination of mission planning tool and sonar data recording feature is something I want to implement in my solution.



Sea-Machines

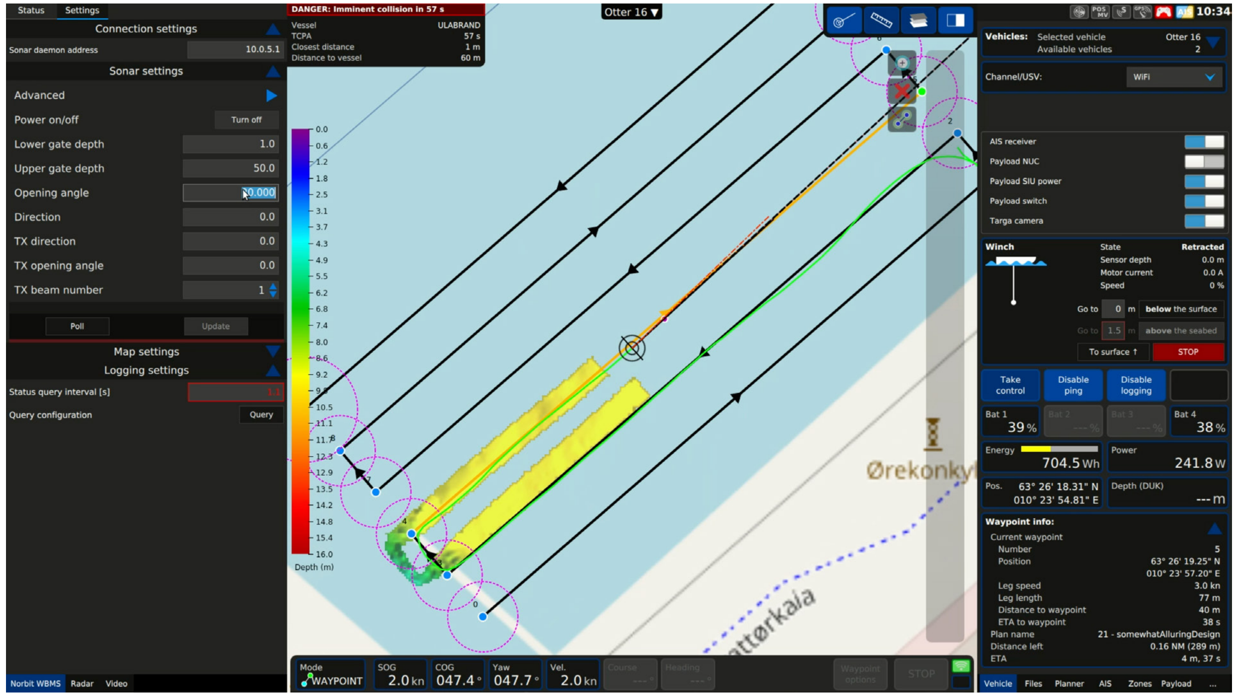
Their own mission planning software with a visual drawing tool. Interesting palette though.

Source: sea-machines.com

Maritime Robotics

They have developed their own control software and it has some untiutive functions like the rotating compass for courese change when their USVs are in "direct control" mode. They also have a joystick control app, where you can stear the small "Otter" USV with your thumb.

Their interface has a mode control section on the bottom of the screen for choosing the mode of operation: Standby, Station, Course, Heading, Waypoint and Formation as well as SOG (Speed Over Ground), COG (Course over ground), Yaw (moving from side to side) , Velocity (rate of speed change, and Course (direction), as well as a start and stop button.



On the Right is a Status window with fuel level, GPS coordinates, and several functions that does not apply to the smaller electric USVs. I never got the chance to test their software but it seems to be well fitted for their use, which is mostly controlling one USV at a time, or in the case of several, by running in formation.

One of the key applications for their USVs is bathymetry mapping, which is a 3D sonar mapping of the sea floor using side scanning sonars t. The result is "painted" directly onto the map using a gradient to visualise depth differences, which seems to work very well.

For my project it was important to explore problems and possibilities that they aren't already solving.

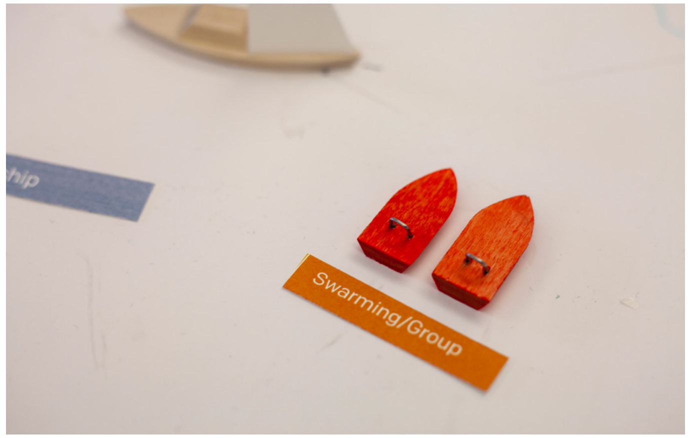
Therefore I am not focusing on trying to redesign their current software (EGGS Design has already done that) but to zoom out, in order to create something new.

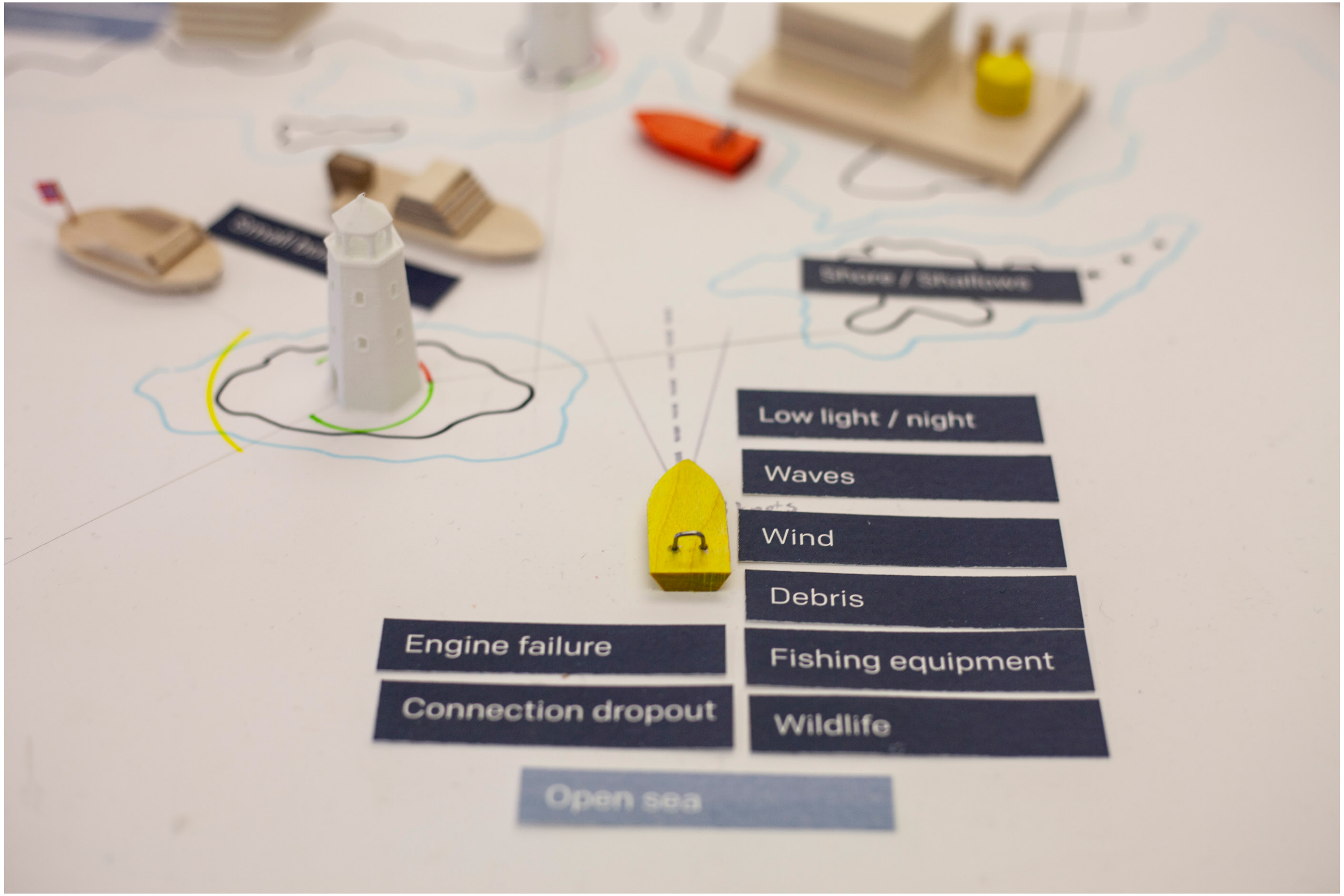
INTERFACE MAPPING

After my initial research, I printed cards of interfaces used in USV autonomous sytems, control centres, conceptual workstations. I sorted what I could to find similarities that I could take further. Common features includes: Maps and visual chart plotting tools, timelines for mission plans, instruments for weather and ship status.

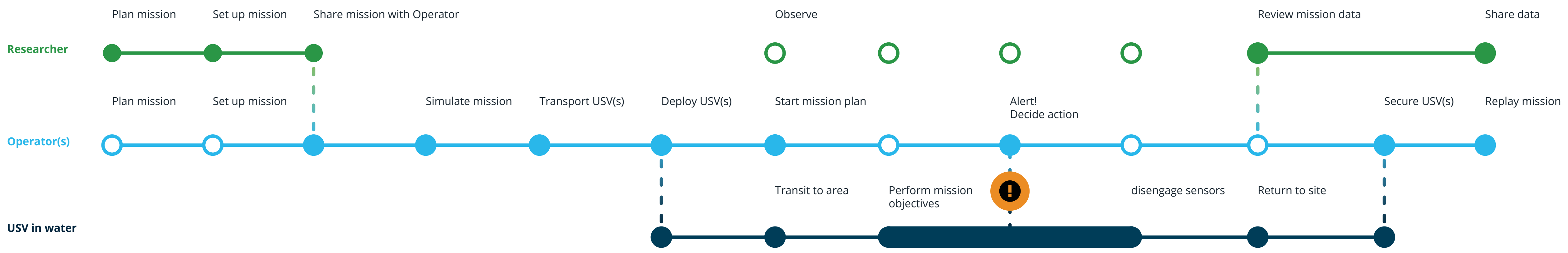
SPATIAL SCENARIO MAPPING

As part of the analysis i made my own excersise often used in service design and strategic planning. By using small models and a large map mockup I could spatially map actors, functions and risks in potential situations that could be interresting to explore further. It also gave me a different way to visualise how it could look on a screen interface.





Example of complete mission interactions by involving 2 users



Functions and use cases

Listening to the people I've met, looking at their work-tools, anlysing current systems, and by mapping excercises I ended up with with a set of key main functions that needed to be included in the system.

Function analysis 1

Users

MARINE RESEARCHERS

OPERATORS AND OWNERS

Communication

NEEDS	←	Science data	Mission execution ←	SKILLS
GOALS	→	Mission objectives	Live information →	TOOLS

Workplaces

RESEARCH STATION

AT SEA

ON THE BEACH

SHORE CONTROL CENTRE

IN THE FIELD

FROM HOME

Functions & Spectrum of control

MAP WAYPOINTS

TIMELINES

SENSOR DATA AND SHARING

CAPTURED MEDIA

FLEET CONTROL OVERVIEW

DETAILED STATUS & ALERTS

DIRECT CONTROL

TIMELINES AND REPLAY

Function analysis 2

Secondly I grouped the functions and information needed into 2 axis, X axis for time, Y axis for level of abstraction. These could them be grouped into sections of an interface. These sections could be separate screens in a multiscreen setup, or grouped applications within a scaled down version, like tablet.

Modularity

This grouping of functions implies that the interface should be modular to fit the different users hardware. The OpenBridge library of components is already built with responsiveness in mind and would therefore support this.

LOW ABSTRACION

FUTURE-PAST — NOW

HIGH ABSTRACION

Map section

Mission planning
Ships and Mission overview
ECDIS & AIS info
Map layers (Radar, Satellite)

Live view

Cameras (if available)
3D simulation
Alternate map view
Direct control

Timeline section

Linear mission view
Sensor data
Captured media (video & photos)
Weather (history and forecast)

Detailed status section

Detailed USV status
Conning instruments
Connection quality
Weather

SCOPE

Based on the insight from phase 2 I learned a lot and discovered very different needs for the potential users of a autonomous system. Researchers need different interface elements and don't necessary want to own and control all aspects of a USV. Owners and expert operators however might need to know much more detailed information on a fleet of USVs. After my first midterm review I decided use my remaining time to explore a primary and secondary focus.

Primary focus

MISSION PLANNING

FLEET CONTROL OF MULTIPLE VESSELS

SHARING MISSION TIMELINES

MULTISCREEN SETUP

Secondary focus

PHYSICAL WORKSPACES

ALARMS (AUDIO AND VISUAL)

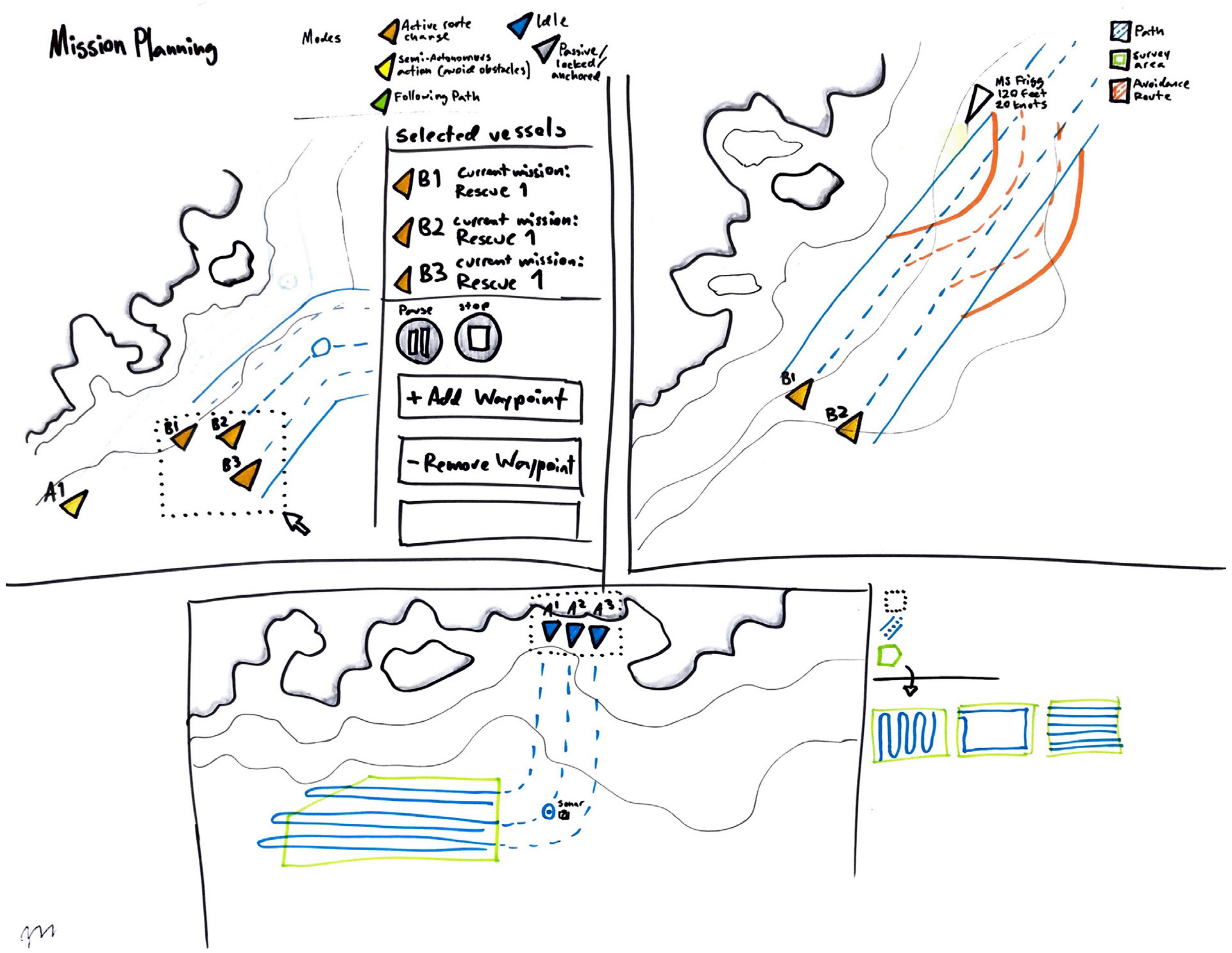
SCALED DOWN MOBILE VERSION

3 DEVELOPMENT

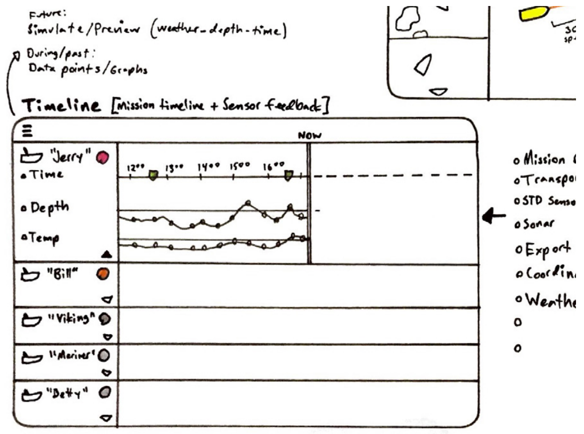
I had already done quite a bit of paper sketching early on, so I had several ideas of where to go, but going from paper to digital doubles the amount of time just to test quick ideas. I kept sketching on paper throughout the entire project.

Early sketches

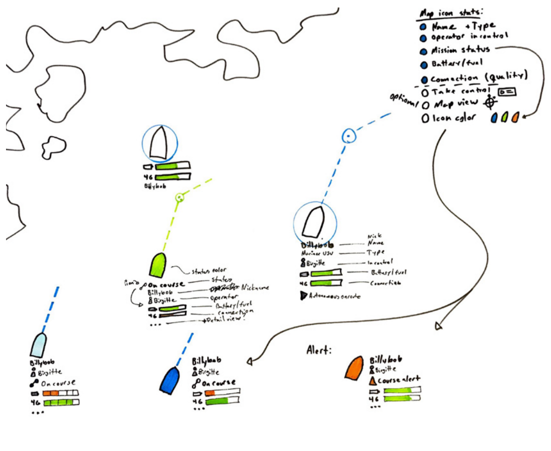
I started sketching on paper early on, with the knowledge I had about existing systems and a with a bit of interaction principles from strategy games. There are many similarities between the two. In this sketch I was exploring how you could see your fleet of USVs in a “mission planning” view.



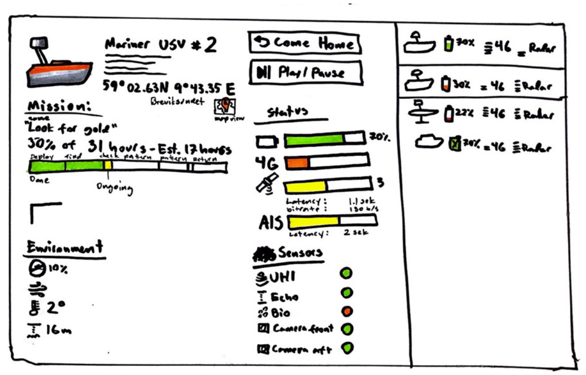
In this sketch I looked into how colored symbols could be used to show the status of a vessel in a map view



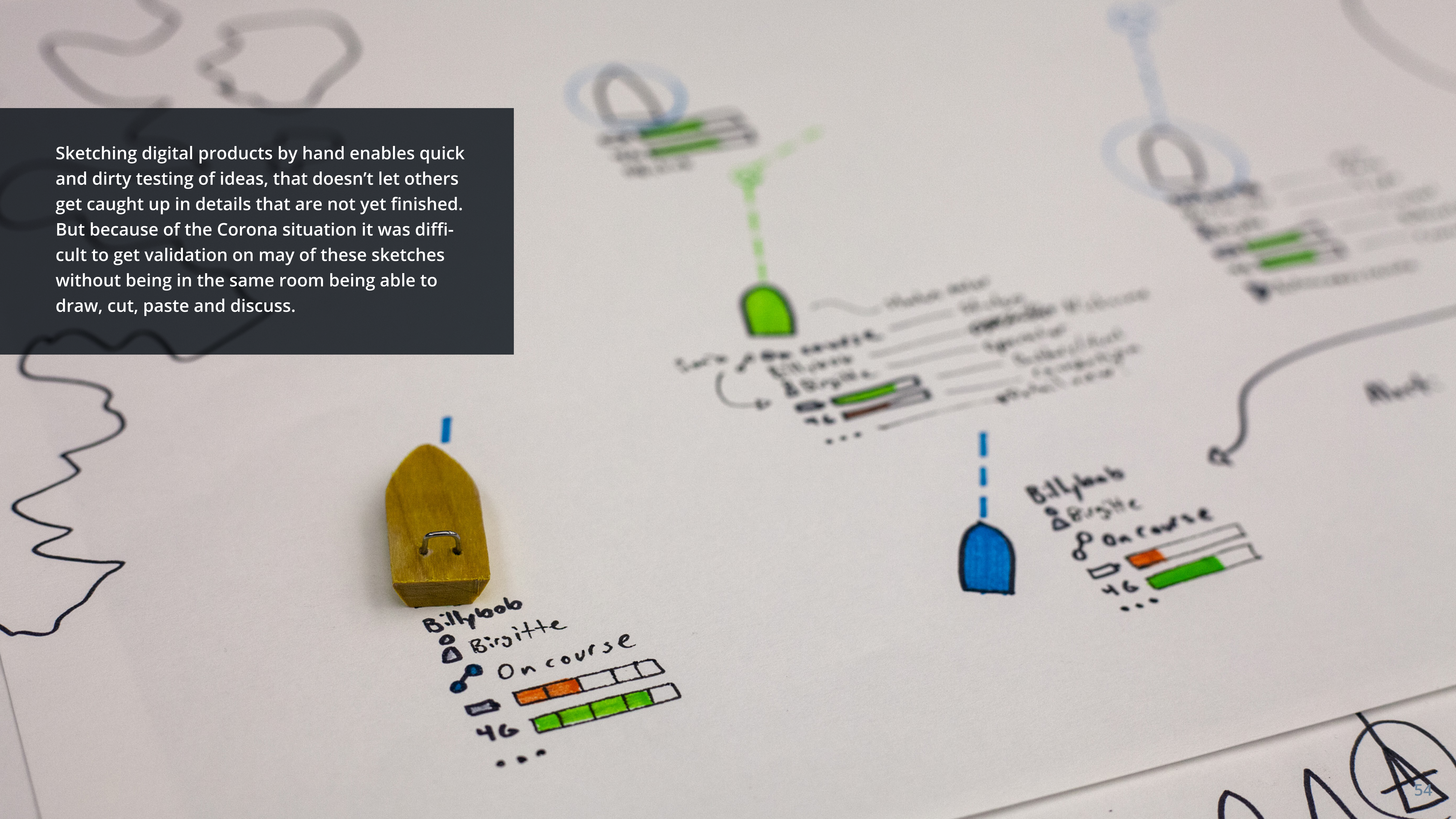
Quick and dirty timeline section sketch for 5 individual USVs.



Here I was exploring the use of contextualized text and bars to indicate name, operator, battery status and network status.



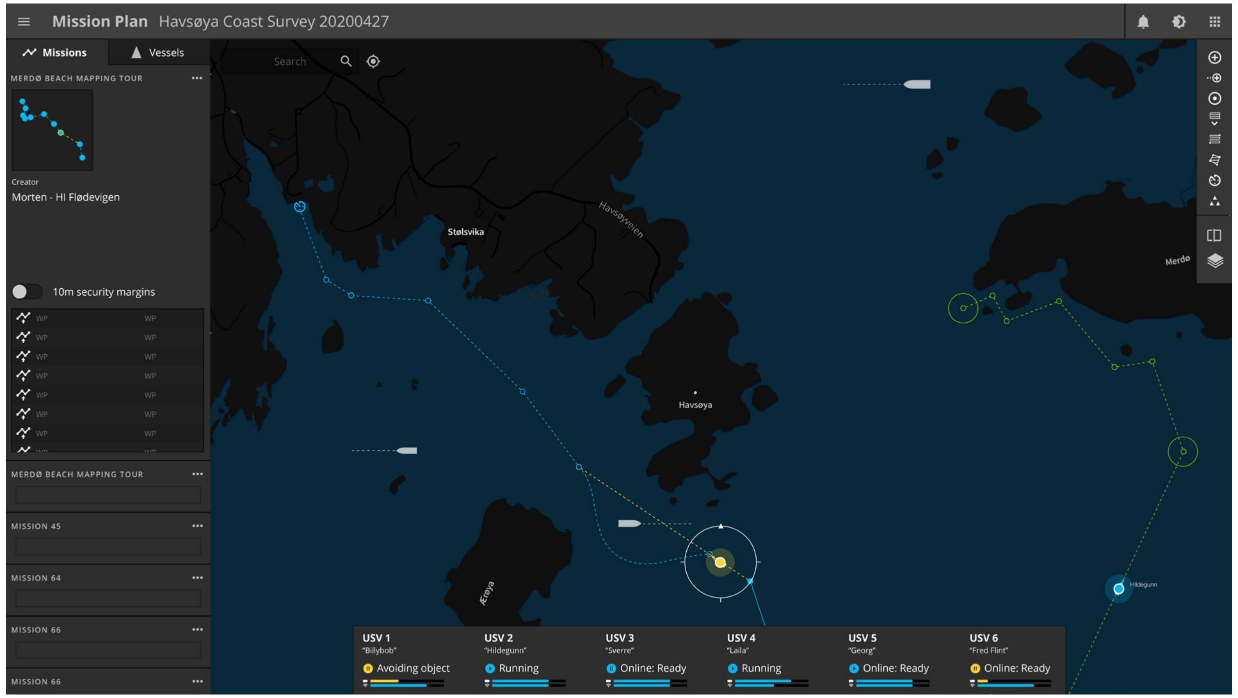
Here I am testing out various ways to visualise the current information of a mission in progress.

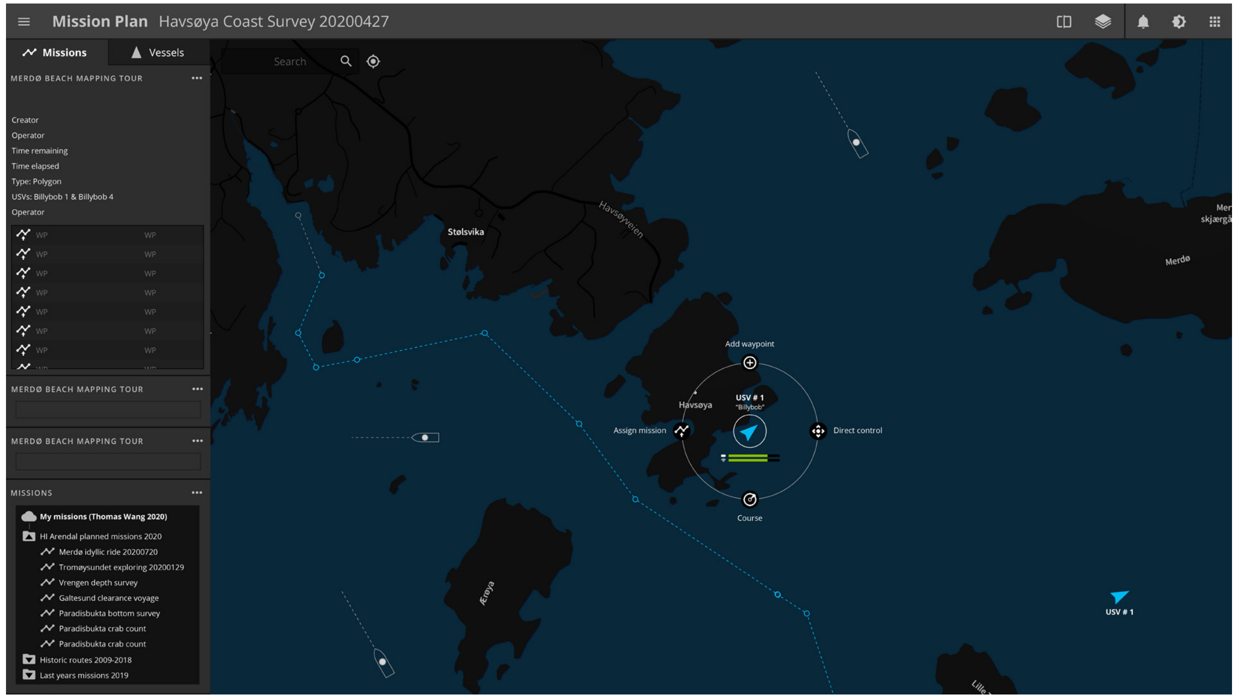


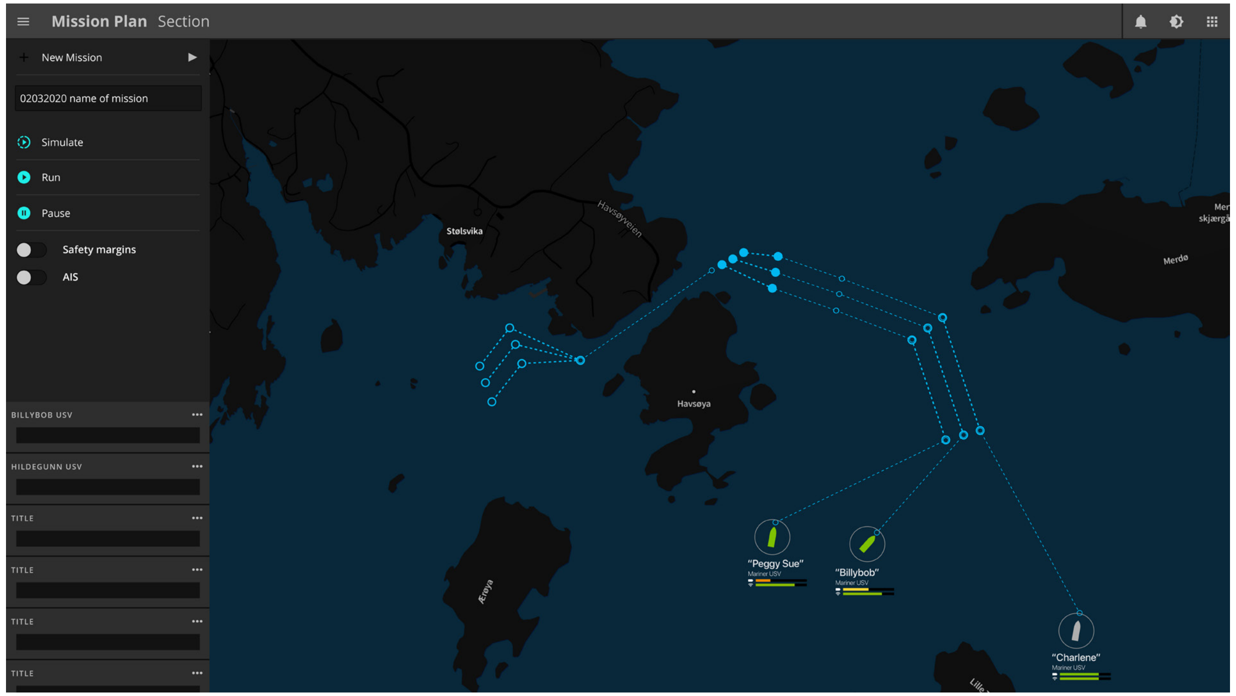
Sketching digital products by hand enables quick and dirty testing of ideas, that doesn't let others get caught up in details that are not yet finished. But because of the Corona situation it was difficult to get validation on may of these sketches without being in the same room being able to draw, cut, paste and discuss.

-Planning
-Simulation
-Realtime
Past Review
Export data
Often
Switch between vessels
Future Planning
Seldom
Rare
Active (selected) vessels
Live Camera view OR simulation
Alt. Big Screen (shared)
Collision alert:
time
Selected or Most important vessel
Other Vessels
Single vessel select
Vessel box
Multiple vessel select

Early digital sketches







WORKING WITH MAPS

Maps are complex visual representations of the real world and could have been a diploma project on its own. Well structured maps with focus on just the right data can be beatiful pieces of graphic design.

Almost all forms of navigation systems as based around are maps. 2D maps, both analog and digital are something we are all familiar with, from Google maps, games, to weather forecasts, and paper maps for those of us who grew up in the era before iPhones.
It was obvious that I had to spend quite a bit of time working with maps in this project.
I have looked into several digital maritime map systems used for both navigation, plotting and
Electronic Chart Display (ECDIS) interfaces and similar interfaces use vector maps with optional layers.

The purpose of most maps is to give as accurate information about the world as possible. However, too much information can cause information overload and lead to wrong conclusion in critical situations.

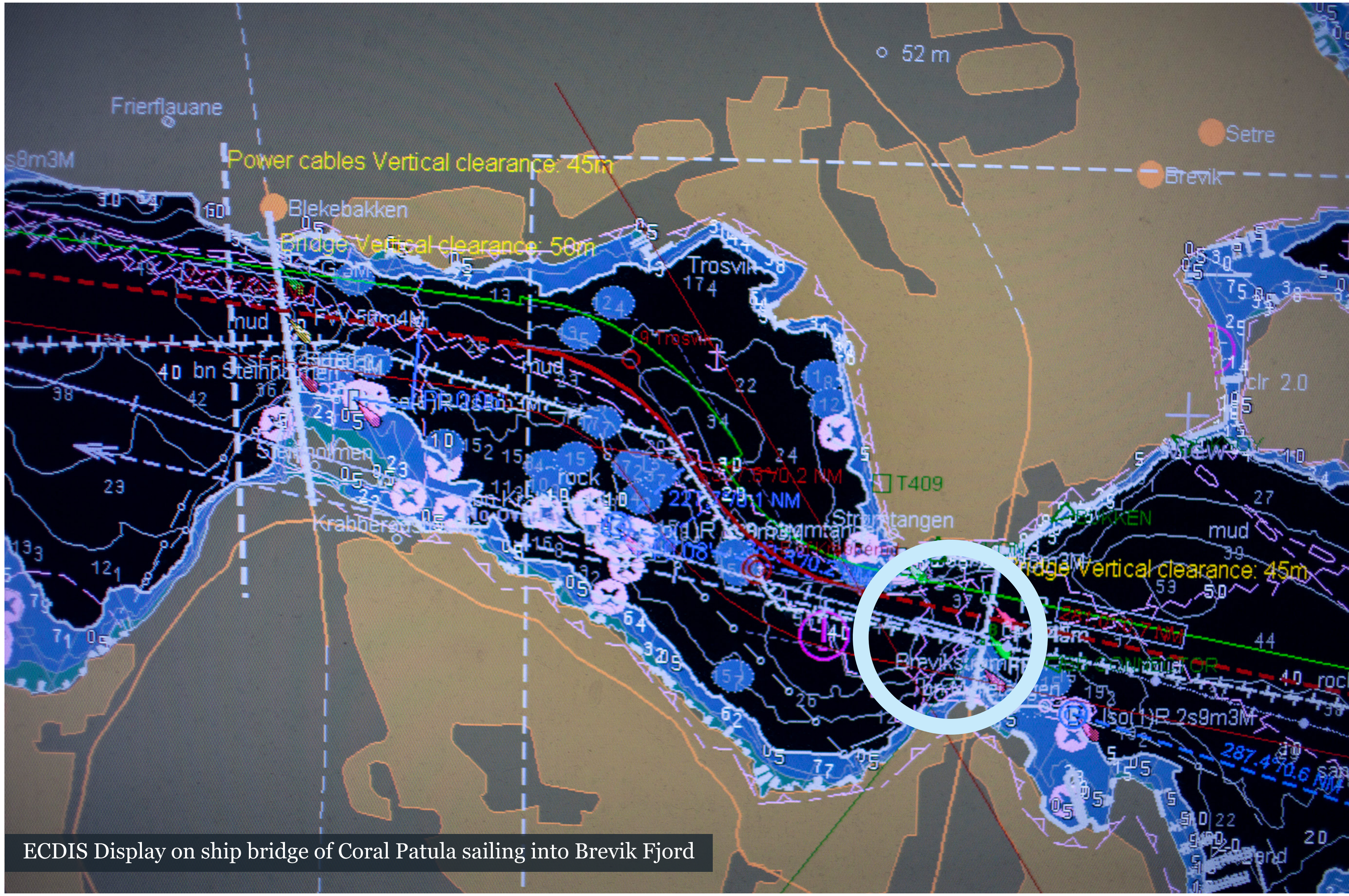
> ***We envision information in order to reason about, communicate, document and preserve that knowledge - activities nearly always carried out in two-dimensional paper and computer screen. Escaping this flatland and enriching the density of data displays are the essential task of information design.***
>
> ***Too many data presentations, alas, seek to attract and divert attention by means of display apparatus and ornament. Chartjunk has come to corrupt all sorts of information exhibits and computer interfaces, just like the "ducks" of modern architecture.***
>
> Source: Edward Tufte - Envisioning information (1990)
>
> Click here to see what Tufte means with the "ducks" of modern architetcure

ECDIS

One of the main takeaways from my field study with Lostjenesten supports what Edward Tufte is talking about. The ECDIS displays on 2 of the ships had similar problems. All overlay settings were turned on, leading to important information being lost. In this example it is almost impossible to see the location of your own ship, because of too much information and contrast. I have put a circle around the "own ship" symbol which is a white outline of the ship. This is a narrow fjord with several bridges, powerlines and harbours. Other places with less infrastructure would produce a less cluttered image.

In a online meeting with Henrik Lenes from Maritime Robotics we starting talking about ECDIS displays and I showed him the ones I had seen:

> ***These kinds of maps would be totally useless for us that navigate mostly in narrow and shallow areas.***
>
> Quote: Henrik Lenes (Maritime Robotics)



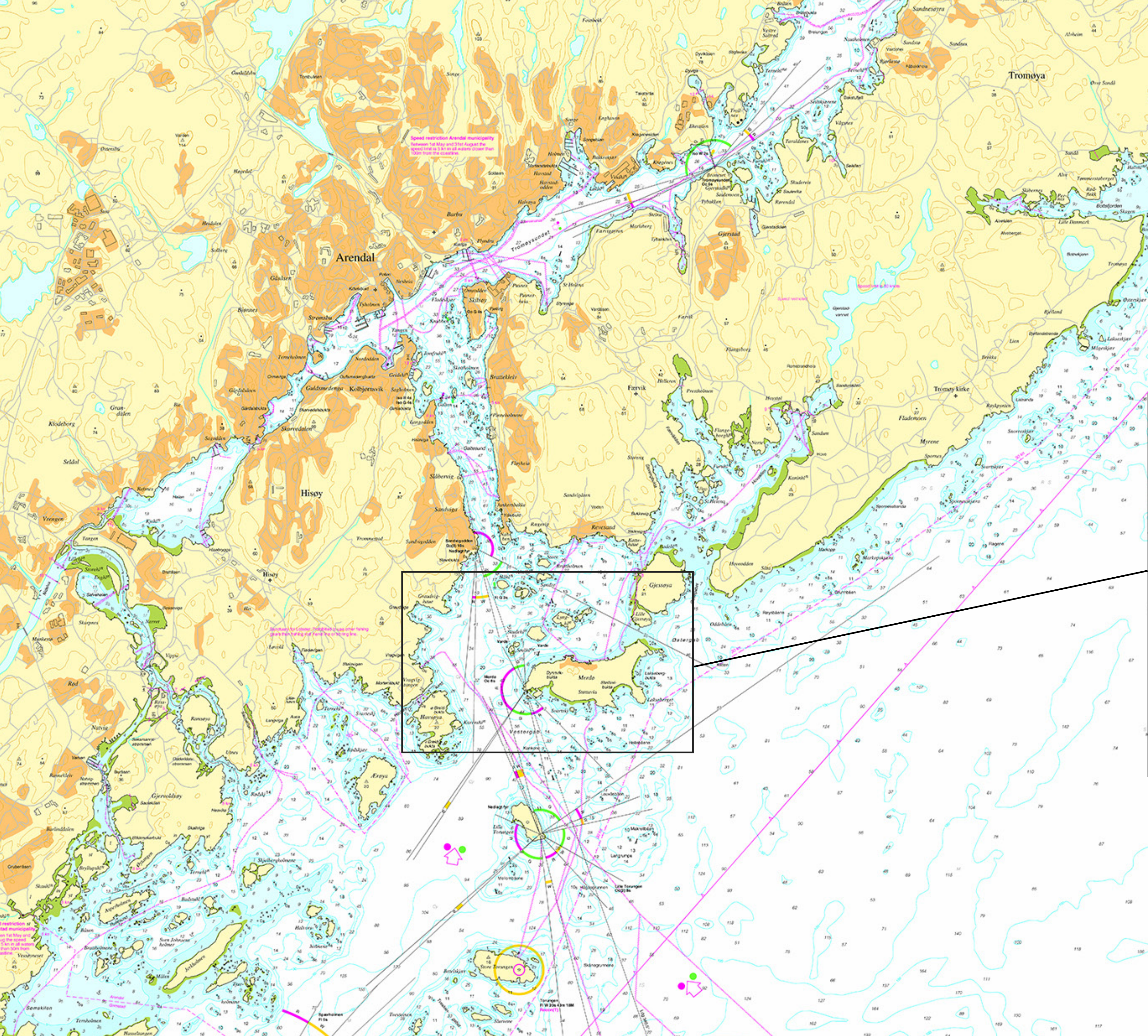
ECDIS Display on ship bridge of Coral Patula sailing into Brevik Fjord

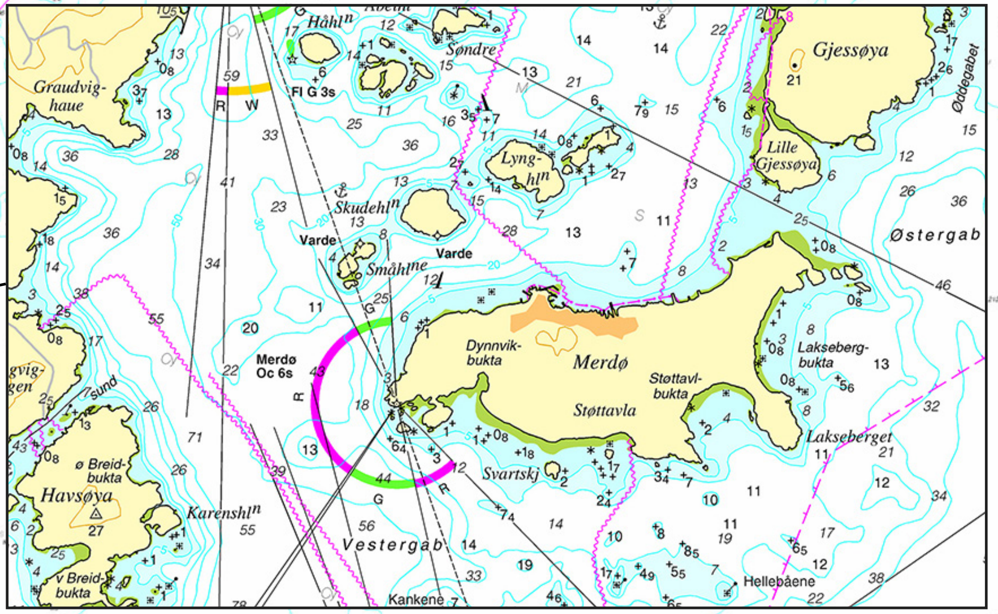
Tried and tested static maritime maps have a clear distinction between land and water, difference in water depth contours, and information useful when navigating at sea.
Problems arise when there is a need to display additional dynamic information on top of these maps like routes, ships, warnings, UI elements, notes etc.

I started out signing up with the vector map service Mapbox, used by major services today like Lonely Planet, Facebook, the Financial Times, The Weather Channel and Snapchat.
It made it possible to edit, style and scale the different elements of a maps, as well as text labels, satellite imagery, custom datasets like coordinates and vector shapes. The majority of services using Mapbox are land based, so there is obviously a great majority of features available for use on land.
The fact that the situation I was designing for happens to be on water meant that some important information like water depth wasn't available through the map box interface.

So, I gained access to Kartverket's database and downloaded high resolution geotagged maritime maps of the norwegian coastline. These maps are beautiful on it's own and is rich with information, but are designed for static situations, not for dynamic digital services were UI overlays and are needed.

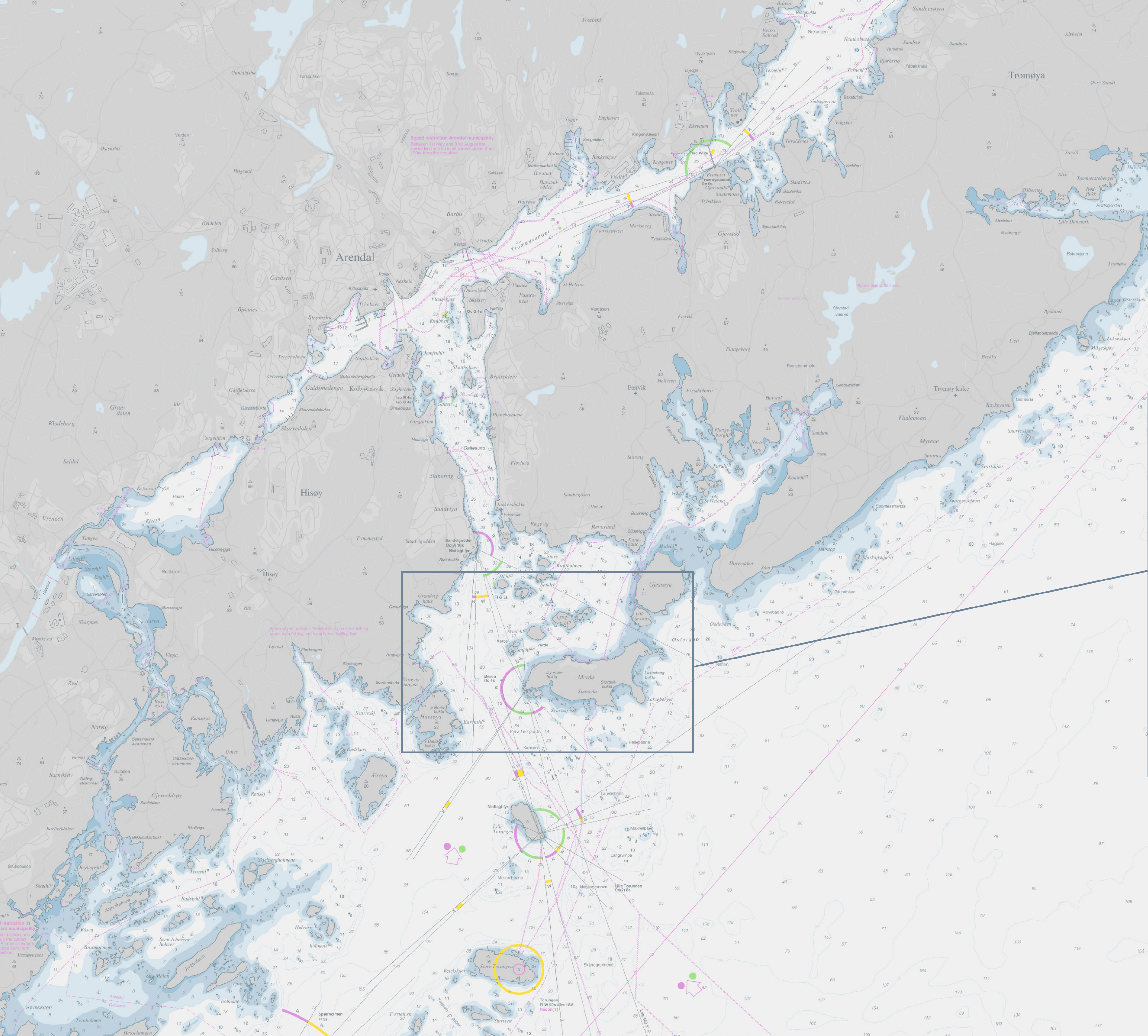
By adjusting the available colours in the maps I could explore variations in more subtle palettes suitable for displaying an additional layer of information as well as variations for the day and dusk mode.
I printed a variation of these maps and tested combinations with "paper USV symbols" to see what color combinations worked best for a dark and a bright palette.

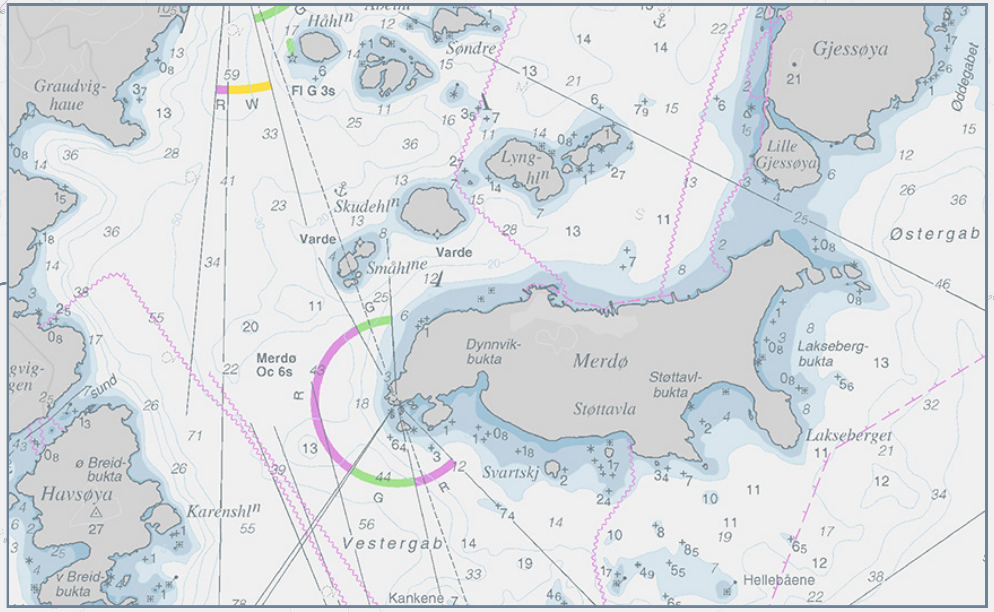




Original map from Kartverket

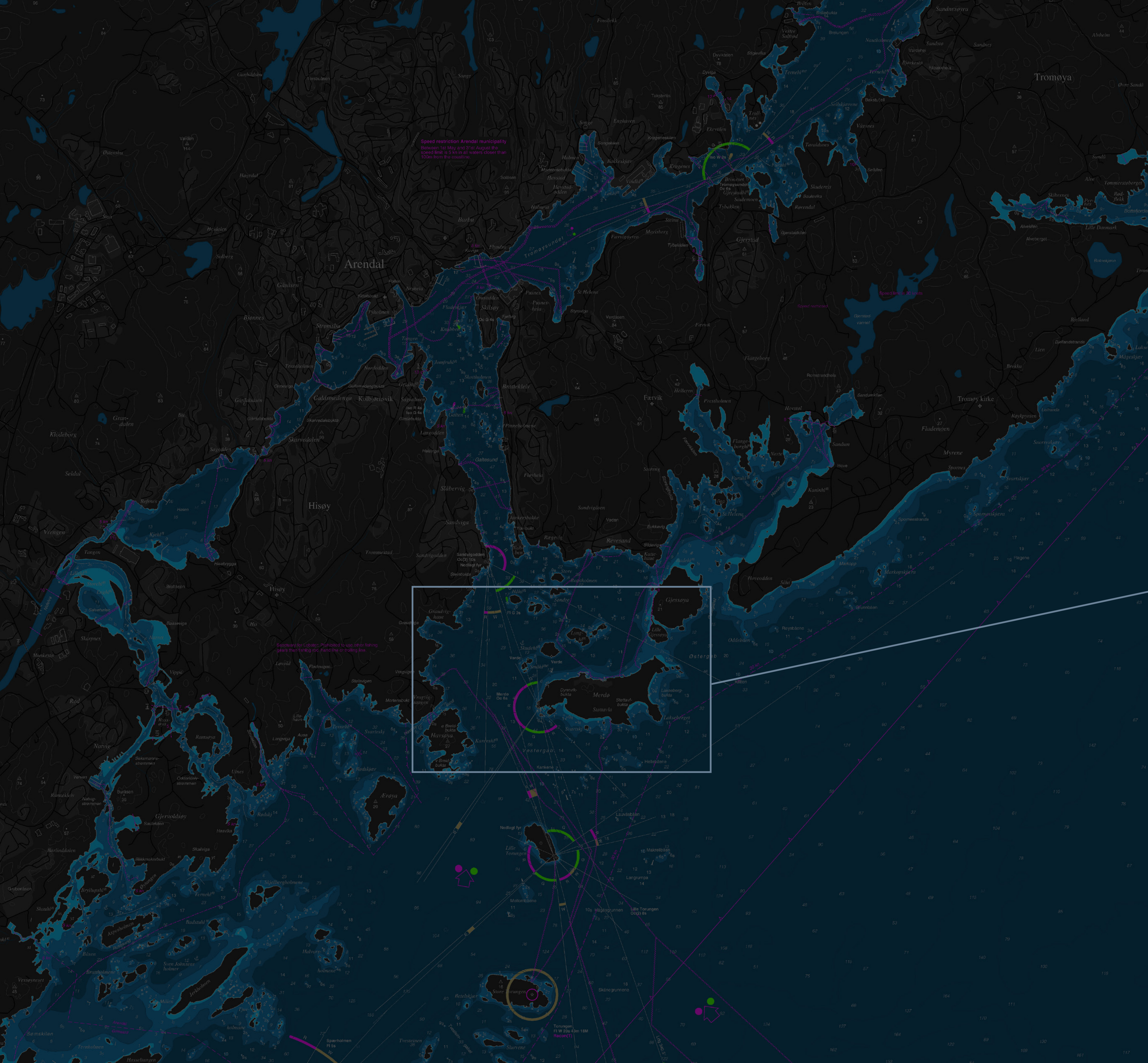
Bright contrast and intense colors against a white background are great for navigation referencing but maybe not for digital interfaces that require several layers of information on top. This text is not exactly easy to read even though this particular area has little background information.





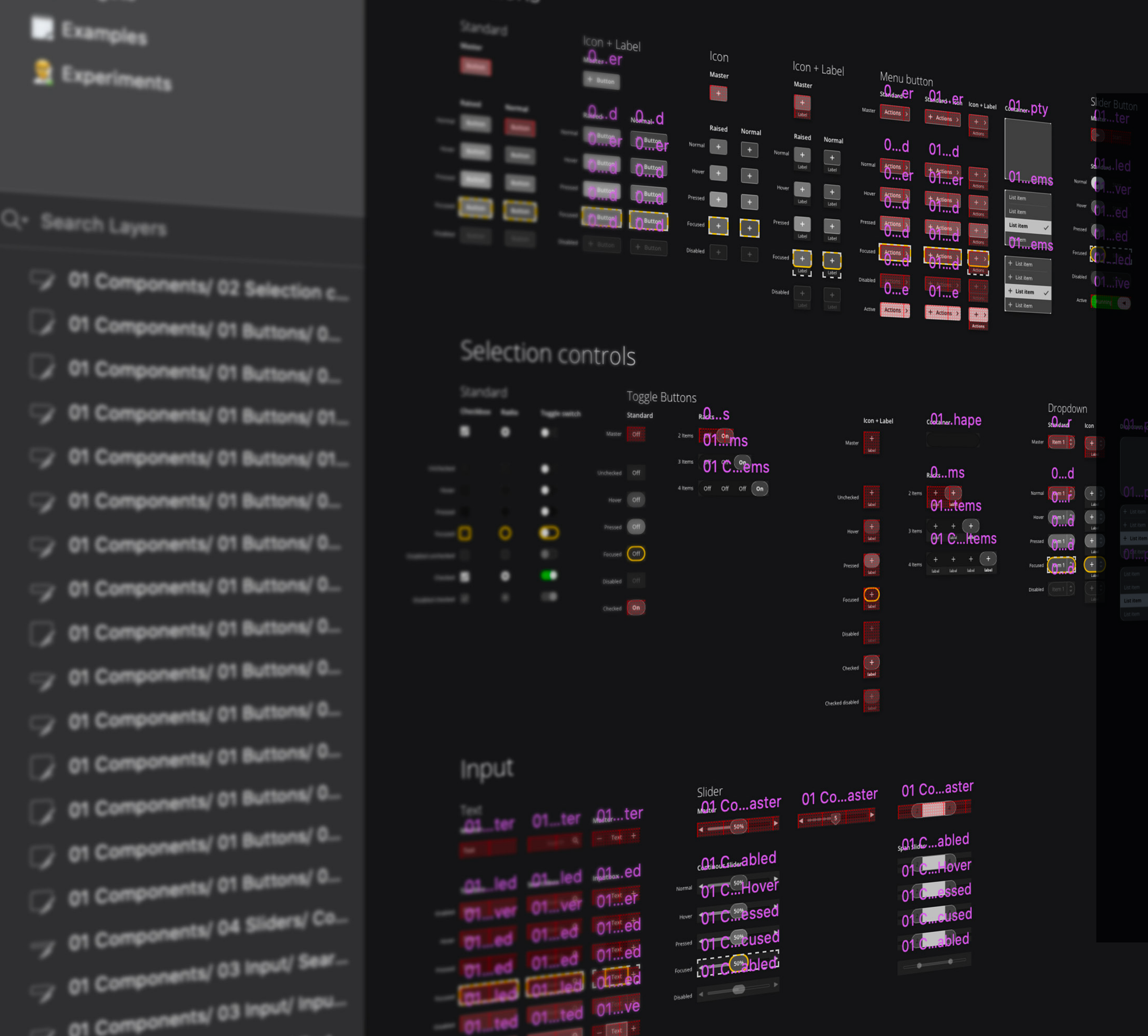
Edited map for bright mode

All information is kept but softer contrast makes additional information easier to read. Land mass is less important when voyaging at sea so area names are visible but not in your face all the time.



Edited map for dark mode

A mellow dark blue tone for water with slightly brighter hues for shallow water makes overlays more visible while keeping the information like depth and, shipping lanes and landmarks visible without being intrusive.



Working with the OpenBridge design system

When finally “going digital” the intention was always to use the OpenBridge design system as a base for my interfaces. Not having to build every icon, button, menus and other generic element from scratch meant that I could focus on the more intricate parts of my delivery.

I was given a set of Sketch libraries with the basic interface components in 4 different palettes. In short the library consists of:

- Palettes : Bright / Day / Dusk / Night mode
- UI components : checkboxes, sliders, menus, toggle switches, windows
- Maritime components : Compass, rudder, thruster display
- Typography
- Icons from google material design
- Alert center components

Although this might seems complete to build a ton of stuff, I ended up dismantling many of the components in order to build my own library of components.

All of my designs are using the Dusk palette. The users of my system would need to switch between a bright and dark palette. Norway has long dark winters and bright summers. Since I have a tendency to work late, I chose the Dusk palette for my designs. The examples from OpenBridge shown here are all in the Day palette.

OpenBridge
Design Guideline

- About
- Getting started
- Regulations

- User interface patterns
  - Application
  - Widgets
  - Settings
  - Vendor menu

- Palette
  - Typography
  - Colors
  - Styles

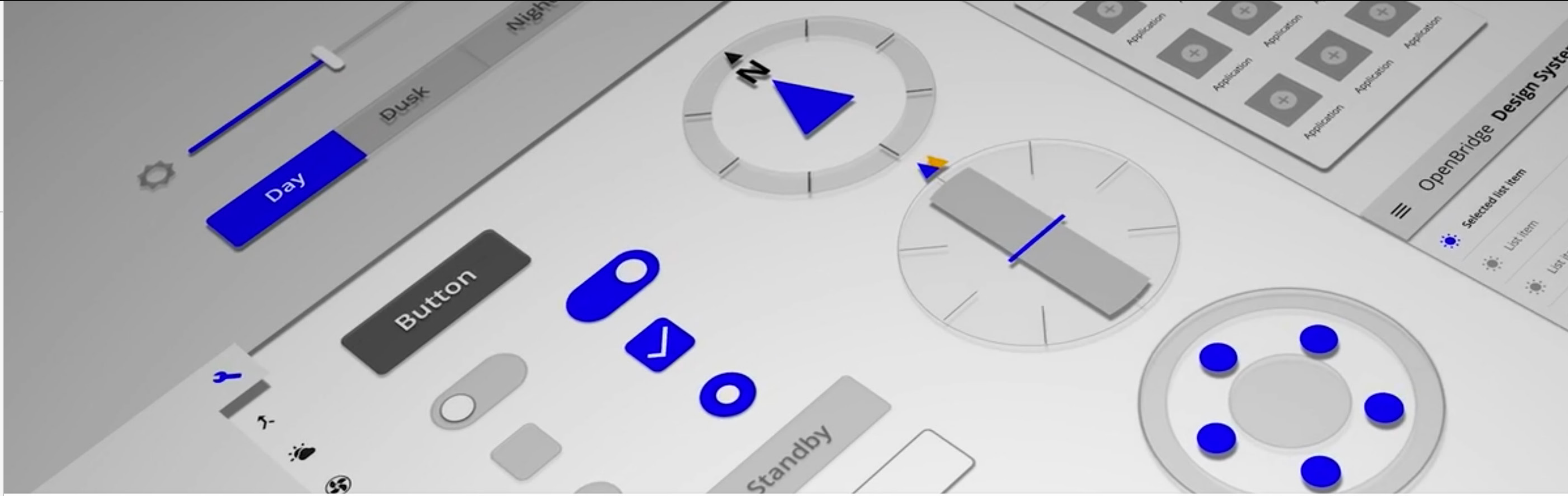
- Components
  - UI components
  - Navigation components
  - Alert components
  - Maritime components
  - Request component

- Icons

- Sizing

- Case studies

- Downloads
- Develop
- Publications



OpenBridge
Design Guideline

A free resource for design of safe, user friendly and modern maritime workplaces.

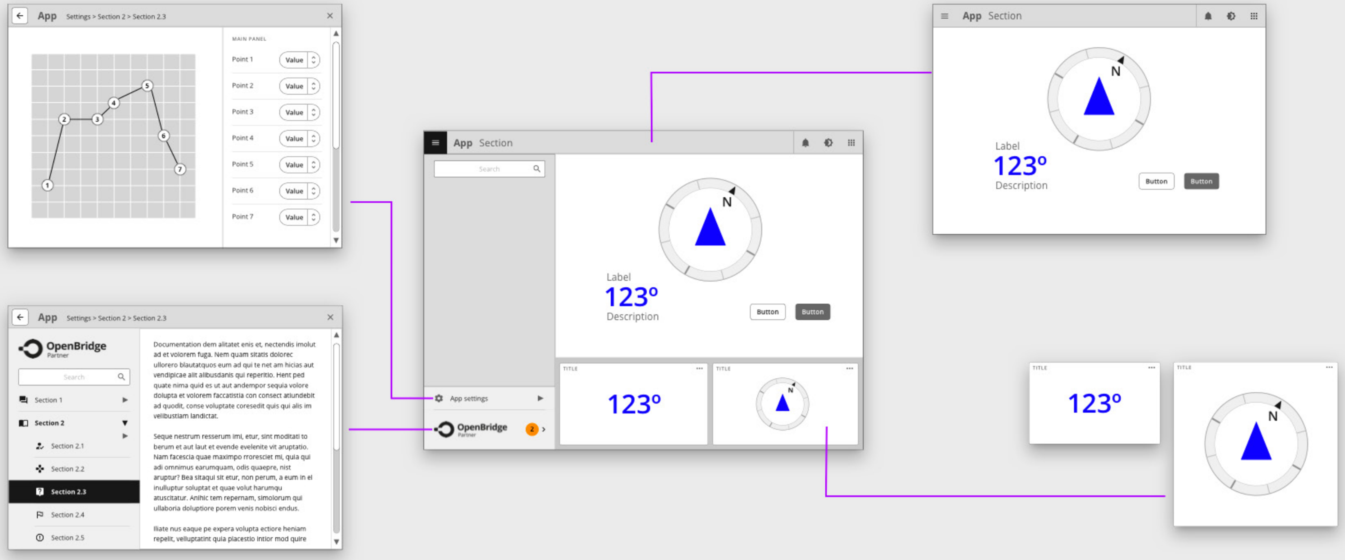
Get started | **Latest updates**

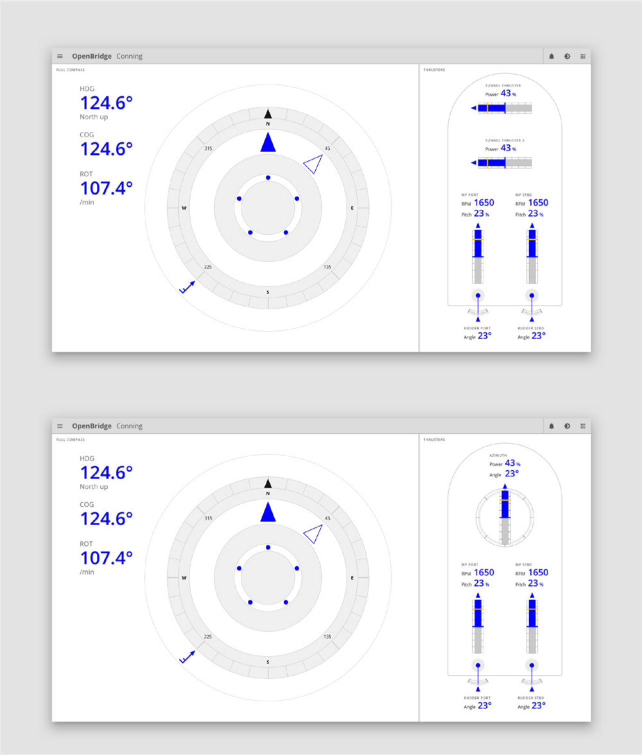
OpenBridge Design System offer a collection of tools and approaches to improve implementation, design and approval of maritime workplaces and equipment. OpenBridge Design Guideline is a prominent part of OpenBridge Design System that explains how to design OpenBridge user interfaces.

It is a free resource built on modern principles of user interface and workplace design, adapted to maritime context and regulations.

Openbridge user interfaces have a uniform structure based on a set of principles and components that allows the structure to scale across screens and distances. The applications layout describe the generic design of all applications and how to embed shared functions such as dimming and alarms into every application.

Source: openbridge-ds.webflow.io





Voyage Anatomy of interfaces

FIXED WIDGET

OpenBridge base UI components in dusk palette for my proposal.

OpenBridge top bar with alert center, Dimming menu and app menu.

Main area container with a fixed widget where main information in each section is displayed. information follows what is selected in the map: a specific mission or a specific USV.

Toolbox: Operational functions like mission drawing tools, map layers, etc.

REUSABLE WIDGET

Reusable widgets that can contain any widget; a list, an instrument, a camera window.

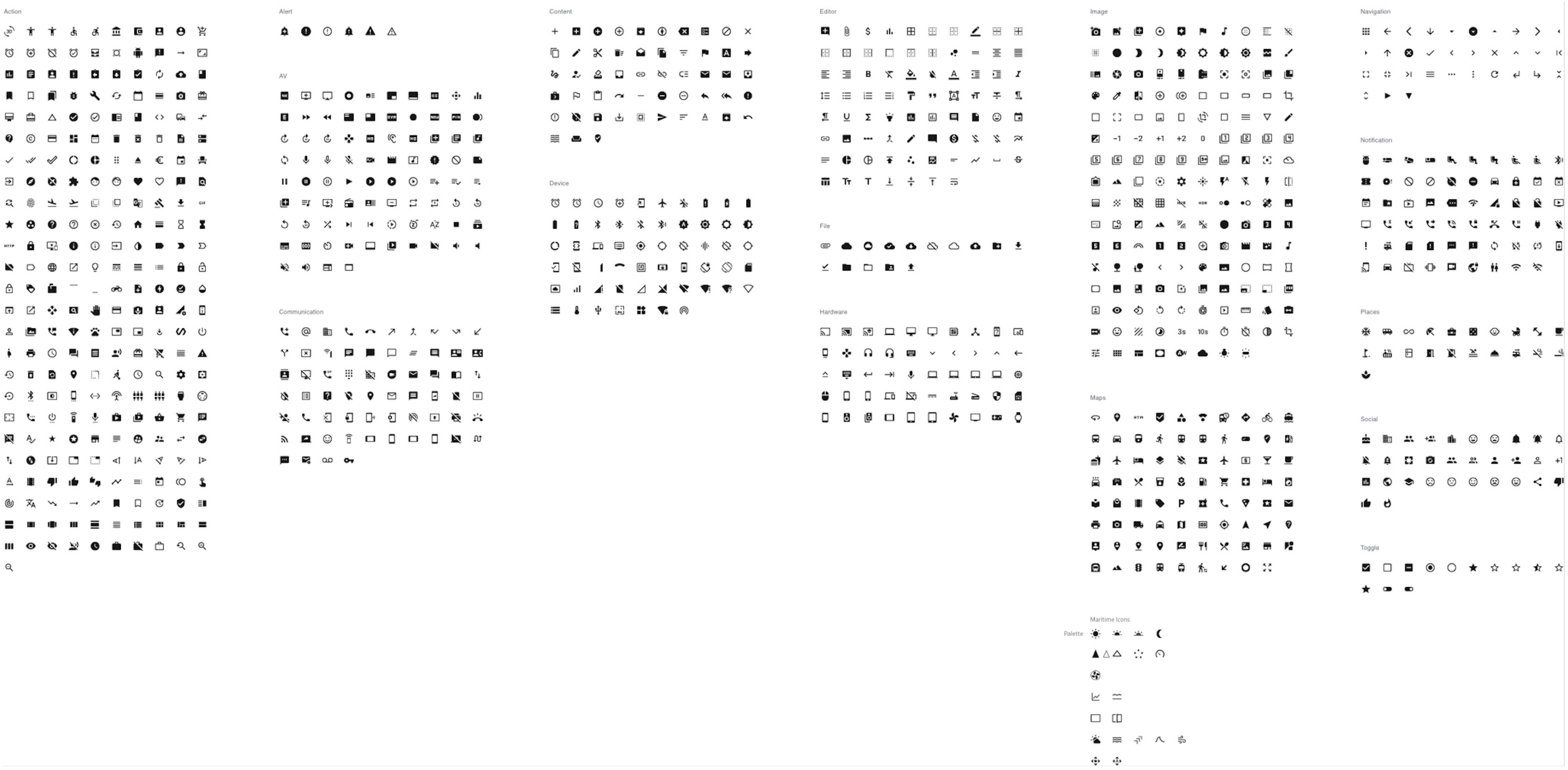
Optional section for timelines or widgets

REUSABLE WIDGET

REUSABLE WIDGET

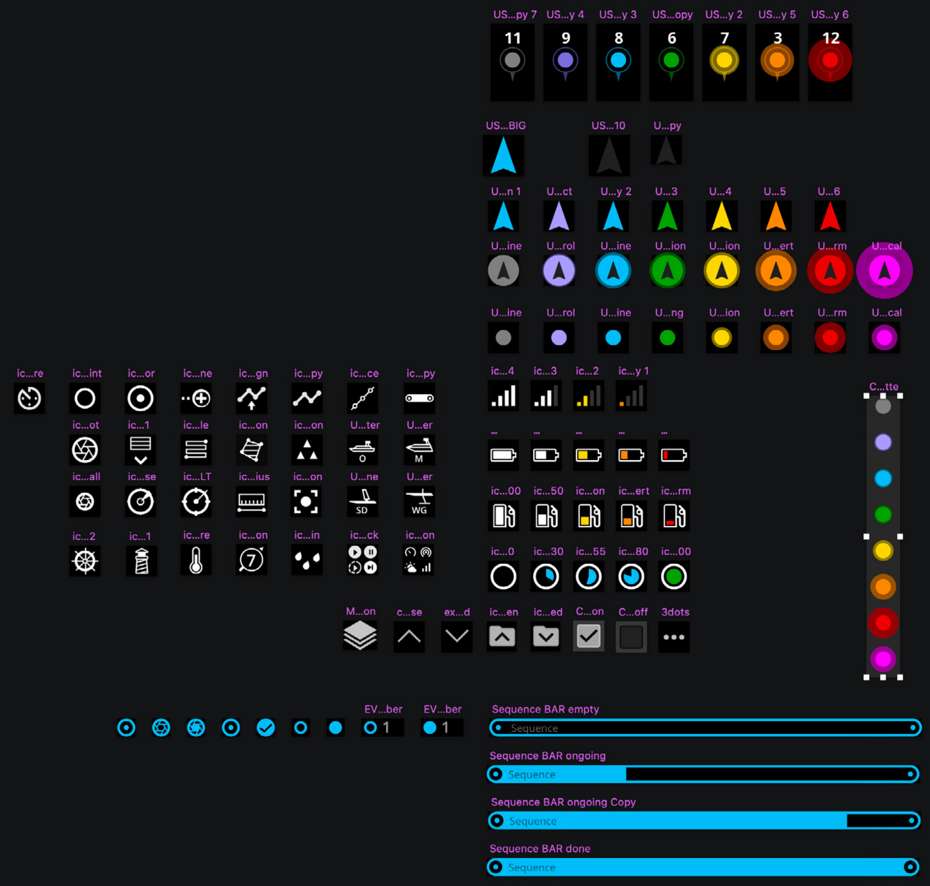
REUSABLE WIDGET

Google material design icons



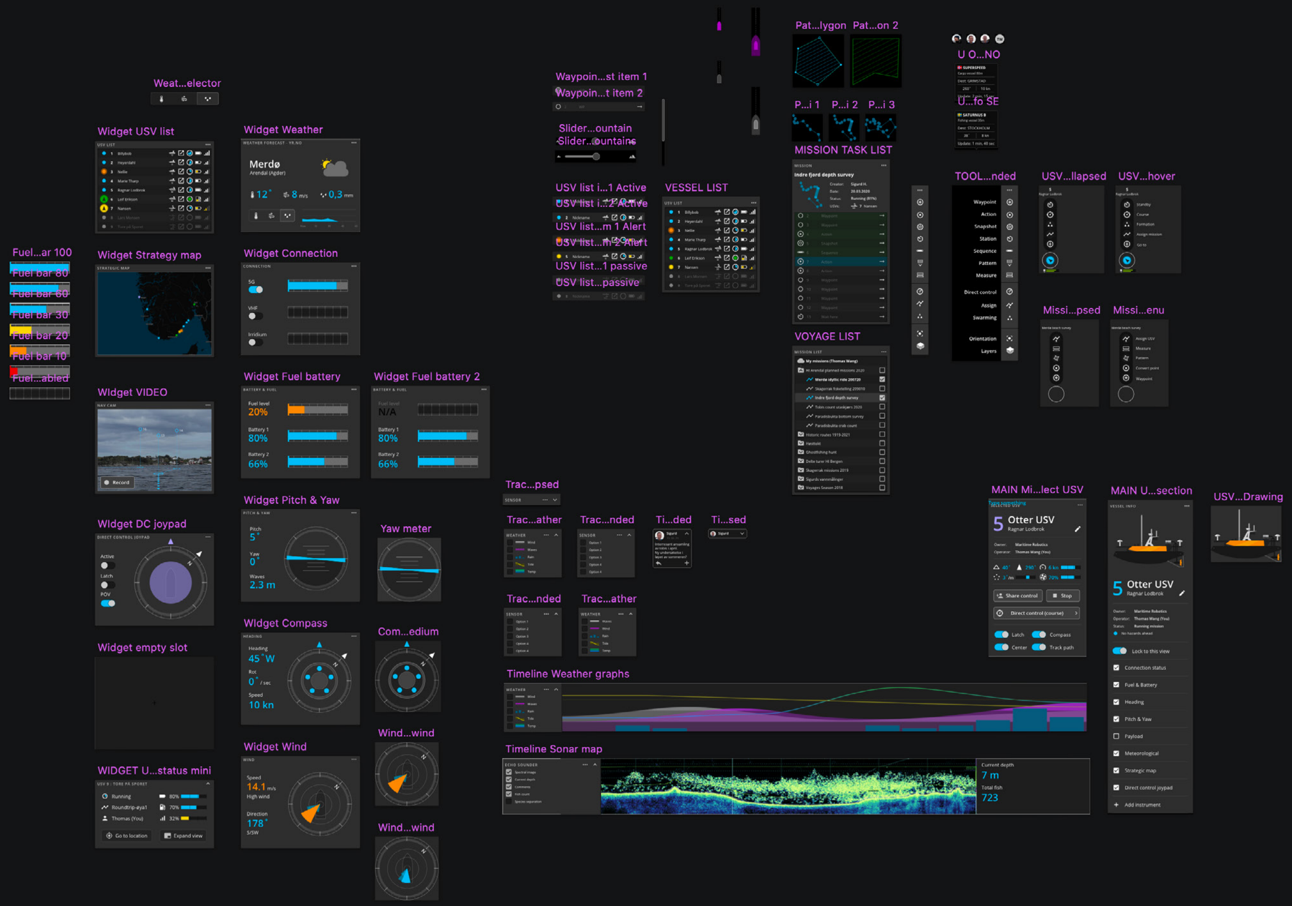
Building my own library

OpenBridge and Google material design is a great resource for building UI, but during the process I found the need to make unique new task specific icons.



Tweaking the OpenBridge system

By building on the OpenBridge components I could then add my own functions and flavor to the entire design. I will go through a handful of specific elements in chapter 4 of the report.



Feedback from experts

As I have explained in my introduction, testing during a nationwide lockdown poses some difficulties. I was able, thanks to the contact network of my supervisors, to gather a team of experts that could give me feedback during my process on sketches and prototypes through Zoom meetings and Miro boards.

In this example we had a collective Zoom meeting with 5 members of the Ocean Industries Concept Lab. I presented my sketches and we discussed iterations on how the USV symbols should look in a map at different zoom levels. A boat shape? A triangle? A circle like in Google maps? What about selection? And how should it scale?

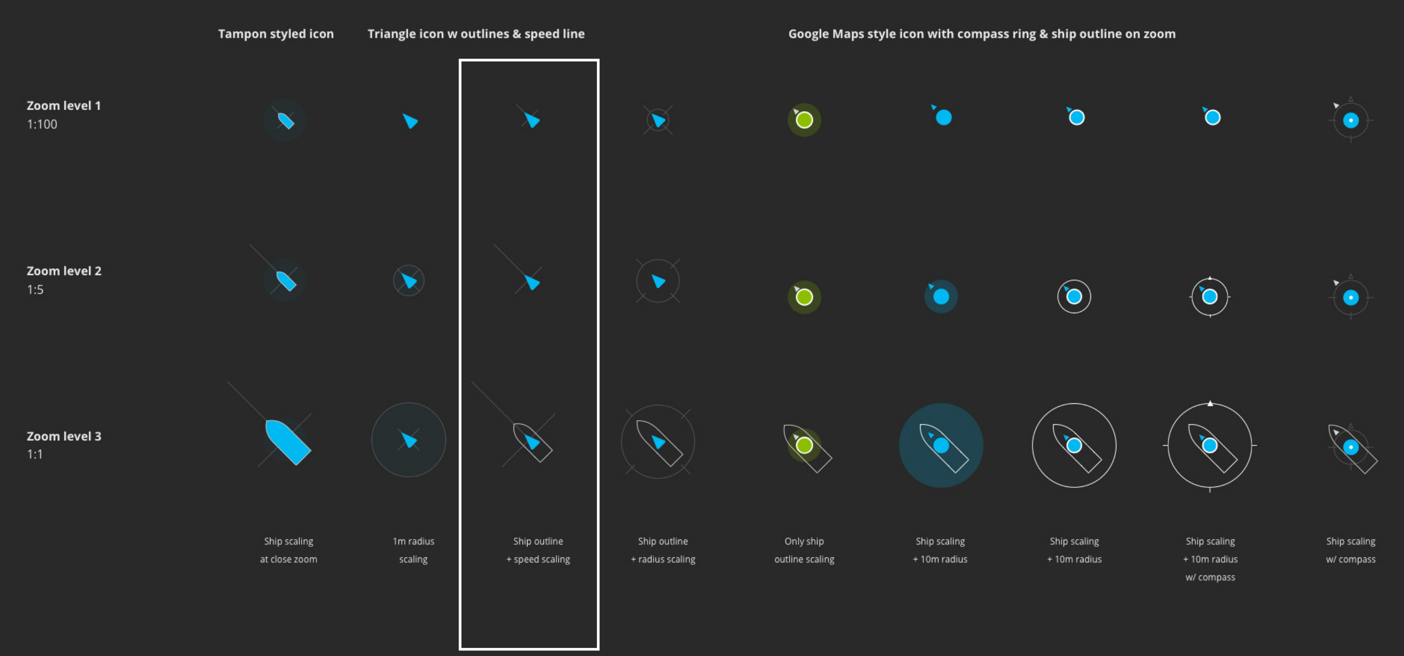
Steven: Showing which vessel selected: use outline circle.

Jan Olav: What are the main goals. Google maps; its not really important what direction you're in. For this it is.

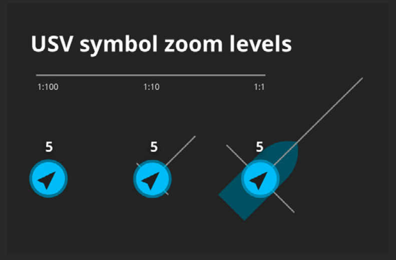
Triangles, easy to misinterpret direction:
Use direction lines (like ECDIS). Where you are going.

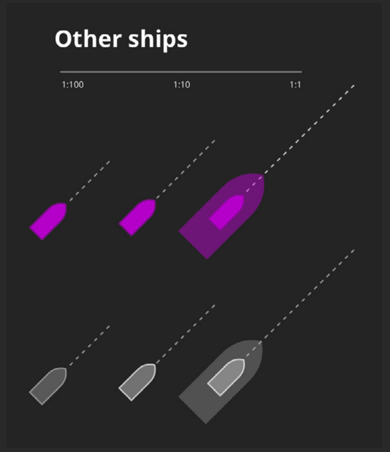
The heading and the course can be different, depending on wind.

Jesper: Triangles can be hard to see, use heading lines.



They agreed that row number 3 was the best combination of symbol and scaling. I proceeded with this and refined the triangle into a more arrow-like symbol in combination with a circle backround.
The reason being the ECDIS standards clearly separating YOUR SHIP with a circle and OTHER SHIPS as triangles.
I also needed a clear distinction between own USVs and other ships, by including color.





ECDIS Standards and regulations

In light of my research and first hand experience with cluttered ship navigation tools like ECDIS, I spent a decent amount of time sketching out different types of icons used for ships and objects. I made my choices based on the following considerations.

- Symbol distinction: between own vessels and other vessels.

- Symbol colors: available colors that does not indicate alerts or alarms.

- Symbol sizes: visible in a large map without causing clutter

- Symbols or indication of USV's outside the main map window that needs attention.

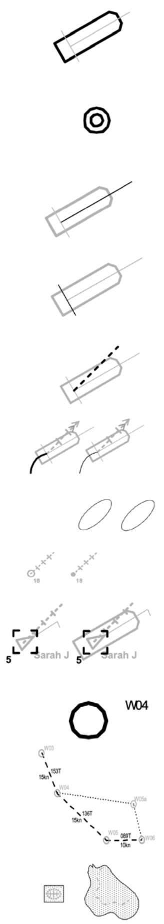
- Symbol scaling at different zoom levels.

Because of the close relations with navigation tools like ECDIS and route plotting tools, I have chosen to follow most of the guidelines decided by the IEC (International Electrotechnical Commision).

However, since this is an explorative task and with the specific use case of small USV's, I wanted to give myself a certain degree of freedom to in order to keep a consistent visual language. In addition; the guidelines provided by EIC is meant for ECDIS systems on a ship bridge, never showing more than one symbol for your own vessel. In my case there might be as much as 10 own vessels in the same window, creating a higher risk of clutter and visual noise.

The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

Navigation related symbols for own ship FOLLOWED:



- 1.1a True scaled outline (with semi transparent color)
- Simplified symbol (with colored arrow symbol instead of circles)
- Headling line
- Beam line
- Velocity vector (as length of heading line)
- Past track (as a thinner less visible line along voyage path)
- Predicted area of dangers (Referred to as voyage path with color and/or alert symbol)
- Selected object (But with a circle instead of square)
- Waypoints
- Routes (referred to as mission paths)
- Mariner enteren danger (referred to as danger points or areas)

Navigation related symbols for other ships followed:

- Activated AIS Targets (Referred to as simply “other ships”)

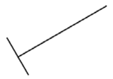
- Activated AIS Targets - True outline

- Heading lines

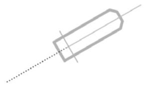
- Velocity vectors & Velocity vectors - time increments

- Activated AIS Targets - Dangerous targets. (As pink symbols, and these small USVs all other ships are dangerous, and must be avoided)

Navigation related symbols for own ships NOT FOLLOWED (and why):



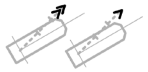
- 1.1a Minimized symbol, optional (why: The Simplified symbol color shows basic USV status)



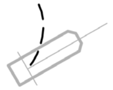
- Stern line, optional (why: symbol indicates direction)

- Radar antenna position (optional (why: these USVs are small)

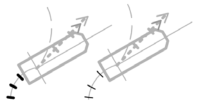
- Velocity vector – Time increments, optional (why: The velocity vector serves the same purpose with dotted lines)



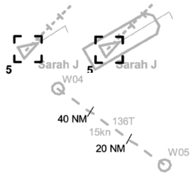
- Velocity vector – Stabilisation indicator, optional (why: optional)



- Path predictor, optional (why: the path indicating alternate path does this in voyage mode)



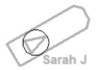
- Past track - Time increments, optional (speed could be tracked as part of the timeline)



- Selected object (a with a circle instead of square)

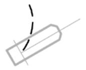
- Plotted position (Mission waypoints does this)

Navigation related symbols for other ships NOT FOLLOWED:

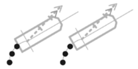


- Assosiated AIS targets - alternative

- Heading lines - turn indicators



- Path predictor



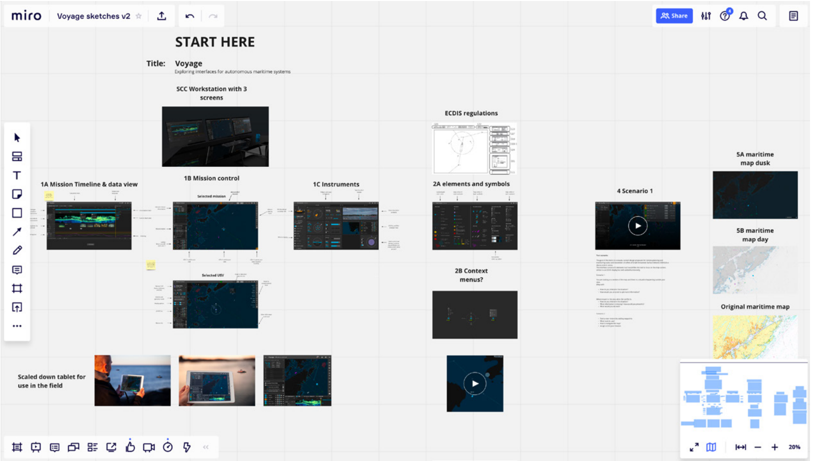
- Target past positions

Navigation related symbols not taken into concideration:

- Distance to run
- Planned position
- Visual limits of lights
- AIS aids to navigation
- AIS search and rescue transmitter
- Lost targets
- Other ship Routes
- Target acquisition area
- AIS SAR aircraft/helicopter
- Tidal stream
- Look-ahead alarm highlighting
- Danger bearing
- Event marker
- Wheel over line
- User cursor
- Electronic bearing
- Variable range marker
- Range rings
- Area notice
- Area gap
- Environmental report
- Fairway closure

Feedback from experts

I had a Zoom meeting with designer Caterina Forno from EGGS Design, to discuss current prototypes, overall information architecture and detailed elements like context menus for quick actions on individual USVs in the map view.



It looks very real. Looks like a software I could open on my computer.

Quote: Caterina Forno

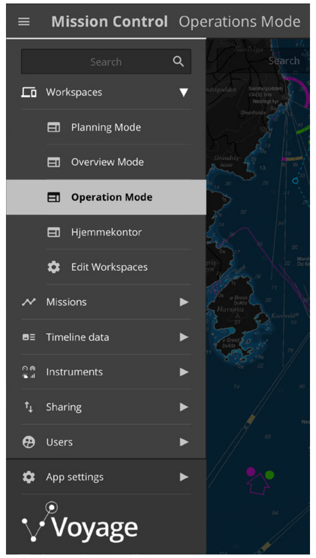
Context menus:
The wow effect in being geometric, coming from the centre.

This one (on the left) is more efficient with shorter distance.

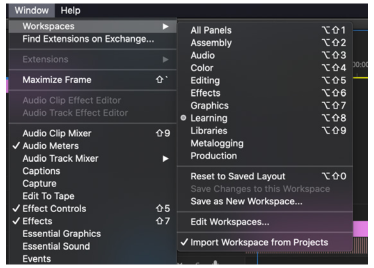
Maybe use a low opacity background?

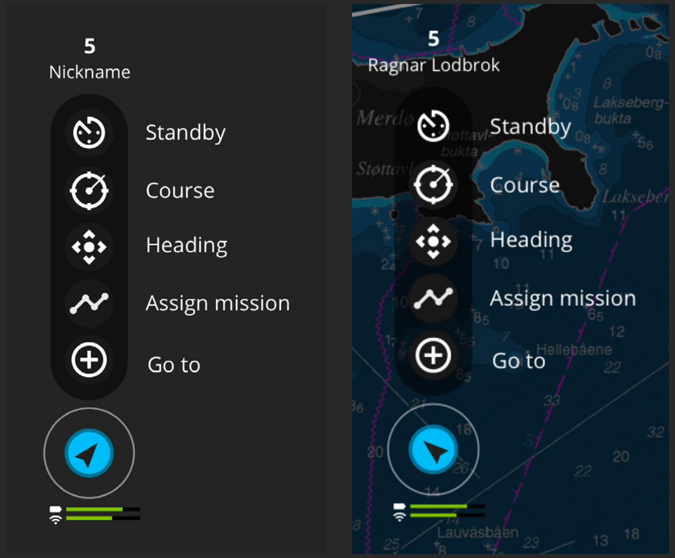
Making it possible to set up a mode, separately from the view you're having?
A mission mode, and a operating mode. Moving some tools showing relevant information for the mode.

Quote: Caterina Forno



I solved this by using the OpenBridge menu system with a Workspace tab for different custom modes. This is directly picked up from Adobe Premiere Pro.

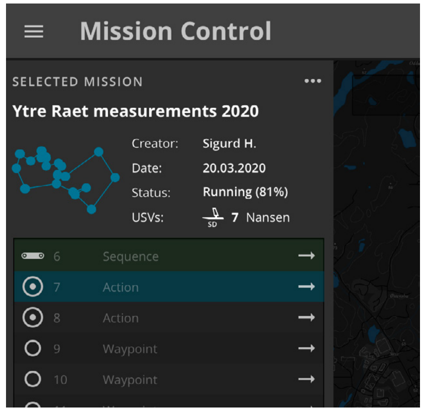




I solved this by vertically stacking the tool icons with a low opacity backgroundand having supportive text on the side.

Feedback from experts

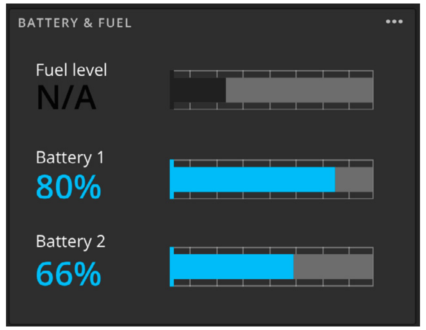
Late in the project I had a online meeting with Henrik Lenes, software developer in Maritime Robotics to validate some of the same interface patterns and elements. He was able to question and comment on situations that I or any other had thought of. If I had more time to develop this project further I would take it into account in my final proposal.



If you have a lot of plans (ref: missions) you should know what you are clicking.

Quote: Henrik Lenes (Maritime Robotics)

Commenting on how a thumbnail of the mission is visualised in the fixed mission widget.



One thing I don't see in the instruments, there is alot of hardware on a boat (ref: USV) like voltage on batteries.

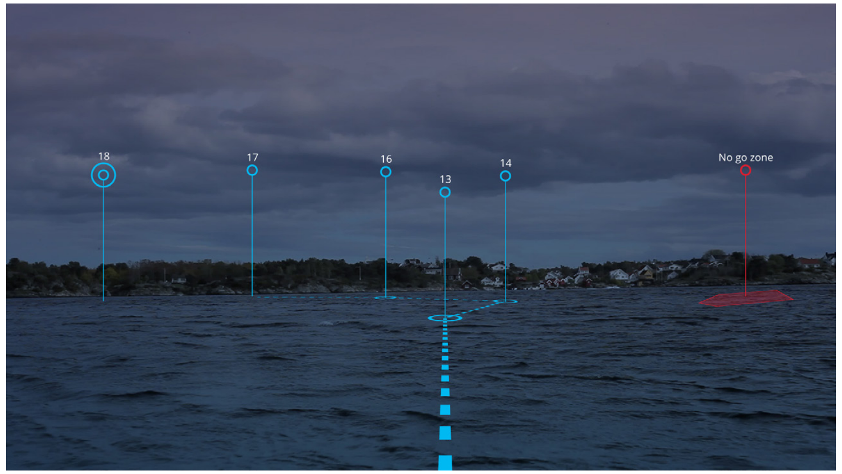
Quote: Henrik Lenes (Maritime Robotics)

Commenting on the instrument widgets with possibly a bit simplified information for an operator who knows the boat.

AIS information is handy. This is a smart way of showing info of the ships. But what if the ship is outside our view and heading towards you only 20m away?

Quote: Henrik Lenes (Maritime Robotics)

It was obvious afterwards that other "dangerous" ships outside the main view should have some kind of similar visualisation as your own USVs do.



Really neat with the camera with waypoints, that's something we have talked about.

Quote: Henrik Lenes (Maritime Robotics)

Universal color codes

PASSIVE OR DISABLED ELEMENTS

DIRECT REMOTE CONTROL

ACTIVE / RUNNING

FINISHED / SAFE

CAUTION

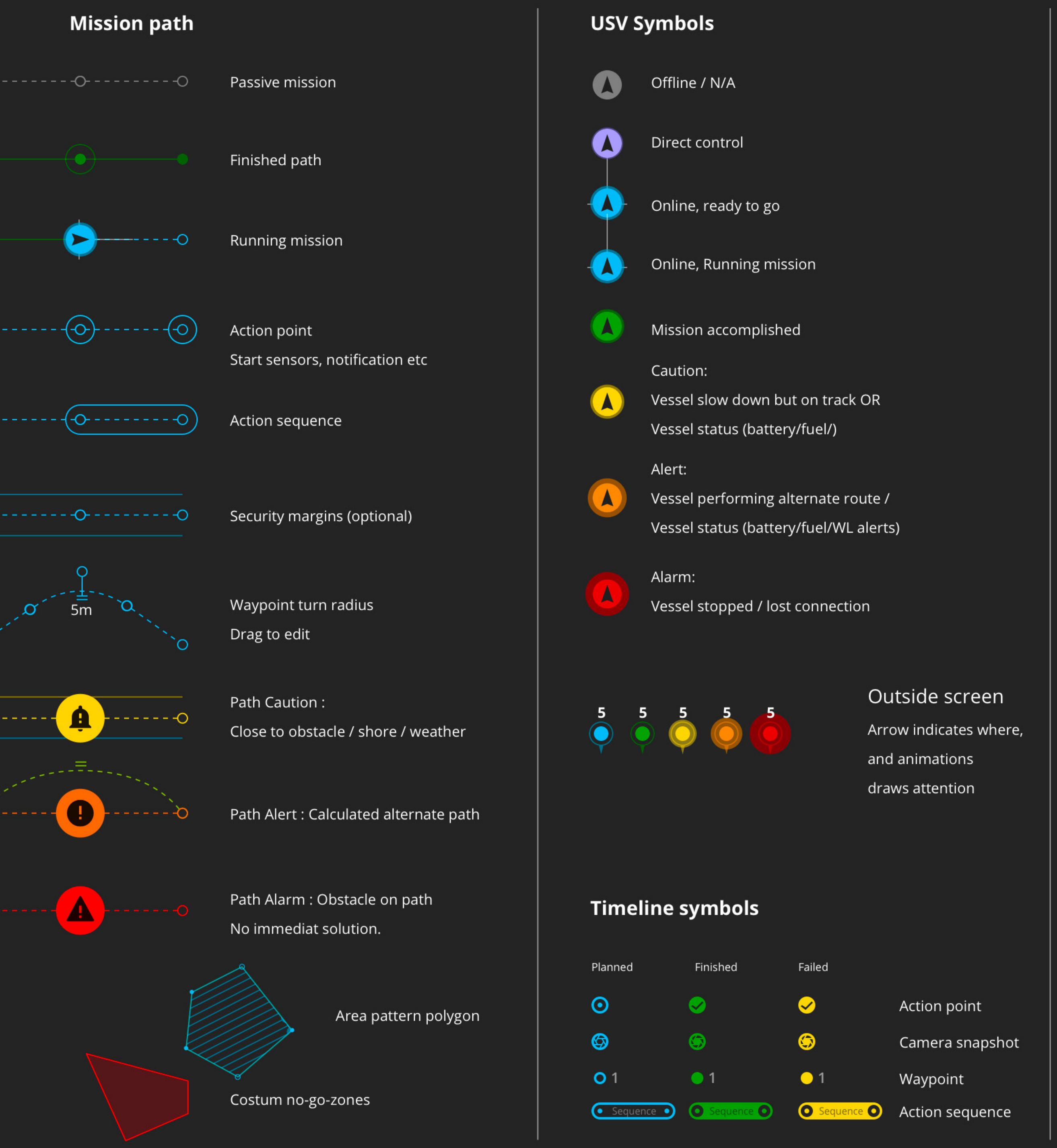
ALERT

ALARM

OTHER SHIPS / DANGER

The OpenBridge Design Guidelines includes a color palette for all UI elements like text, borders, containers and buttons as well as colors dedicated to alerts and alarms.
Yellow, orange and red should only be used to indicate “Caution”, an alert or an alarm.
In addition to these I added colors for a “direct control mode”, a mode of operation which is done by setting a course or heading, as well as a separate pink color specific for “other ships” that might need attention.

Color name	rgba	HEX + Opacity
color-alert-running	rgba(0, 160, 0, 1)	#00A000 + 100%
color-alert-caution	rgba(255, 213, 0, 1)	#FFD500 + 100%
color-alert-warning	rgb (255, 140, 0)	#FF8C00 + 100%
color-alert-alarm	rgba(204, 0, 0, 1)	#CC0000 + 100%



Mission and USV symbols

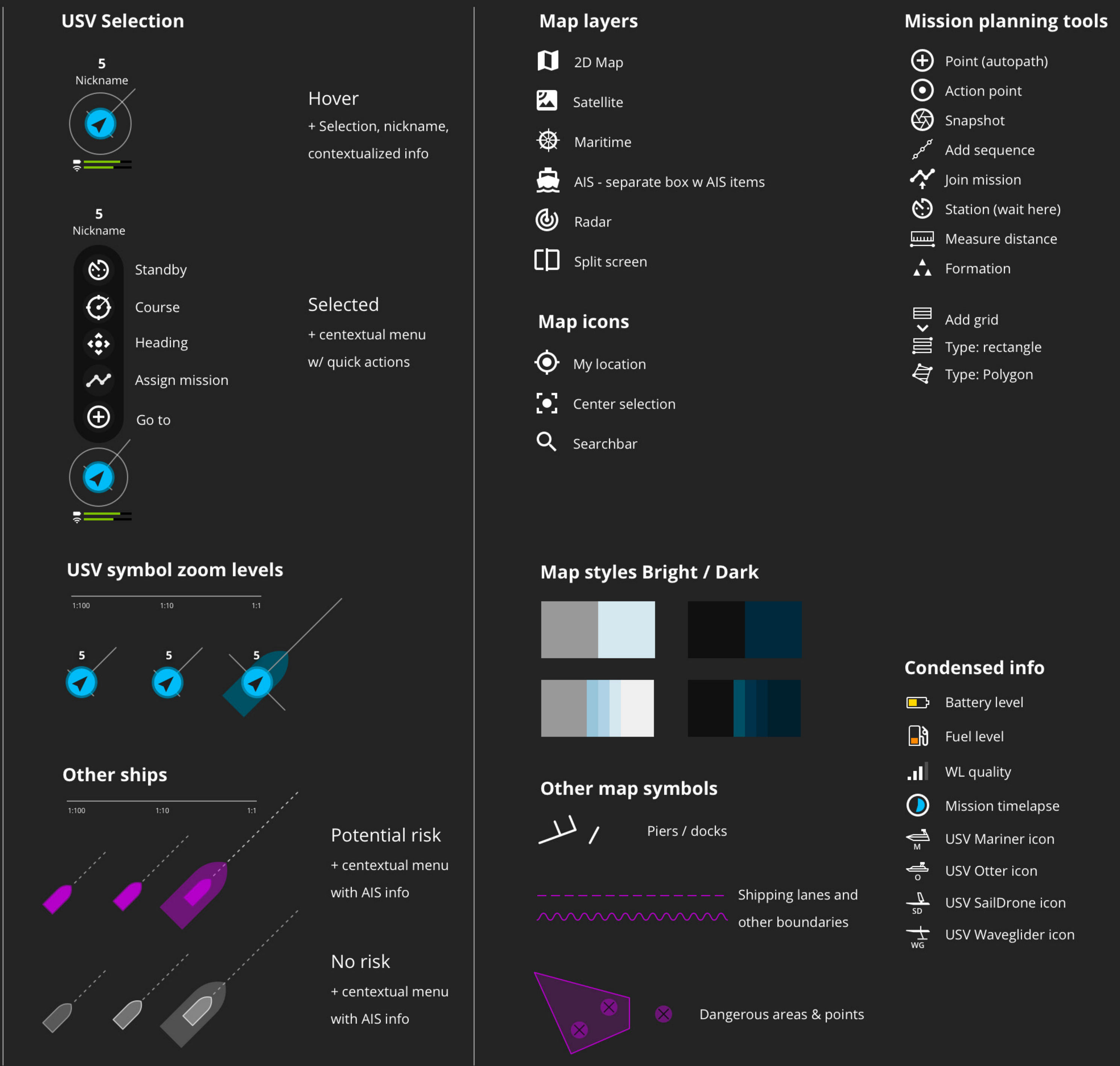
Throughout the project I continuously worked the details of the components that would make up the interactive elements and applying the color palette to visualise the levels of danger and modes of operation. These are the final versions.
There are similarities between what happens on a planned mission path and the USV which is running it. For example; If you are drawing a path too close to shore, the path lines will turn yellow, indicating caution.
You might still want to run the mission with a USV but with a higher risk involved.

USV symbols are similar, but colors indicate a more urgent state of danger, since a USV in operation is "live" but the mission path is not.

> *The MUNIN proposal is a monitoring interface where ships are flagged (Green/Yellow/Red) according to the status of their information hierarchy. This is a great architecture as a basis for designing a further developed interaction for operation. MUNIN's intended system uses Green flags for OK. However, the use of attention grabbing colors for steady states should be limited to reduce attention to aspects where no attention is needed.*
>
> Source: A.E Ottesen - Situation Awareness in Remote Operation of Autonomous Ships (1999)

Other elements

The need to distinguish your own vessels from other ships is an important aspect of fleet control. The pink color is specific to other ships or potentially dangerous areas which is within a certain area of your own USVs. The colour derives from the shipping lanes from maritime maps. The three variations relates to the zoom level on the map, and if you zoom in, the outline of the actual size of the ship will be shown relative to the scale of the map.



Source: Blizzard Entertainment

STRATEGIC WARGAMES

Through my research and from previous experience I have found many similarities in the interface and systems used in control centres, fleet control systems and in strategy games. I have enjoyed playing several games during this project but focused on 3 that have useful and relatable interaction principles: Sim City 4, StarCraft and Kingdom Rush. They are completely different games but they share a number of similarities:

MAP BASED INTERFACE

MULTITASKING

HIGH LEVELS OF COMPLEXITY

PLANNING FOR FUTURE EVENTS

ENTITIES MOVING AND ACTING SEMI-AUTONOMOUSLY

VISUAL AND AUDIO FEEDBACK FOR DANGEROUS SITUATIONS

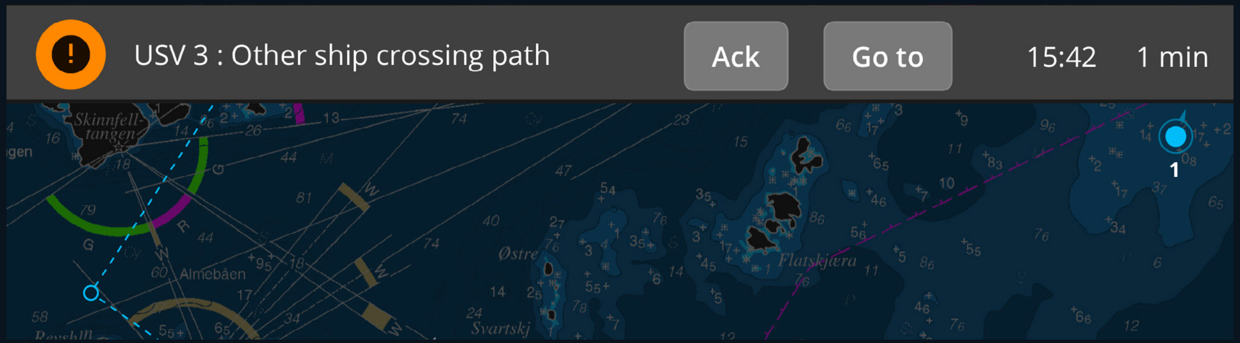
CLUES OF WHAT IS HAPPENING OUTSIDE YOUR VIEW

> *In controlroom settings you have the old folks that know the processes very well but don't understand computers. Then you have the new young ones who know this to the fingertips, but not the core processes. They are more volatile than their previous generation. Which paradigm should you choose to make something that works for all?*
>
> Quote: Kristoffer Husøy (Cognite)

Fleet control and dangerous situation in Sim City 4

In Sim City, every fire station has available fire engines depending on its size and funding. When a fire breaks out, there is a warning telling you to dispatch available fire engines to a specific location. They have used a clear and unavoidable visual warning as a red frame around the screen, as well as having a “go to disaster” (1) button in the emergency menu.
Once you have dispatched each fire engine, they will start to drive from the stations and start putting out the fire. Symbols with numbers and arrows along the edge of the interface tells you where they are in relation to your location.
I have used this type of visualisation in the map view, where active USV under your control are displayed as minimized symbols along the edge of the screen, giving the user an instant and clickable overview of each USVs relative location.

Warning and “Go to” button in the OpenBridge alert top bar:

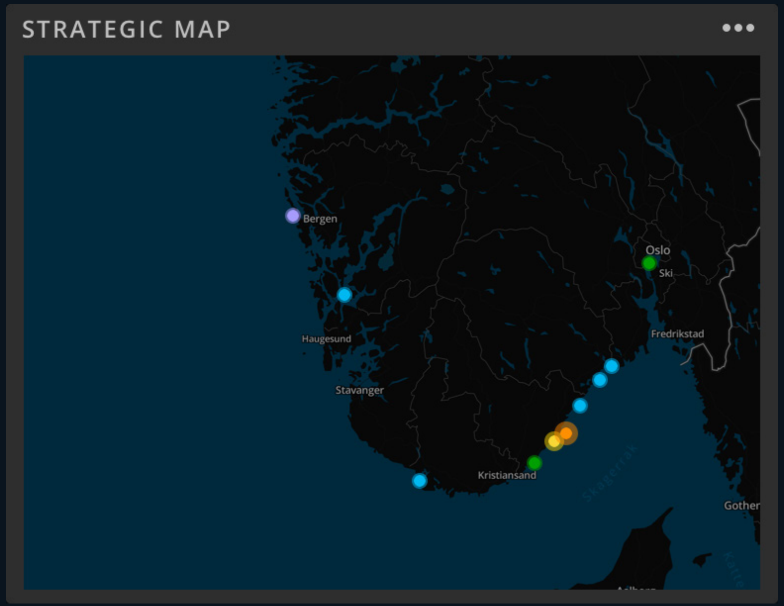


USV 7, 6, 4 and 3 are south on the map. USV 3 needs attention. Icons are clickable and will take you to their location.

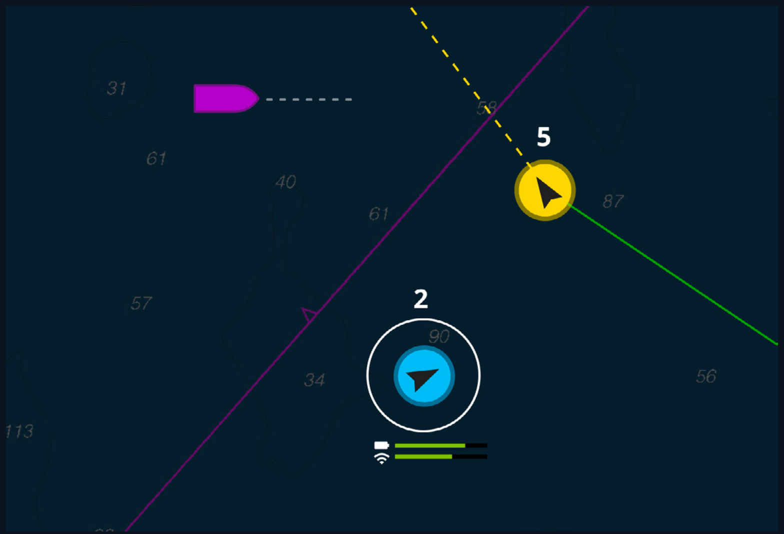
Health display and fleet control in StarCraft

In Starcraft your goal is to build and maintain a base on alien planets by collecting resources, explore the surroundings, and execute mission objectives along the way without getting slaughtered by hords of nasty aliens.
As you build infrastructure you are responsible for handling a large number of soldiers at different locations on the map. There is no zoom option here so you largely rely on a strategical mini map (1) visualising each of your entities as colred dots indicating their health or danger level. The nasty aliens have a separate, orange color to separate them from your own. I have used a similar kind of color scheme to separate other ships from your own, level bars (2) to indicate health (or battery and connection level) as well as an optional strategy map available as a widget.

Strategic map widget with overview



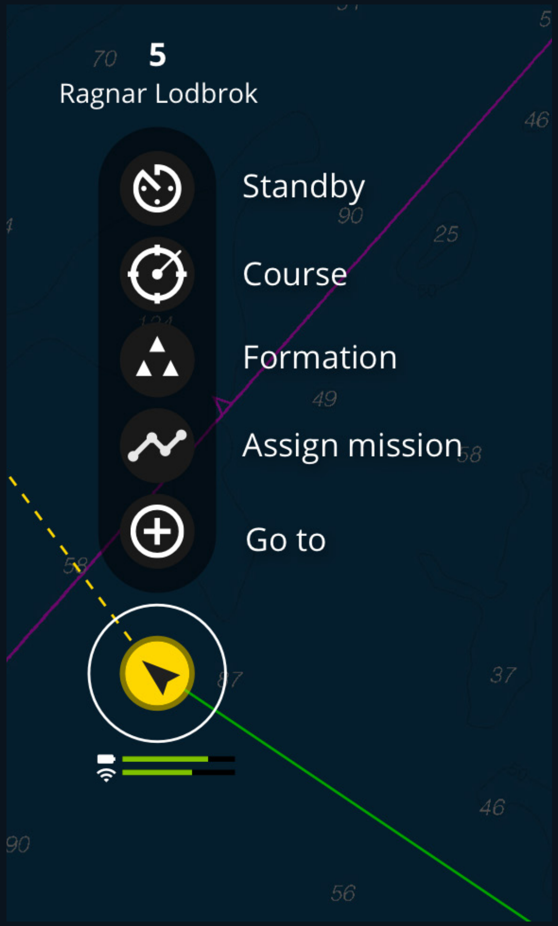
Potential dangerous ship (pink)
USV 2 has good battery and ok wifi signal
USV 5 is entering a potential situation



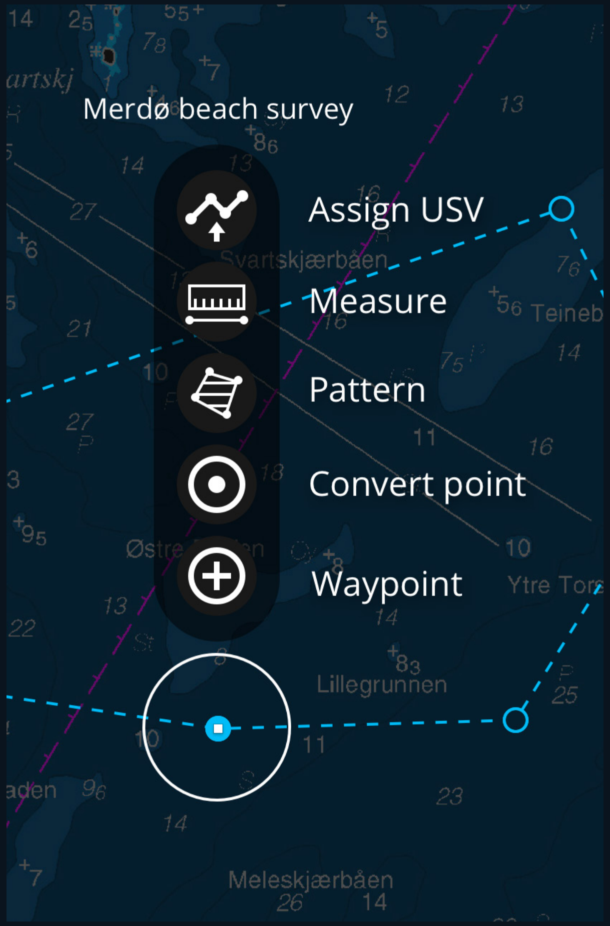
Quick actions and contextual menus in Kingdom Rush

Kingdom Rush is a charming cartoon-looking strategy game where your goal is to defend your kingdom against invading armies of trolls, orcs, evil wizards and zombies. Some of your entities have fixed locations like archery towers and cannons while others are mobile such as knights and superheroes. In order to keep up with attacking armies, fast paced control is needed on individual entities to make sure they are ready for the next army of attackers. In this case contextual menus (1) as overlays avoids the need for moving focus away from the critical area where the attack is happening. I have used this type of tool in the selection of USVs and Waypoints.

Selected USV with sontext menus for common USV actions



Selected mission waypoint with context menus for common actions



> ***Context menus on waypoints sound like a good idea, to start and set up an action point. It is neat with interactive maps. One frees up space on the bottom. (ref: where their controls are in their own interface)***
>
> Quote: Henrik Lenes (Maritime Robotics)

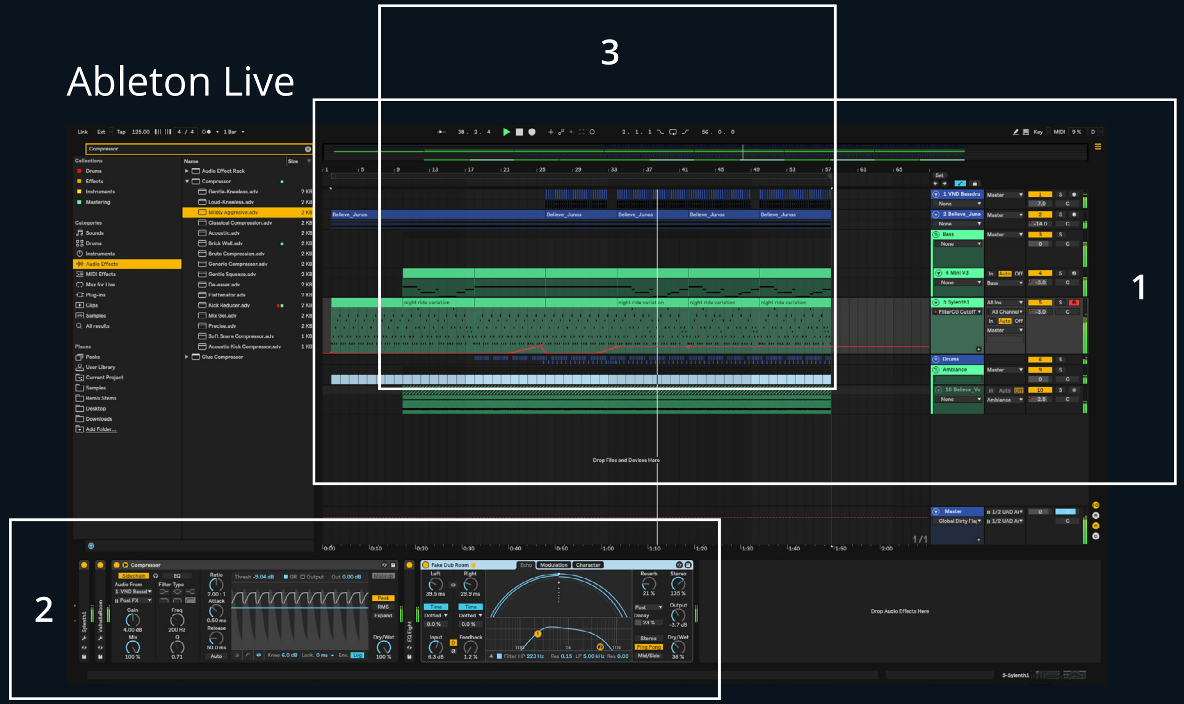
TIMELINES AND AUDIO

I have been working professionally with audio in the last 10 years and have learned and used a bunch of different software for this purpose. There are many similarities between Digital Audio Workstations (DAW), video editing software and potential interfaces for autonomous systems. The most obvious ones are timelines, visual display of media, plugins and modularity.
DAWs like ProTools or Ableton Live have two different main sections; a sequence (timeline) view (1) and a mix (elements) view.
In addition, plugins for specific instruments or effects can be displayed as floating widgets for immediate control. (2)

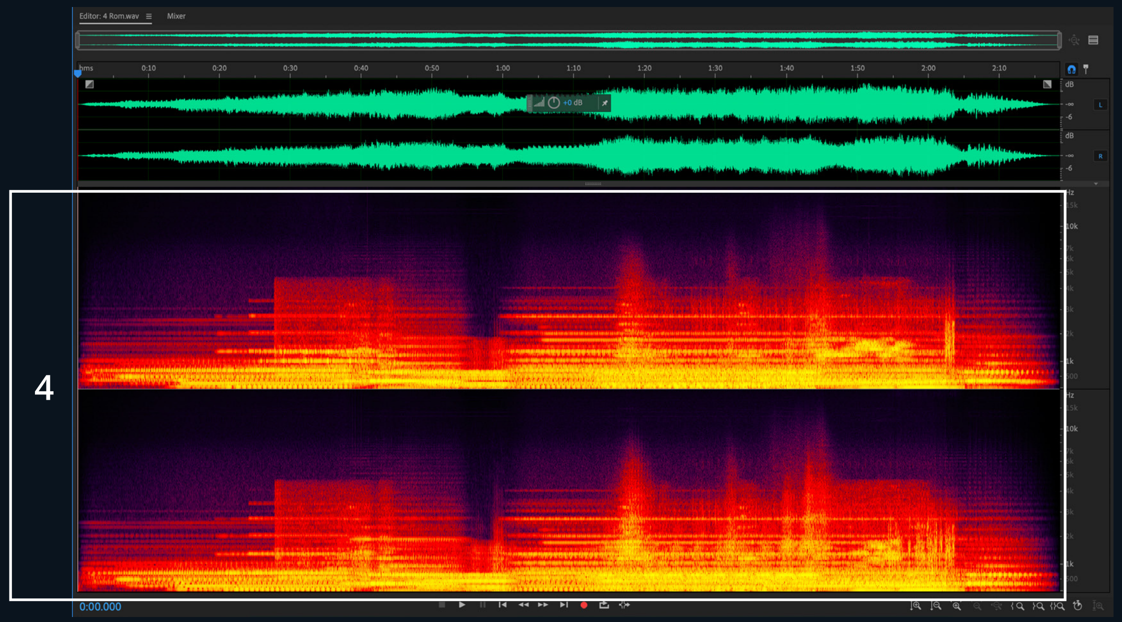
In a multiscreen situation you would place the two main sections on separate screens and a selection of plugin widgets in a third screen. In a typical laptop situation you would jump between the 2 views and open plugin widgets when you need them.
Actions to be performed; midi notes is visualized as “trigger dots” and automation as lines.

Audio is linked to the timeline as individual tracks and can be visualised as waveforms or frequency spectrums (4); which is exactly what echosounder images are.

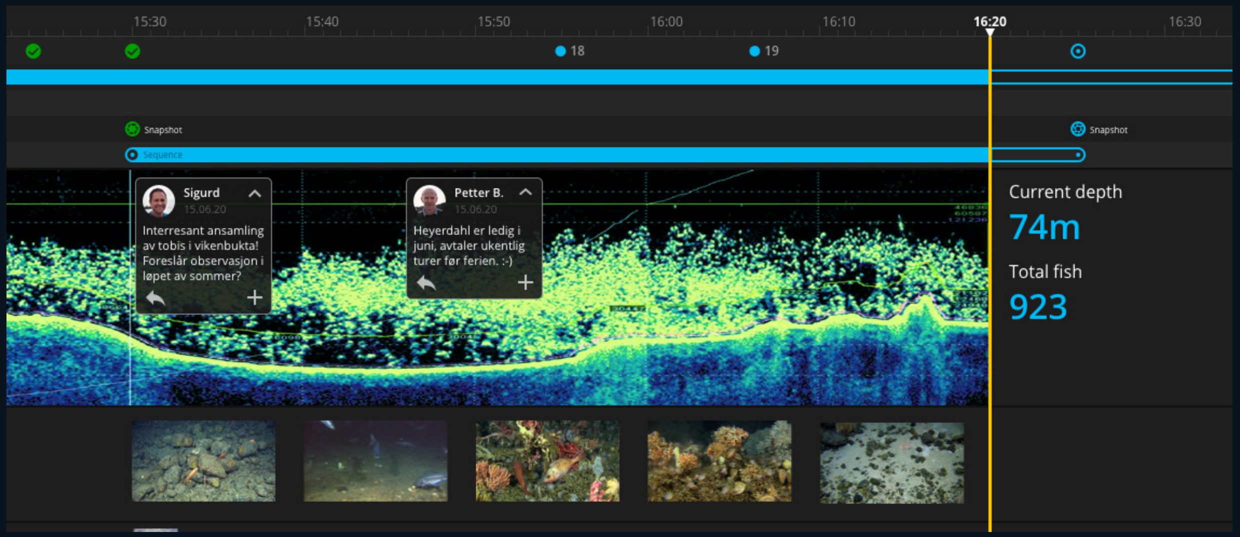
Ableton Live



Adobe Audition



Voyage Timeline view detail



Why use timelines?

Active use of timelines will simplify the demand for the brain to make its own sequences of actions and thereby free capacity and smoothen the workflow. This improves decision-making, as the importance of data is clear. The implementation of this concept should go beyond the voyage planning and be utilized for multiple purposes. Timelines can be an effective tool to provide current data accuracy through simplified visualization of update sequences.

Source: A. E. Ottesen - Control centre for unmanned ships (1999)

The timelines that MUNIN have developed are presenting operational shifts and marks for upcoming tasks with ETA's and other important information in a simplified and informal way. These timelines are again connected to the ECDIS system, enabling geographical pins along the route to create a simplified visual understanding of the upcoming events.

Source: A. E. Ottesen - Control centre for unmanned ships (1999)

4

PROPOSAL

In this final section I will present my final design proposal in context. There are several components in the design that is difficult to visualise in a static PDF, like animations and microinteractions. More vivid visualisations will be seen in my presentation, and in my portfolio: thomaswangj.myportfolio.com

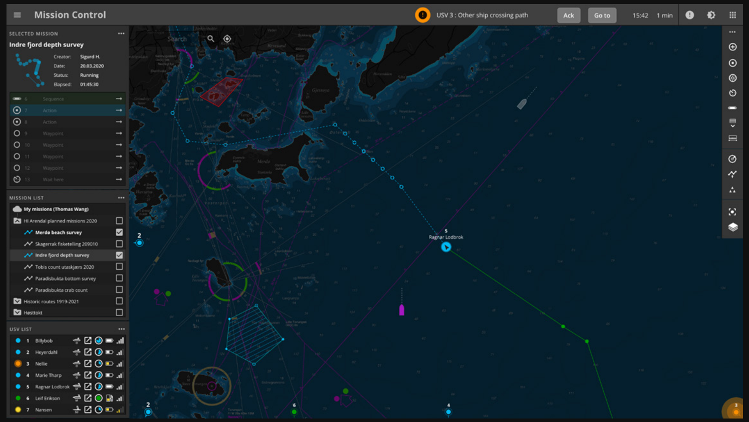
Voyage

A MODULAR FLEET CONTROL AND DATA MANAGEMENT TOOL FOR UNMANNED SURFACE VESSELS

SYSTEM OVERVIEW

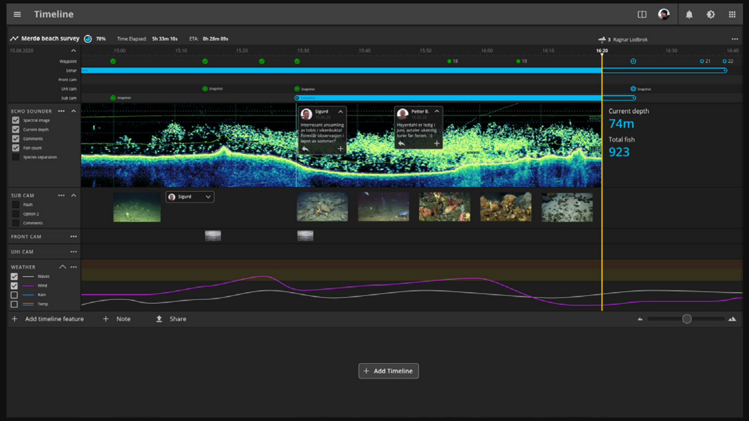
Voyage is a collection of interfaces within a software that can be scaled to fit to the users needs. The 3 main components have individual ways of interacting with the system; Planning and overview, data analysis and observation. Scalable widgets could be dragged into any section. It is designed to be used with a standard mouse and keyboard, but should have big enough interface elements to work with a touch on a tablet, although it was a secondary focus in this project.

By allowing the user to swap between setups, the operator doesn't necssarily have to sit and watch the screens all day, but could bring his or her iPad or laptop to the lunchroom or to a home office, while still having sufficient situation awareness.



Mission control

This is where most of the user input happens and where the user can draw with missions i a graphical UI while at the same time have a spatial overview of all the USVs in your control. Alerts and alarms for USVs are shown here as well as AIS info on other ships in the area.



Timeline

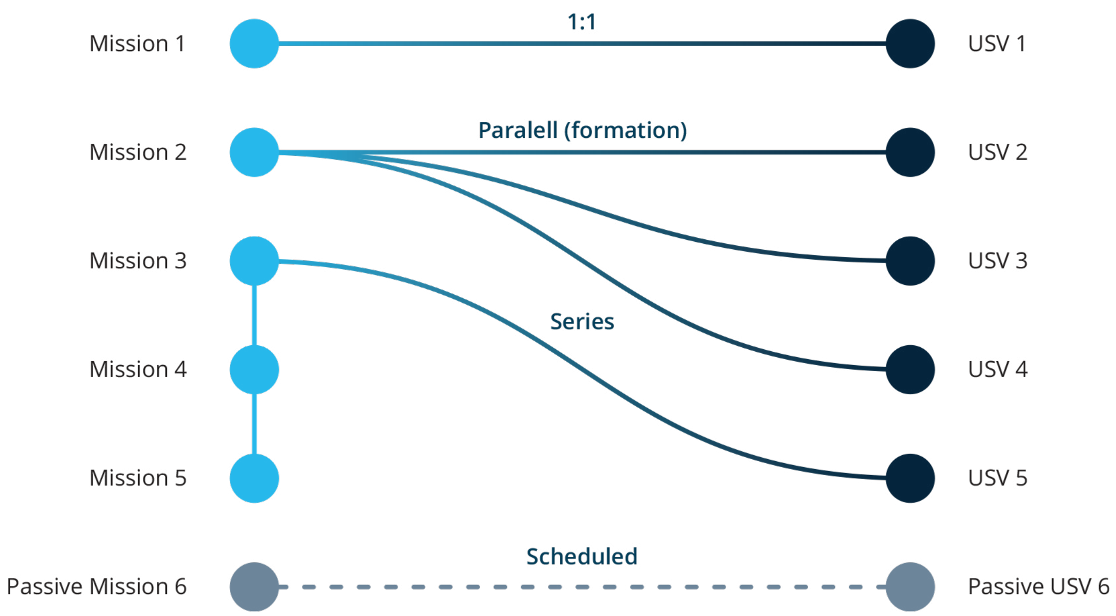
A selected mission will be shown here as a sequence of events at the top and tracks with sensor output, comments and snapshots taken so far. The data collected is logged and timestamped so it is retrievable and referenced with time, location and environmental data.

Instruments

A detailed view of the selected USV split into tabs, like in your browser. Current status and. There is also space for other widgets like live video, direct control and miniature tactical maps.

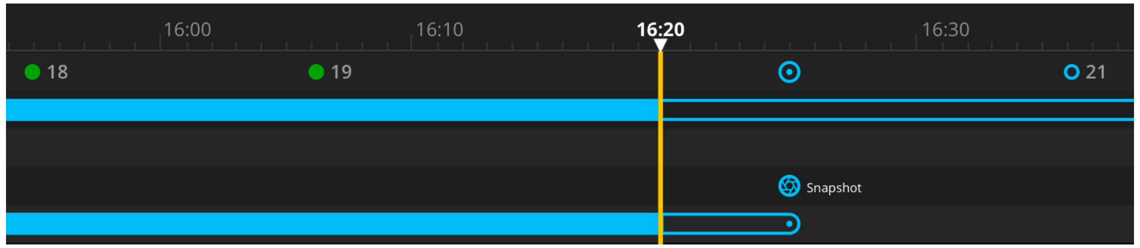
Missions

In my solution USVs and missions are separate entities. They are both controlled within the mission control section, but missions could be imported, shared, run several times by different USVs or in series. A USV can be assigned to a mission or vice versa via the contextual menus.



Missions can be displayed in 3 ways: waypoints and lines in the map (1), as a list of waypoints (2) and as a timeline with more detail on actions and events (3).

All missions are shared, stored and retrieved through the Mission list widget (4) and created using the tools in the toolbox. (5)



3

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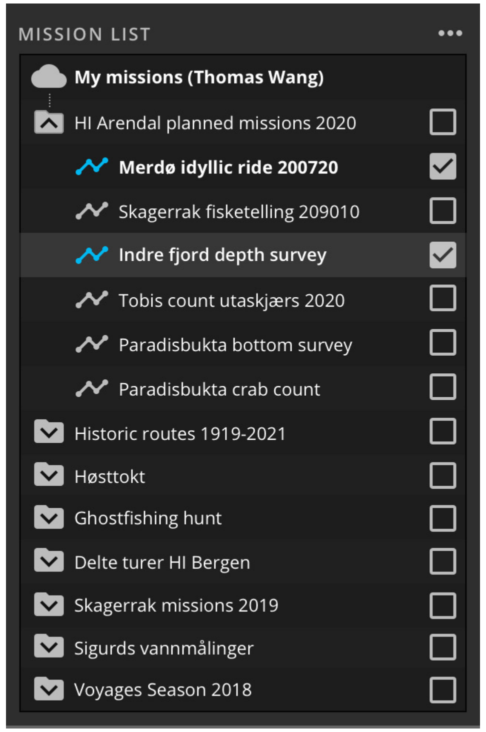

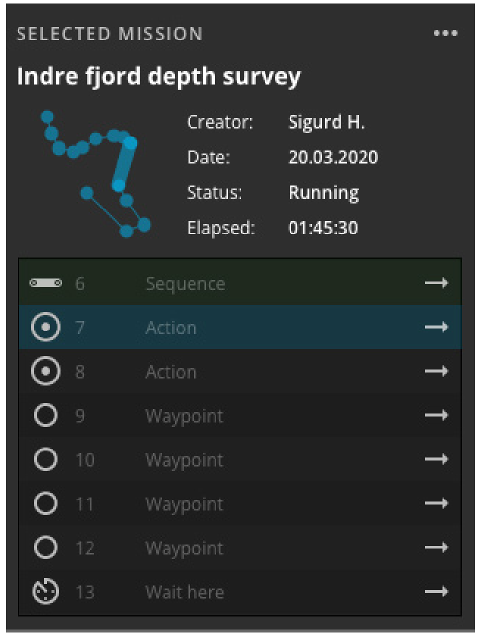

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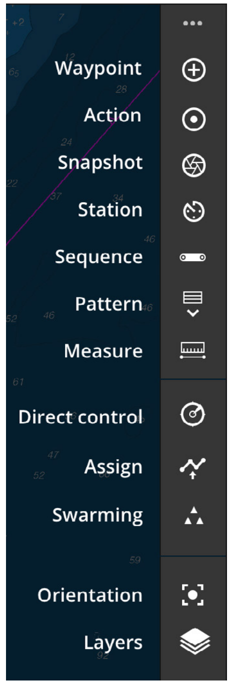

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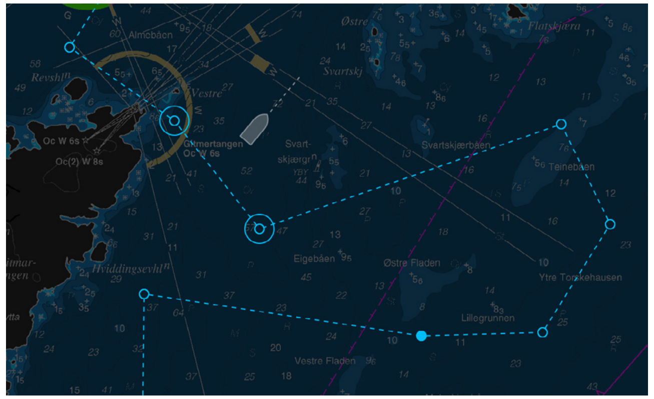
1



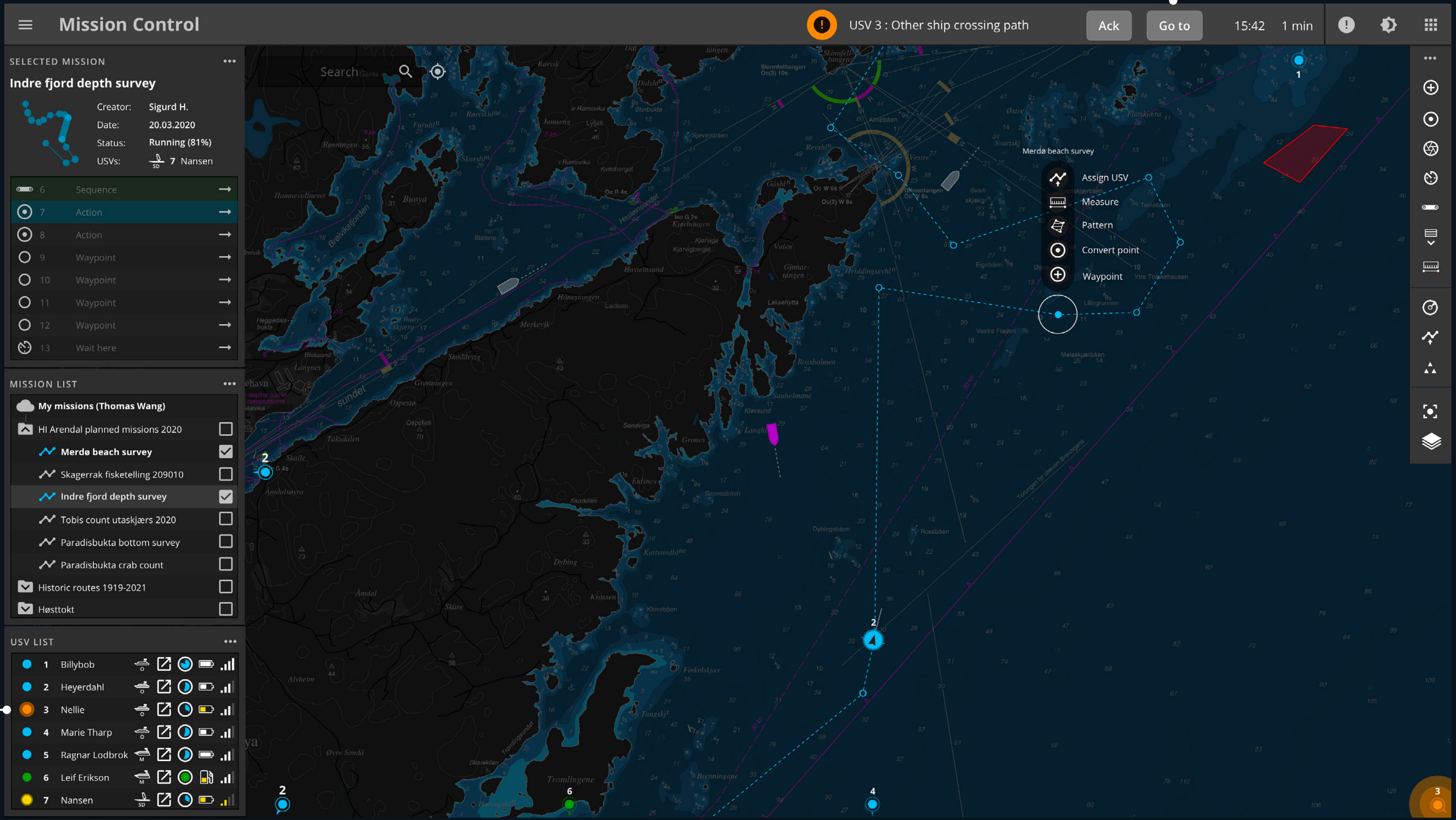
Mission control collision avoidance scenario

In this scenario the operator is working on a mission (Indre fjord depth survey)
At the same time there is a potential risky situation happening with USV 3 outside the main view. The situation is visualised in 3 ways, and the user has 3 options:

1: Click the “Go to” button in the alert center
2: Click on USV 3 in the USV list
3: Click on the animated symbol in the lower right corner.

All 3 choices moves the focus to the area where USV 3 is located.

ALERT CENTER INFO



STATUS OF THE USV

WHERE

Mission control collision avoidance scenario

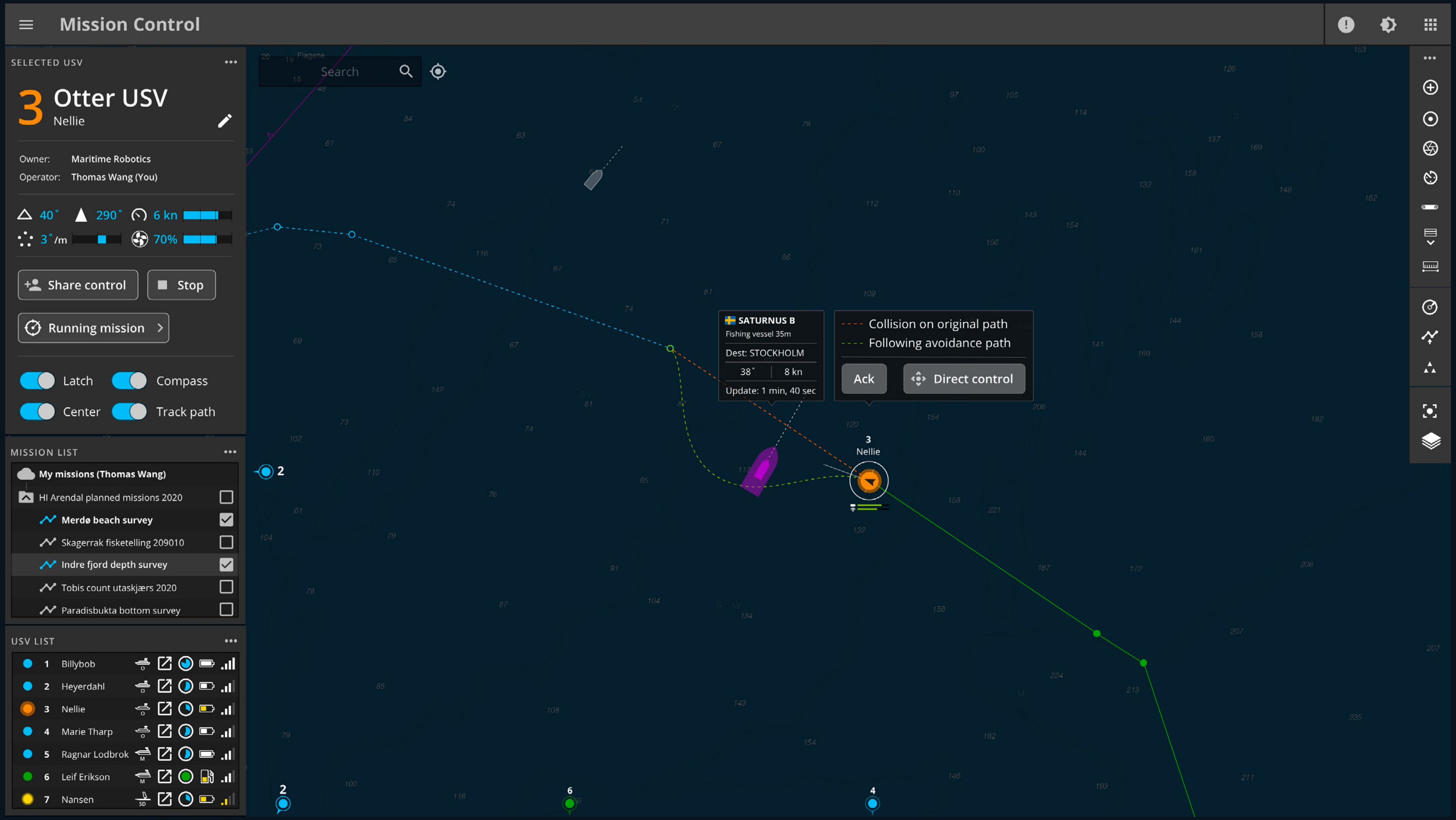
The USV 3 is automatically selected, which enables detailed information within the fixed widget in the mission control. The alert from the top bar goes away.

The USV is planning for an avoidance maneuver to avoid the swedish ship and starts to turn left from its original path and moves along the green path.

The operator has options:

1: To acknowledge
2: To take direct control over the USV

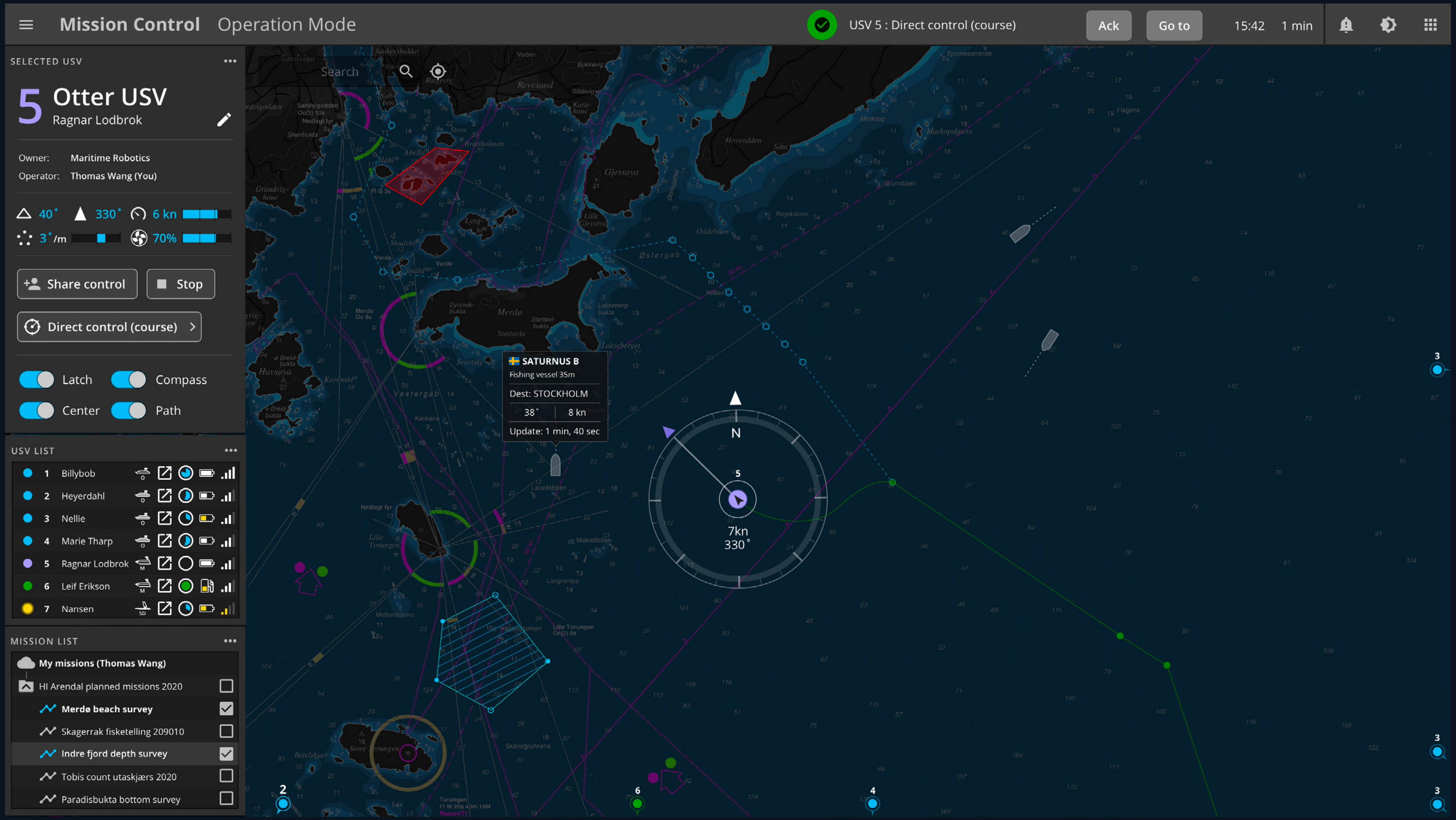
If all goes well, Nellie will live to see another day.



Mission control collision direct control

If the USV is connected to wifi or cellular it is possible to remote control it directly, just like a drone. I adapted the “compass wheel” from the Maritime Robotics interface. Drag the arrow to where you want it to go and it follows that course.

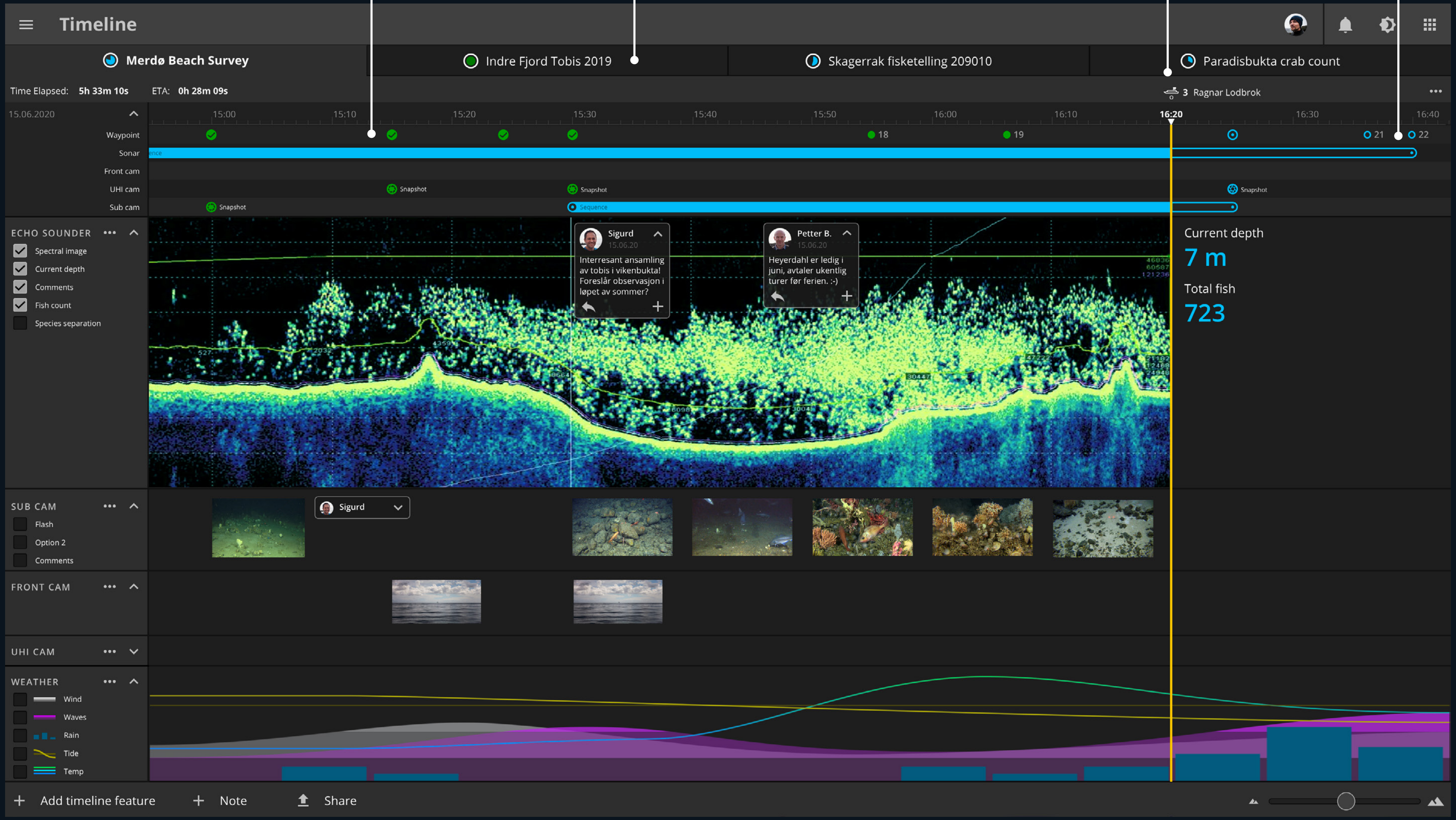
See information on other ships in the area by hovering your mouse over them and a dia-logue box appears with updated AIS info.



Timeline section

In this view, users can follow the planned mission and get an overview of the data collected in realtime. Users can add comments on important events such as here; where an unusual large school of fish has appeared during the Merdø beach survey. All comments, data and photos recorded are geotagged and time referenced for comparison with older data or new surveys.

Users can jump between mission timelines by using the tabs under the top bar, just like in a browser.

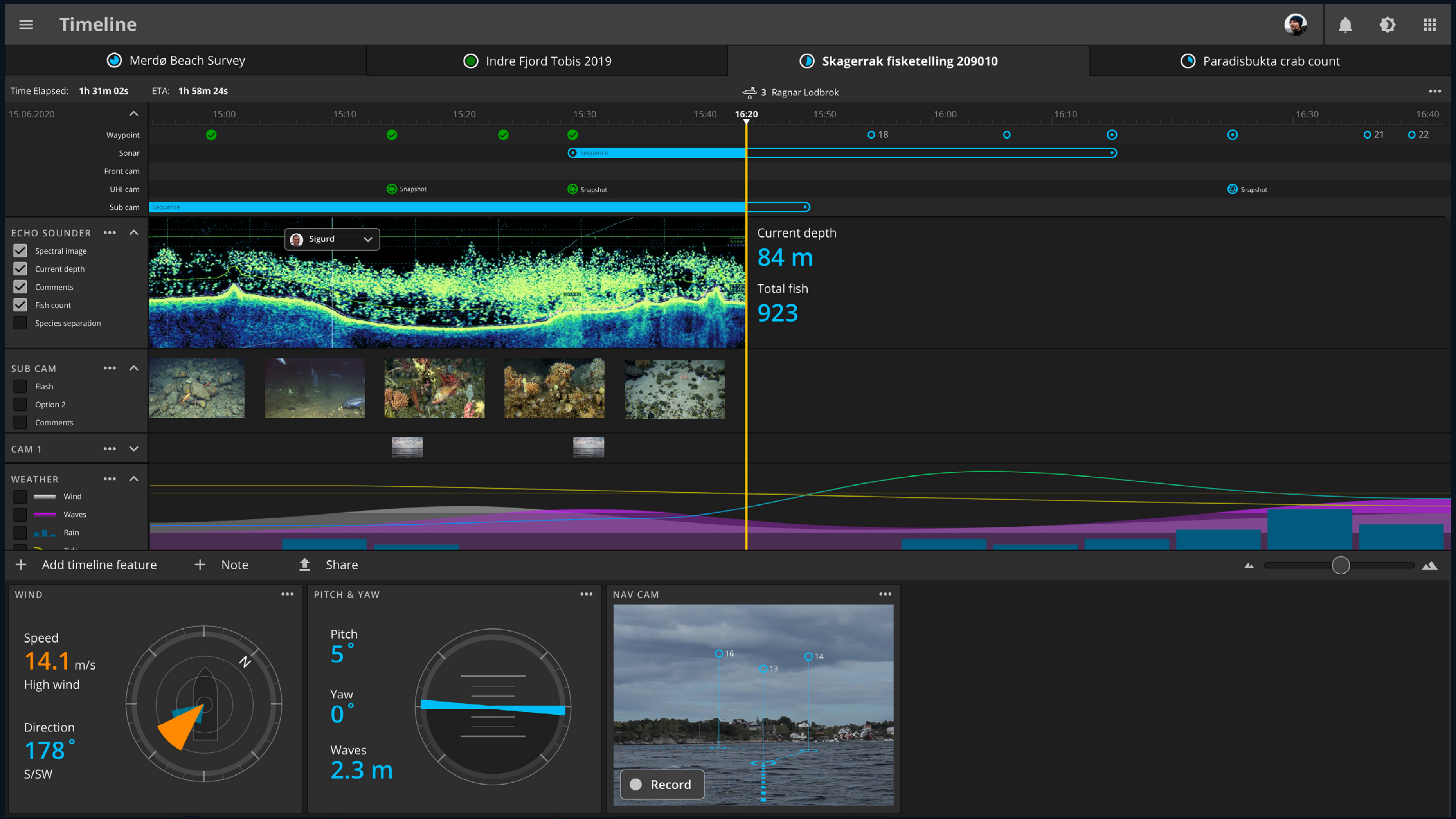


Timeline section

In this view another mission timeline is selected. The bottom part of the screen is used for widgets for the active USV.

ECHOSOUNDER SPECTRUM

ACTUAL WIND AND DIRECTION

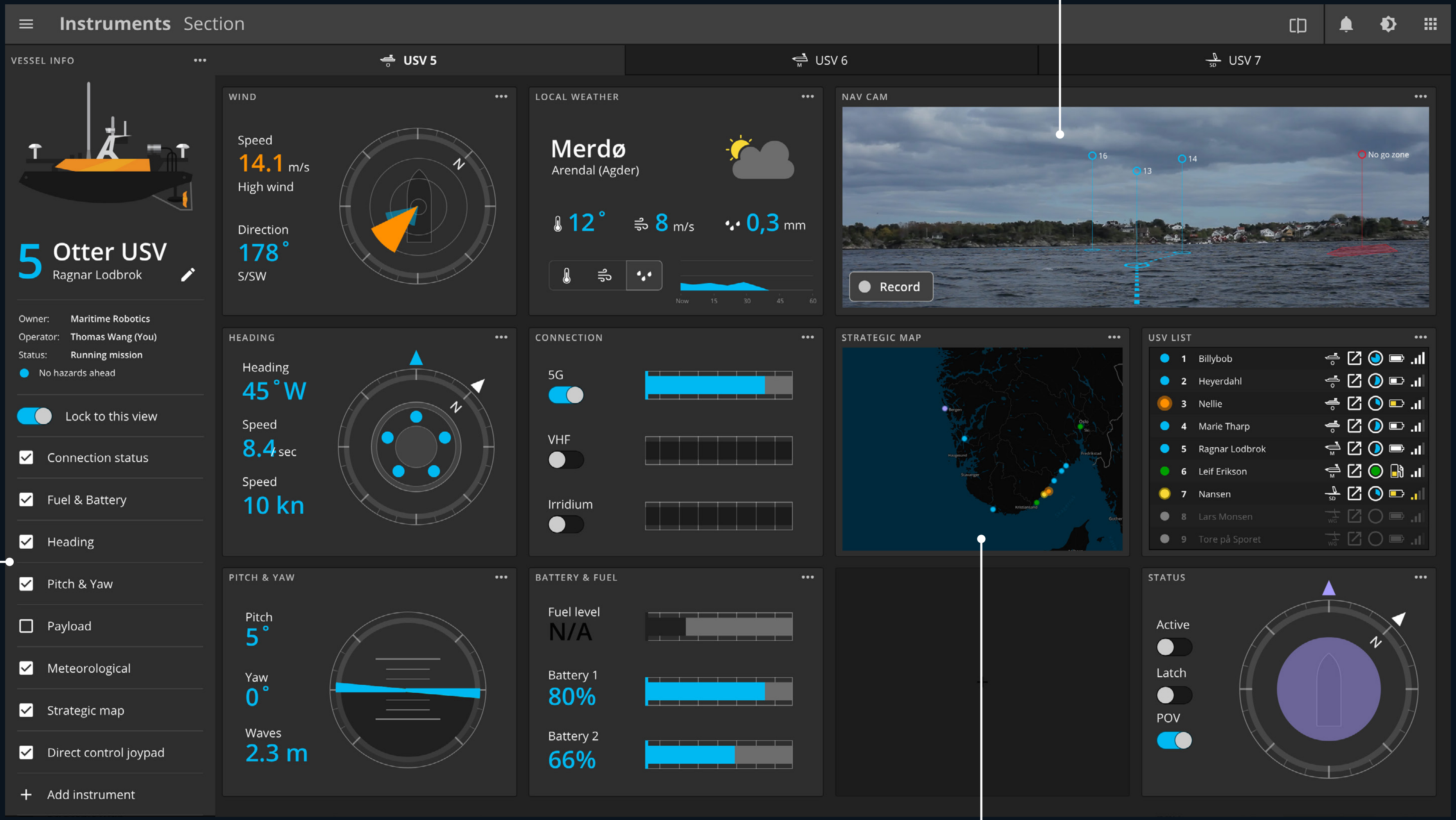


PITCH & YAW - INDICATES WAVES

Instrument section

The Instrument sction includes a description of the USV in the left fixed wighet where you can check and uncheck which instruments youd visible. Other USVs are selected from the tabs and the user can choose to lock the screen to one specific USC, regardless of which one is selected in mission control.

LIVE CAMERA WHEN AVAILABLE



SELECT INSTRUMENTS

STRATEGIC MAP OF ALL USVS

WORKPLACES

SHORE CONTROL CENTRE

TANGIBLE INTERACTIONS

ON A SHIP BRIDGE

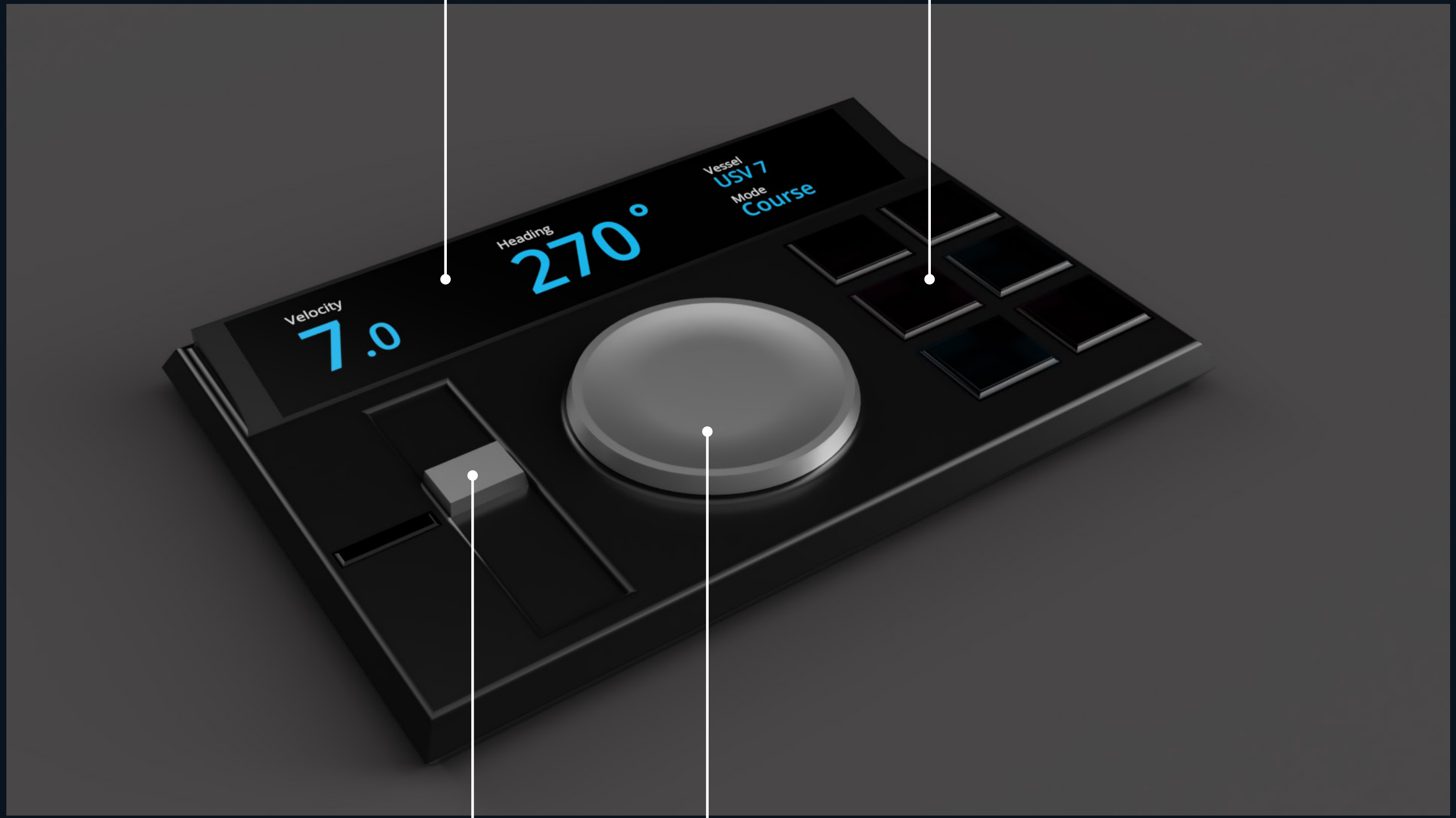
MOBILE IN THE FIELD

Workstation in a Shore Control Centre


Timeline
Mission Control
Instruments Section
Current depth
74m
Total fish
923
+ Add Timeline
Otter USV
Merdø
14.1
178°
45° W
8.4
10 kn
2.3 m
80%
66%
7.0
270°

LED DISPLAY

ASSIGNABLE FUNCTIONS



ROTARY KNOB TO SET THE COURSE BY DEGREES

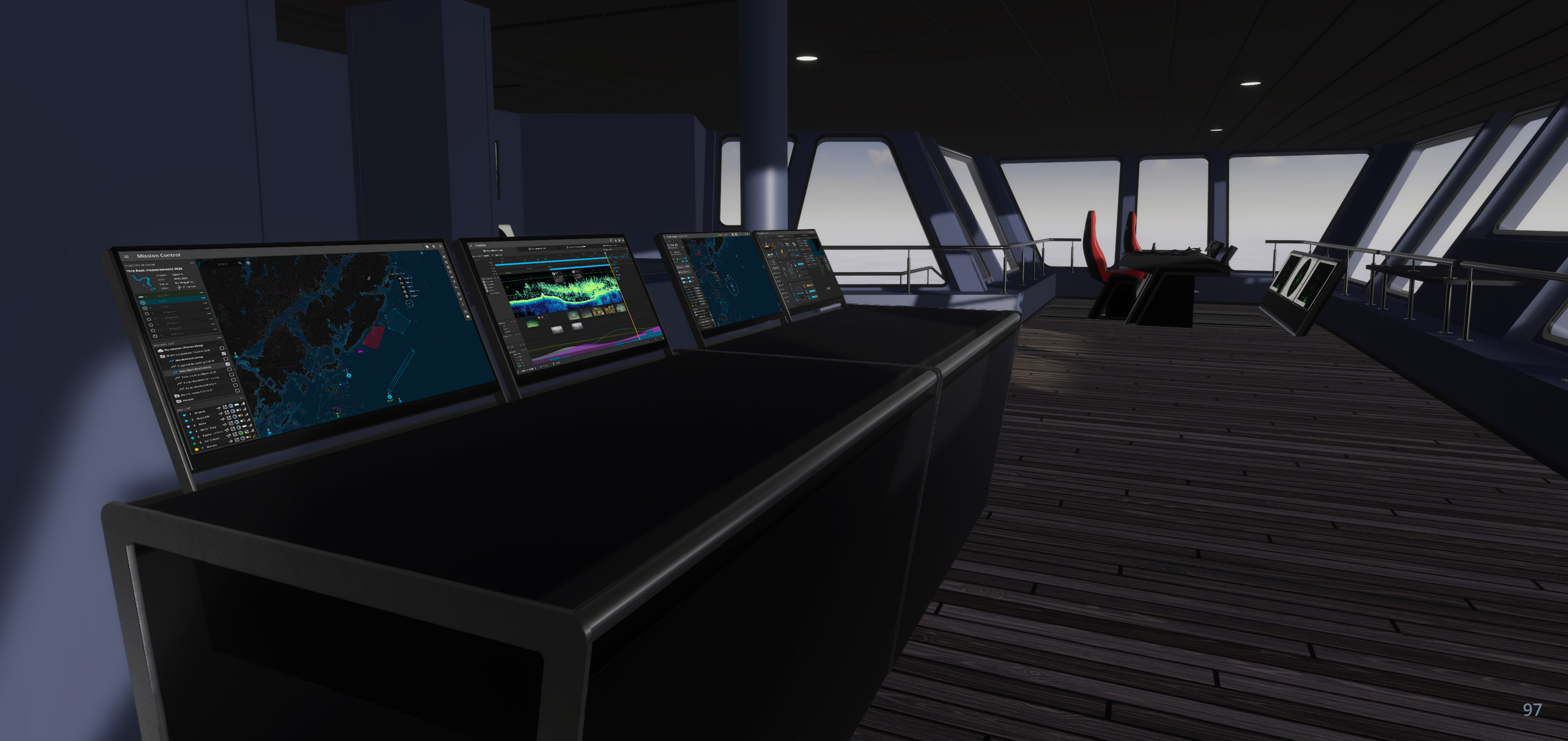
SLIDER FOR ENGINE CONTROL FORWARD AND AFT

Controller

Having physical tangible controllers might ease the workflow when using screen based interfaces over longer periods of time. It was far down in the secondary focus in this project, but I decided to spend an evening working on it anyway to accompany the typical mouse and keyboard setup. This controller is based on the rotary autopilot used on all ships and is intended to use when USVs are in Direct control mode.

Workstations on a ship bridge

from the Ocean Industries Concept Lab - SEDNA arctic navigation project



Worksstation with an additional live camera feed

In the hands of a researcher in the field

By being modular and scalable this could be used by researchers or other that might have use for USVs in their work without being tied to a physical location.


Mission control
USV LIST
1 Billybob
2 Heyerdahl
3 Nellie
4 Marie Tharp
5 Ragnar Lodbrok
6 Leif Erikson
7 Nansen
MISSION LIST
My voyages (Thomas Wang)
Indre fjord depth survey
Superspeed
Dest: GRIMSTAD
Current depth
74m

Voyage

A MODULAR FLEET CONTROL AND DATA MANAGEMENT TOOL FOR UNMANNED SURFACE VESSELS

5
REFLECTIONS

This diploma project started out as a discussion and a search for interesting combinations. I understood early that the use of cutting edge technology could be applied in fields that matters.

This project is not so much about the system and the robots. It is about people using better and smarter tools in their work. The process has been explorative and analytic, and the people that I met early in the project clearly shaped my decisions and helped me find my way. By being forced into nationwide lockdown due to a pandemic simply underlined the importance of getting real insight by meeting real users early in the process.

Challenges

This diploma project has proved to be (as suspected) complex, difficult and astract, and in a field which is in constant development. I was often afraid it would be too technical, too analytical. Some of the reports I have been reading on the autonomy and situation awareness are over my head, but I did want to make my last project at AHO to be both interesting and challenging.

My goal was never to build a finished solution. The extent of covering the basic functionalities of the type of system I am proposing is far beyond what is achievable in a 6 month project by one person. Rather I wanted to explore the technology, and to seek possible directions that could prove to be useful for people and the planet, not just for the sake of technology. In my last online meeting with Maritime Robotics, I got the feeling that several design concepts were surprising and interresting, that in some time could be implemented. I am really interrested in hearing what other other industry actors have to say.

What we as designers are bringing to the table is possibly a new approach to this industry, driven by research and guided by design.

If there was more time (and you always need more time) I would have liked to explore further a number of directions. VR and AR technology are tools that could be applied into a remote control setting. But to me that would have been too much of a steep technical challenge to embark in a diploma project. I would have wanted to go further into the use of audio, as it is a very powerful tool in interaction design and clearly relatable to situation awareness. We take in as much information through our hearing as we do from visual stimuli. This is also why sound design is so important in film and game design, but the fact is that it is often overlooked in other more critical systems.

It would have been fun to go further into the gaming aspects of interaction design, to see what it would have done to my delivery. I believe that a great deal of important knowledge can be gained from gaming interfaces and applied in critical systems.

I still hope that my work could spark some interest within the maritime community and possibly some discussion on what the future of workplaces in a world with autonomous machines could be like.

I want to thank all my contributors helping me stay above water in this project, especially my supervisors Mosse Sjaastas and kjetil Nordby.

Thanks to the amazing staff and co-students at AHO for 5 unforgettable years of hard work, inspiration and fun!

THOMAS WANG JOHANNESEN // 2020


THANK
YOU

GLOSSARY

USV : Unmanned Surface Vehicle
ASV : Autonomous Surface Vehicle
AUV : Autonomous Underwater Vehicles
UMS : Unmanned System

AI : Artificial intelligence
LoA : Level of Autonomy
GUI : Graphical User Interface
HMI : Human-Machine Interface
MBS : Multi-Vendor Bridge System
NTSB : National Transportation Safety Board
ODES : OpenBridge Design System
SCC : Ship Control Console / Shore Control Centre
VTS : Vessel Traffic Services
UHI : Underwater Hyperspectral Imaging

COG : Course Over Ground
SOG : Speed Over Ground
GPS : Global Positioning System
DNC : Digital Nautical Charts
EBL : Electronic Bearing Line

AIS : Automatic Identification System
The automatic identification system (AIS) is an automatic tracking system that uses transponders on ships and is used by vessel traffic services (VTS). When satellites are used to detect AIS signatures, the term Satellite-AIS (S-AIS) is used. AIS information supplements marine radar, which continues to be the primary method of collision avoidance for water transport.[citation needed] Although technically and operationally distinct, the ADS-B system is analogous to AIS and performs a similar function for aircraft.

ECDIS : Electronic Chart Display and Information System
ECDIS is a navigation information system that complies with the requirements set by the International Maritime Organization (IMO). When used with an approved backup system, it is considered a legal replacement for paper charts – if the data is prepared in accordance with the stipulated requirement specifications (S57 ENC Product Specification). The ECDIS must also be type-certified.

LIDAR : a surveying method that measures distance to a target by illuminating the target with laser light and measuring the reflected light with a sensor. Differences in laser return times and wavelengths can then be used to make digital 3-D representations of the target.
Lidar is commonly used to make high-resolution maps, with applications in geodesy, geomatics, archaeology, geography, geology, geomorphology, seismology, forestry, atmospheric physics,etc.

HYDROGRAPHY : the branch of applied sciences which deals with the measurement and description of the physical features of oceans, seas, coastal areas, lakes and rivers, as well as with the prediction of their change over time, for the primary purpose of safety of navigation and in support of all other marine activities, including economic development, security and defense, scientific research, and environmental protection.

BATHYMETRY : the study of underwater depth of lake or ocean floors. In other words, bathymetry is the underwater equivalent to hypsometry or topography.

IRIDIUM : The Iridium satellite constellation provides L band voice and data information coverage to satellite phones, pagers and integrated transceivers over the entire Earth surface. Iridium Communications owns and operates the constellation, additionally selling equipment and access to its services. It was originally conceived by Bary Bertiger, Raymond J. Leopold and Ken Peterson in late 1987 (in 1988 protected by patents Motorola filed in their names) and then developed by Motorola on a fixed-price contract from July 29, 1993, to November 1, 1998, when the system became operational and commercially available.

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