Designing Maritime Domain Awareness Platforms

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Dec. 9, 2022

Introduction / Background

Maritime Domain Awareness (MDA) relates to being aware of activities occurring in the maritime domain that may have an impact on the security, safety, economy, and environment of the ocean (Tetreault, 2005). The goal of MDA is to develop understanding and transparency of activities and threats at sea (Bueger, 2015). So, it must collect sufficient and accurate information of ongoing maritime activities to identify potential threats, make informed decisions, take appropriate action, share information with relevant partners, and respond to maritime activities by working with the government incorporating situational awareness to minimize resulting damages (Transport Canada, 2020). However, collecting and interpreting the data to develop systems to detect such anomalies is socially, politically, and legally complex with different laws, rules, and practices governing different areas (Bueger, 2015).

A common way to collect information like vessel detection, movement, classification, identification, and consistent monitoring of the vessel which supports surveying the waters is with Automatic Identification System (AIS) (Tetreault, 2005). AIS transmits a vessel's position, showing its position to other vessels and organizations. The International Maritime Organization and other management entities require large ships like commercial fishing vessels to use AIS to locate their position as it prevents collisions (Global Fishing Watch, n.d.). Over 400,000 AIS devices are used for vessel location, identity, course, and speed information annually (Global Fishing Watch, n.d.). This information is critical for MDA, with risk assessment tools like Global Fishing Watch (GFW) and Skylight (SK) depending largely on AIS data. The quality and quantity of data is essential for productivity (Emmens et al., 2021). Yet, only two percent of the world's fleet uses AIS so situational cases cannot be made (Belhabib, personal communication, 2022).

Also, AIS does not provide concrete data. Existing risk assessment tools require lots of human analysis to interpret the AIS data. This puts a strain on the functional requirements which are to provide awareness of maritime activities and identify possible threats, since these platforms alone cannot inform users of these events. And, AIS itself can be unreliable and insufficient for users' needs, making human analysis more difficult and subjective. Vessels commonly turn off their AIS signal to hide their whereabouts when engaging in illegal activity (Emmens et al., 2021). But, vessels also turn off their AIS signal when they feel unsafe in some regions (Kolla, personal communication, 2022). Another weakness with AIS data is that it can also be "noisy" due to the equipment used, external factors, humans, and dense traffic, making the data unclear (Emmens et al., 2021). This is why Nautical Crime Investigation Services (NCIS) is developing *Grace*, an AI powered risk assessment tool that uses machine learning to predict and identify suspicious activities and notify the appropriate organizations to intercept before it occurs (Belhabib, personal communication, 2022). *Grace* should be able to predict with high accuracy and certainty what and where suspicious activities occur and who is involved, facilitating pattern recognition for what looks like suspicious activities at sea, reducing intervention times (Ghattan, personal communication, 2022).

This report focuses on the early design implementation of the MDA platform, *Grace*. Besides the previously mentioned functional requirements, MDA platforms must convey the information effectively through its interface so users can interpret it accurately for their needs, meaning user experience (UX) research and user interface (UI) design are critical to the design process. UX research focuses on learning the needs of the end users, as well as their behaviour, abilities and fallibilities, and struggles in terms of usability (Rosencrance, 2021). UI design focuses on the visual design of the interfaces and how the interface interacts with users, with goals of making them easy and enjoyable to use, providing a positive experience to the user (User Interface Design Basics, 2014).

Research Scope

The goal of this study is to understand how MDA platforms currently support users and what users' experience is like with these interfaces. The research questions will help us learn which features are essential to MDA platforms, provide insight into user experience, and eliminate assumptions in users' context, needs, expectations, and abilities, minimizing human error (Sharp et al., 2019).

The research questions are the following:

1) *How helpful are the current features of MDA platforms?*
2) *Is the current design of MDA platforms effective?*

Our research involves conducting observations and interviews with end users to identify their habits and learn how we can improve user experience and usability of MDA platforms. This pre-design stage will generate the design requirements for *Grace*, leading us to determine the design concepts and create initial prototypes in the early design stage. Though this report does not cover the early design stage in full, it contains recommendations and lo-fi prototypes for *Grace*.

Related Company Goals

Nautical Crime Investigation Services (NCIS) is a tech corporation that uses a human-centered approach to provide responsible and ethical solutions to detect crimes at sea and bring maritime domain awareness. They strive to be culturally aware and inclusive, creating products that are accessible to their clients' needs, regardless of their responsibilities and backgrounds.

NCIS aims for *Grace* to be usable by many different groups with varying responsibilities and interests. The government, including sectors like the monitoring, control, and surveillance (MCS) and enforcement agencies want to ensure fishing vessels are following regulations, pursuing those that are participating in illegal activities (Whyte, 2016). Fisheries officers are responsible for enforcing the federal and provincial regulations for protecting fish, wildlife, and natural resources (Fisheries Enforcement, 2020). They may use *Grace* to monitor and detect whether vessels enter a prohibited zone, compromising ocean safety. MCS workers focus on deterring illegal, unreported, and unregulated (IUU) activities relating to the sea (International Fisheries, 2019). Thus, they may want to see suspicious activity occurring at sea. Maritime insurers are interested in vessel condition and the safety of the people on the vessels, as they are liable for bodily injuries or deaths of a person, and the damage of the vessels (Marine Insurance Exemption, 2022). Then, they may want to monitor encounters, collisions, or potential dangers to people like piracy, human rights violations, and more. Seafood suppliers may want to know how their product is sourced, using *Grace* to follow their suppliers to understand where and how their products are caught (Whyte, 2016). Maritime journalists and researchers investigate and report news regarding the ocean, including ocean health, impacts of fishing and other ocean activities, and suspicious vessels and activities. NGOs and citizens may also be interested in a variety of topics, including seafood sustainability and suspicious activities at sea (Whyte, 2016). Fishermen may use *Grace* so other vessels are aware of their location for transshipment and encounter purposes, or to prevent collisions. Therefore, *Grace* should provide features for each of these groups, satisfying their needs and supporting their responsibilities.

Approach & Recruitment of Participants

<u>Overview</u>

We used a triangulation approach to enhance validity, collect more in-depth data, and interpret the problem in different ways (Nightingale, 2020). Triangulation involves collecting and analyzing data from more than one source, resulting in researching the same problem from multiple perspectives (Nightingale, 2009). We interviewed with NCIS, performed a competitive review, and conducted a usability test with end users using an observation and interview.

<u>Interview (Internal Stakeholders)</u>

This interview was to understand the goals and vision for the company and their products (Appendix D.2). The participants were the two co-founders of Nautical Crime Investigation Services (NCIS). The interview was open-ended to allow probing to understand deeper, but questions and topics were used as a guide. It covered questions regarding them as a company, their opinions on what a successful MDA platform looks like, and their expectations for *Grace*. It also involved their opinions on GFW and SK to understand their purpose for using these tools, how they support or not support their work, any problems they may run into, what features are helpful, and how easy they find these platforms to be. We collected mostly subjective and qualitative data, as much of their answers were from their perspective.

Competitive Review (Independent)

A competitive review is a form of evaluation of the interface where an individual reviews designs based on their usability experience and knowledge (Schade, 2013). The reviewer was the lead researcher in this study. This was to familiarize ourselves with the platforms and see what works and what does not from our perspective (Appendix D.3). It involved exploring GFW's map directly, using task examples we created to see if the interface could support it. Video tutorials were used to understand how SK worked and what features it offered. Strengths and weaknesses of both interfaces were summarized. We collected mostly subjective and qualitative data as it was from the reviewer's perspective. This data was used to create observation tasks and evaluation goals for the usability test.

The following are the evaluation goals:

1) *How helpful is the map / interface for finding vessels?*
2) *How helpful are the filters in supporting their tasks?*
3) *Is the available information displayed on the interface sufficient for effective interpretation?*

Usability Test: Direct Field Observation + Interview (External Stakeholders)

A usability test helps determine whether an interface is usable by the intended user population to carry out tasks for which it was designed for (Sharp et al., 2019). We used this method to identify where we could improve MDA platforms in terms of usability and user satisfaction. The usability test was structured as an observation and interview to understand the context of when and how end users use MDA platforms and allow users to summarize their overall experience. The evaluation goals mentioned previously were used to evaluate the interfaces based on how users complete the tasks during the observation and their opinions and comments during the interview. We used GFW and SK as the MDA platforms to test. We recruited participants who worked in the maritime industry and sent emails detailing the purpose and structure of the study. Four observation sessions were set up, three using GFW and one using SK.

The observation session consisted of four tasks and were consistent across users and interfaces:

1) *Can you find Long Wang Chyun NO37 in 2021 and tell me a bit about what you know about the vessel from the interface?*
2) *Can you find a Spanish trawler fishing in a prohibited zone?*

3) *Can you identify an encounter between 2 vessels and tell me what each of their flags are?*
4) *Beside fishing related activities, can you identify any other crimes from this interface?*

A coding sheet was used to collect qualitative, quantitative, subjective, and objective data during the observation. Examples of data were the time it took to complete a task, whether a task was successful, what features were used, body language / facial expression, and comments made during the observation.

The interview was conducted immediately after the observation and consisted of nine questions. Most were open-ended, allowing users to elaborate on their answers, and many were paired with a Likert scale to allow for better comparison between participants. The data collected was qualitative, quantitative, subjective, and objective. Examples of questions include what they did for work, their familiarity with the MDA platform they used, and how easy the platform was for them.

The qualitative findings were analyzed separately while the quantitative findings were analyzed together (Appendix D.1).

Key Findings

Global Fishing Watch Qualitative Analysis

From our affinity diagram for GFW observations, we identified themes relating to three strengths, three weaknesses, and one limitation (Appendix C.1).

Strength: Cues help with interpretation, learnability, and usability

Users often referred to the colour identification and legends to understand what features were currently being used on the interface. Many also used the information button *i* that describes the purpose of each feature to learn how to use them. They used this to find features to help them with their tasks, especially task 4, suggesting it helps with discovery purposes. Finally, every user was drawn to the *question mark bubble* which revealed instructions about the interface, improving learnability (Appendix A.4).

Strength: Encourages discoverability

Users felt comfortable playing around with the interface. For task 4, every user went through every visible button and icon on the screen, including the filter panel on the left side, the buttons on the right, the timeline on the bottom, and even the toolbar furthest to the left (Appendix A.1). This led to users discovering other GFW's features like the type of sources they get their information from (AIS, VMS, SAR). Users also clicked on random grids on the map and any buttons that popped up.

Strength: Helpful features offered

Every user used the *Search for vessels* function and also played around with the timeline. Users also commented about how many helpful and relevant features GFW offered, including the different reference layers and source types. Every user mentioned GFW had at least one feature that would be helpful in their line of work, whether it was to help them monitor vessels, deter illegal fishing, detect entry / jurisdiction violations, or other responsibilities. However, this may have traded off the efficiency of the platform as users also commented about it being slower to load and refresh, leading us to our first weakness.

Weakness: Slow and heavy / overwhelming interface

A consistent finding across each GFW observation was that the interface was very slow. Although GFW has attempted to make as many of their features as visible as possible, it may be why the system is slow to load queries. Every user commented about how slow it was, refreshing as they thought it would make the page load faster. One user turned their hotspot on as they thought it was their network. Fortunately, most of the users found that shortening the timeline helps GFW load faster, suggesting the amount of data impacts the efficiency. This shows that users incorrectly understand why the system is slow, affecting their learnability and experience with the interface.

Weakness: Unclear cues and poor feedback results in misinterpretation

Users' expectations for their actions sometimes did not match the system status. First, every GFW user had difficulty finding the *Filters* feature, suggesting this cue was poorly designed. Guidance was given to all GFW users to find the filter icon and the task was easy to complete after locating where *Filters* was on the interface. Second, users assumed the text under the list of vessels reading *+45 more* is clickable, suggesting their mental models led them to believe the text would show the other 45 vessels (Appendix A.2). This is a common cue used to show more of similar items so using this text under a list may have caused poor feedback. Similarly, some users tried clicking on the circle with a number when looking for encounters (Appendix A.3). GFW uses these circles to indicate the number of activities occurring in the area and is not a call to action. This error suggests users are not learning the interface effectively.

Weakness: Confusion around using some of the features

Although users found the features helpful, most felt there was an initial learning curve as features were difficult to learn. We heard lots of *"How do I do X?"* and saw a lot of hovering over features as if lost or confused. During the tasks, users questioned *"Is this what I should do?"* and *"I don't know what X means"*, suggesting there was confusion around using the features. There was also one user who requested a user manual several times, suggesting the interface was not as intuitive as it could be.

Furthermore, there was particular difficulty for task 2, and we hypothesize it was due to the extra step of interpreting the data, but this critical incident will need to be looked into further. Also, although every user used the vessel detection function, many used it incorrectly, inputting in the characters for the abbreviation for a country to search by vessel flags, but the system returned a list of vessels with the characters in the vessel name.

Limitation: More concrete information requested

Users wished there was a feature that could inform them of more specific activities. The types of activities mentioned included understanding what activity was happening between two vessels during an encounter, the type of vessels shipping where, which areas are prohibited or authorized for specific types of vessels, and more. These activities help MDA platforms fulfill their functional requirements.

Skylight Qualitative Analysis

Only one user used this platform so patterns were not observed, but key differences in visual design between SK and GFW were identified.

Visual hierarchy is the structure of information on a page that communicates order, emphasis, and relationship. SK's features are located in a toolbar at the top of the interface instead of a side panel like GFW (Appendix B.1). The toolbar uses dropdowns to encompass the features, decluttering the interface (Appendix B.2). Dropdown tabs require intuitive labels that reflect the hidden menu items since these features are invisible to the user until they are clicked on. Contrastingly, GFW uses a scrollable side panel, offering more visibility. But, one user mentioned the skinny scrollbar makes it easy to miss and hard to use, offering poor usability. Side panels also require different fonts, type of texts, colours, input types, labels, and imagery to separate groups and ideas (Appendix A.1). These designs must be applied to every feature to provide consistency, and also be well understood so users can learn and use it easily.

Visual cues are the elements our eyes process during visual perception and include everything on the interface we can see (Tidwell, 2010). SK complements their icons with text to signify possible actions. For instance, *Filters* is complemented with a standard filter icon to indicate it is the button to filter (Appendix B.1). SK also includes a number next to each dropdown tab to indicate the number of options selected. And, SK displays a vessel's location differently from GFW, using specific icons to indicate the type of activity and where it occurred. GFW uses different colour shades of grids to show every single occurrence of when and where a vessel is fishing and the hours of activity in an area.

SK and GFW work differently. SK waits for users' queries before loading anything on the interface, while GFW defaults to show everything they have collected from AIS and VMS. SK also organizes vessel data and activity differently from GFW using a separate page listing every activity the vessel has been involved in. However, unlike GFW, SK only shows the most recent position of the vessel and does not show historical tracks, and tracks a much smaller duration for each event. This may be why SK loads a lot faster than GFW as there is less data upon updating. Finally, although both platforms offer basic features like vessel monitoring and features for fishing, SK also covers speed and entry activities.

<u>Quantitative Results & Analysis</u>

We found the average of the following metrics for MDA platforms from every user (Figure 1).

Metric	**Out of 5**
Familiarity (1 = not familiar, 5 = familiar)	2.75
Navigation difficulty (1 = easy, 5 = hard)	2
Interpretation difficulty (1 = easy, 5 = hard)	2.44

Figure 1: Average of ratings from GFW and SK users (Personal Experience and Opinions)

These were subjective ratings and not every answer matched their actual performance. Thus, we also looked at the time it took for them to complete the three tasks (Figure 2).

	GFW Average Time (s)	**SK Average Time (s)**
Task 1	87	10
Task 2	440	120
Task 3	340	120

Figure 2: Average time to complete tasks 1, 2, 3 on GFW and SK.

The time it took to complete each task does not necessarily reflect efficiency, so we also analyzed their behaviours, comments, and overall accuracy.

GFW Accuracy Analysis

Task 1: Every user except one found the vessel on the map and its tracks. Every user correctly interpreted the information regarding the vessel, including their flags, MMSI, call sign, gear type, but some uncertainty and confusion arose regarding the type of fishing and what the dates mean on the interface.

Task 2: This task required knowledge of prohibited zones. Most users assumed where a prohibited zone was based on their experience, with many using EEZ and MPA reference layers. Also, most users tried using the search vessel detection feature that they previously used for task 1. Specific descriptions were typed in this search bar, including different variations and combinations of *"Spanish"*, *"trawlers"*, and *"ESP"*. One user found a Spanish trawler, but no effort was made to identify where the vessel was on the map to check if it was fishing in a prohibited zone. The other users had trouble finding features to help them with this task, so we guided users towards the *Filters* features.

Task 3: The difficulty was around locating the necessary features to complete this task, however, once the *Encounter* feature was found, it was relatively easy to identify an encounter between two vessels and the flags of the vessels involved. Only one user was not able to identify the flags of the encounters.

SK Accuracy Analysis (Significant Findings)

The one user using SK completed every task accurately and was very familiar with SK, so this data may not be an accurate representation of end users. Still, the difference in time the user completed these tasks compared to users using GFW may indicate some design properties may be more helpful to include in MDA platforms. Task 1, 2, and 3 were completed significantly faster than users who used GFW.

Task 1: This difference may be because the search function is very visible at the top of the interface with the label *Search for vessel* clearly identified. The information interpreted was also different, as this user focused more on the events the vessel was involved in, including where it fished and for how long. SK did not display as many vessel properties as GFW, showing an unknown call sign, IMO, and vessel type.

Task 2: This difference may be because of how SK designed their *Filters* function. SK uses a different filter icon with the label *Filters* next to it, making it more visible. This may be easier to locate than the filter icon on GFW. Also, SK allows users to draw and add zones onto their map. This user already had zones drawn and knew of some prohibited areas, making task 2 a lot easier and faster.

Task 3: This difference may again be due to visibility. Though new SK users may spend longer finding a feature to help them with this task, SK only has three dropdowns to choose from, making it a lot simpler. However, users will have to know the feature *Standard Rendezvous* filters for encounter events, which may be a point of confusion without training as SK does not explain what this is on the interface. But, knowing this, users can easily filter the database to only include encounters and click on any of the icons that appear, revealing the vessels involved and their information in a pop-up. This makes identifying the flags easier instead of having to perform several steps to find the vessel information.

Conclusion & Design Requirements

We conclude that MDA platforms, specifically GFW and SK, have helpful features to support users in their tasks and responsibilities. Every user used a vessel detection search function which proved helpful for finding vessels, especially for task 1. Users also used *Encounter* or *Standard Rendezvous* for task 3. The features on these platforms support tasks that do not require much subjective human analysis.

However, some design choices for icons or cues could be improved to better serve the functional requirements on GFW. Specifically, there was difficulty when locating certain features, such as the *Filters* feature. Since every user using GFW could not locate it without help, we conclude this cue does not match their mental model, lending itself to the possibility of confusion, hindering learnability and usability. Therefore, we conclude that the current design of GFW is not intuitive enough for users to understand or interpret icons or cues to take advantage of the features offered. Moreover, we observed lots of misinterpretation and navigation issues with the features when there was a lot of human analysis involved (Appendix C.1). GFW users had difficulty with task 2, suggesting the current design of GFW is not effective enough for users to understand how to use the interface and interpret the information.

To improve the overall usability and user experience, we determined the requirements needed for *Grace*:

1) *Functional: detect / monitor vessels and predict suspicious activity with high certainty*
2) *Usability: easily learned and retained*
3) *User characteristics: globally understood*

Detecting and monitoring vessels and predicting suspicious activity with high certainty are necessities as they are the central tasks for *Grace*. *Grace* should be easy to learn and remember so users can understand and interpret the information accurately and effectively. This requirement helps *Grace* compete with established MDA platforms as users will not trade off switching platforms if it is too difficult to use. Finally, *Grace* should be globally understood to improve findability and discoverability of the features, giving *Grace* a competitive advantage as it is more accessible, attracting a wider range of users.

Design Recommendations: Design Concepts and Lo-Fi Prototypes

Based on the requirements, we propose three design concepts to focus on for *Grace* and present three lo-fi prototypes of specific features based on these concepts. We used GFW's interface as the basis.

Design Concepts

An **affordance** is the relationship between the physical object and the user (Norman, 1988). *Grace* must afford to detect and monitor vessels, report vessel information, identify activities like transshipments and encounters, and filter through these options to make it easier for users to use and read the interface. *Grace*'s differentiating point is to predict potential crimes and identify suspicious activity at high certainty. This serves their functional requirements – providing awareness of maritime activities and preventing crimes to help close the gap between human analysis and risk assessment.

Feedback communicates the results of the action taken so the user understands the consequences of their action. It can be visual, tactile, audio, or anything to notify users of some change. It should also be informative, immediate, planned, and prioritized to help users learn and use the system, and should impact how the user uses this feedback in the future. Thus, the feedback should be easy to learn and remember so users can overcome their mistakes in the future, improving their workflow and usability.

Signifiers are perceivable cues about the affordances (Norman, 1988). They typically take the form of icons or buttons because they should always be visible to communicate possible actions to the user. *Grace* offers various affordances and features to support a wide variety of users which can be overwhelming for individuals when only a few features may be relevant for their work. Thus, signifiers should help users understand possible actions without doing too much mindless exploring on their own. These signifiers must be globally understood to be effectively used by users of different backgrounds and experience to reflect the end-users of *Grace*, meaning they must be universally transferable.

Lo-Fi Prototypes

Colour Code Activities: **Affordances** can be perceivable, but some are invisible, making it hard to know how the object can be used and what actions are possible. To make invisible affordances discoverable to the user, we can implement focal points as **signifiers**, which are deliberate cues to draw viewers' attention (Rusonis, 2022). This is useful for new features as users will not have encountered these features before. **Feedback** then helps users understand the consequences of their actions and learn these affordances.

In this prototype, we designed one of *Grace*'s new features which is to detect suspicious activity at sea (Figure 3). Vessels predicted to be involved in some suspicious activity in an area are labeled by a colorful dot. We arbitrarily chose the colours, so we used a legend to indicate what each colour means. This works because these bright dots stand out in a sea of grids, encouraging users to click on them to uncover what they mean. Upon clicking, *Grace* shows a pop-up, listing the vessel information and highlighting the potential suspicious activities it has detected in the same colour as the dot, providing good feedback as it helps users understand the affordance. For instance, if a vessel is predicted to be involved in drug trafficking and illegal fishing, they are labeled by an orange dot and the list highlights *drug trafficking* in red and *illegal fishing* in purple.

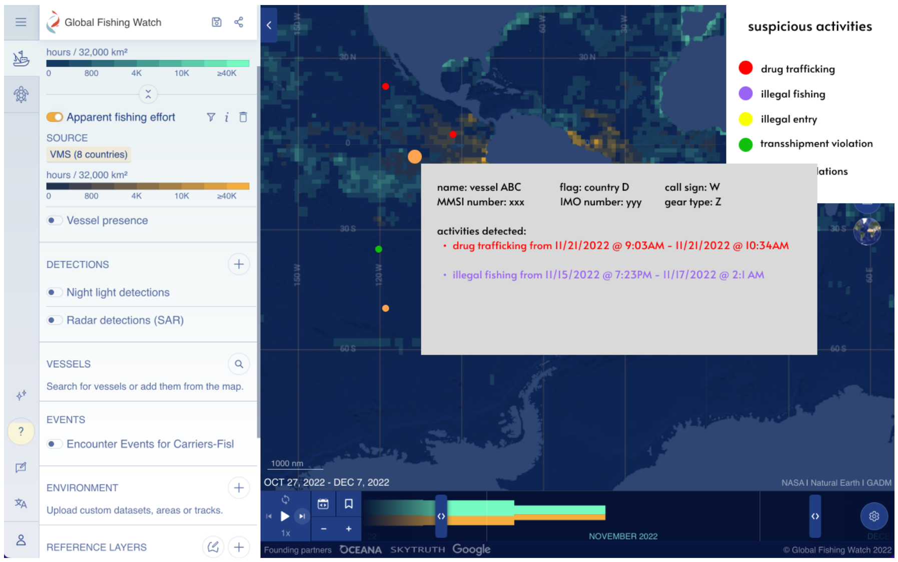


Figure 3: *Colour code activities prototype with an orange dot clicked*

Search Bar: Ensuring *Grace* provides the functionalities a user expects is another way to implement an **affordance**. Many users typed in abbreviations for countries, expecting the system to return vessels of that flag, so we designed *Grace* to be able to search by a specific flag, the vessel name, or other properties to match users' expectations. Users can also search by activity, finding every vessel involved in some activity. The **signifiers** can take advantage of users' transfer knowledge from other types of interfaces, making learning and remembering how to use the interface faster and easier. Then, the **feedback** should match users' expectations, returning a list of vessels that match the criteria.

In figure 4, we designed a search bar. A search bar is a good cue to let users know they can search for specific vessels as it is commonly used to communicate the affordance to search. However, it is only a good cue if it is visible, thus, *Grace* should stick the search bar to the top of the interface, making it visible at the point of entry but also when users move through the interface. Putting it at the top also matches where search functions are on other types of interfaces like search engines, shopping websites, streaming platforms, and more, making it a common place for users to look. Also, since we recommended *Grace*'s search function to be able to search for vessels by specific properties, we added buttons below the search bar to communicate this function to the user. The button selected by the user is shaded darker and the label inside the search bar reflects the option chosen, reading *search by X*. Each time a user clicks a different button, the label changes, notifying the user a change in the system.

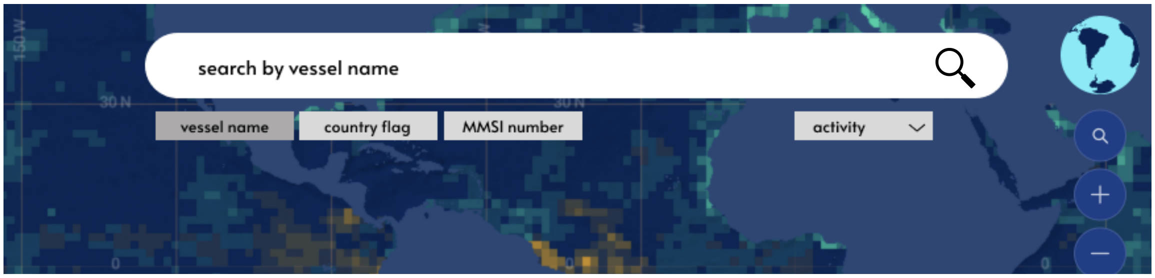


Figure 4. *Search bar prototype with vessel name property selected*

Menu Bar: We designed a menu bar since an **affordance** is to filter the system based on user criteria (Figure 5 and 6). Users had difficulty finding the *Filters* feature from our observations, suggesting the icon itself was hard to identify. Since not every image is universally understood, we complemented the icon with text to **signify** the possible actions, and placed it at the top, making it very visible to users. We also used numbers to indicate the number of filters users applied so they are always aware of the system status. Dropdowns are used to encompass the features, providing a cleaner and less overwhelming look. They also minimize human error since users can only select a number of tabs until they find the feature they are looking for. Checkmark boxes are used to make it easy for users to select / deselect the features they desire, providing immediate **feedback**. And, we added an *Apply filters* button to improve workflow and efficiency. This prevents the system from reloading after every filter selection which can provide a poor user experience. Instead, it only reloads once the button is clicked, providing good feedback.

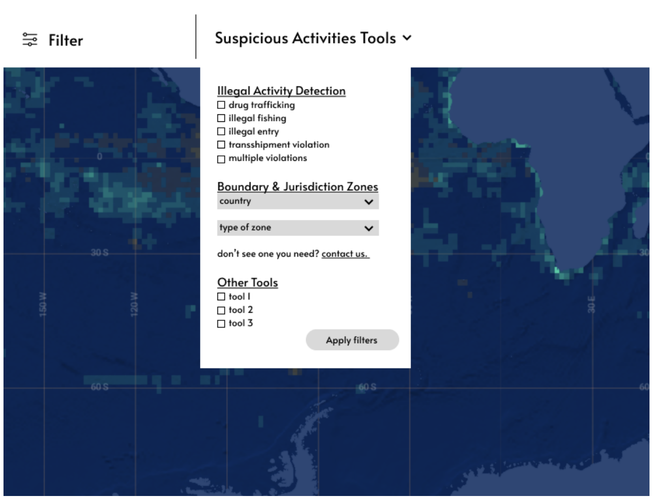


Figure 5: *Menu bar with filter dropdown opened*

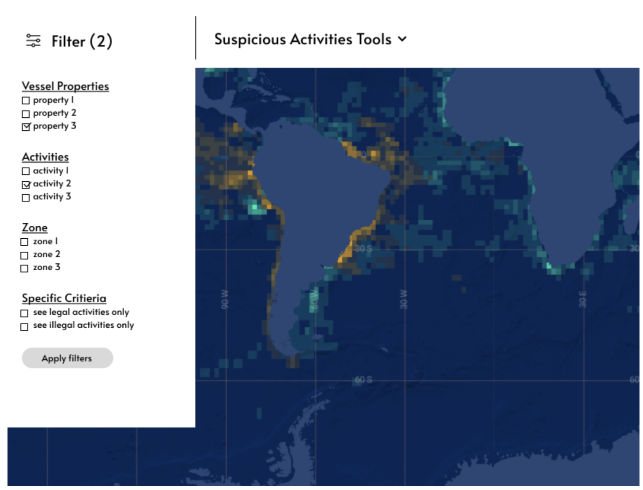


Figure 6: *Menu bar with suspicious activities tools dropdown opened*

<u>Summary</u>

Grace must be organized in a way so users understand how to approach and use the interface. We suggest considering affordances, signifiers, and feedback to improve usability and user experience. Affordances help fulfill the functional requirement, signifiers help with learnability and retention, and the design of signifiers and feedback allows features to be globally understood.

Limitations

Due to time constraints, we were unable to schedule more end users based internationally. It was difficult scheduling times that worked for both the researcher and participants located internationally due to the time difference and internet connection. For a future study, we recommend interviewing more international users to compare their usability and behaviours on MDA platforms.

Due to resource constraints, we were unable to schedule more end users to perform the usability test on SK as it requires an account. Since NCIS used SK and found the interface very helpful, this MDA platform was used for the usability test. For a future study, we recommend creating a testing account which participants can use for a better representation of the usability and user experience for SK.

Future Directions

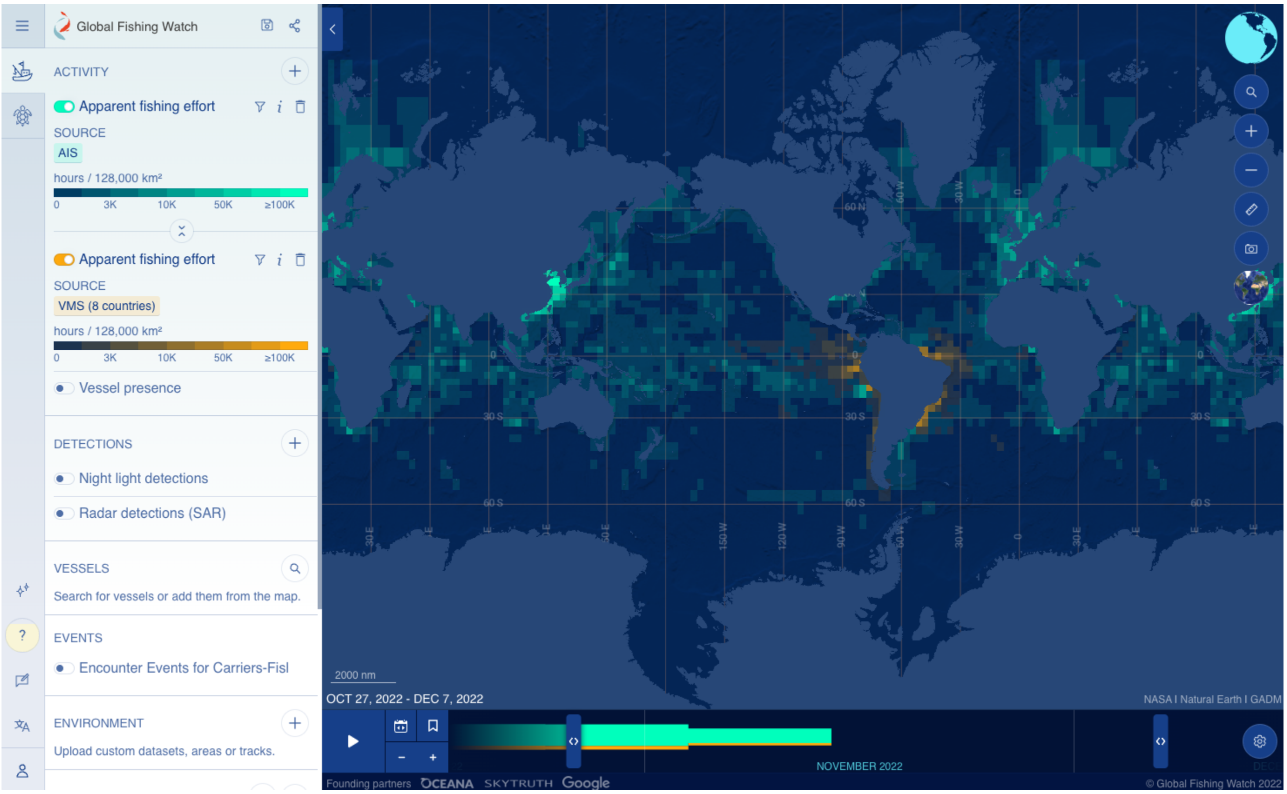
We recommend creating more lo-fi prototypes for *Grace* based on the design requirements and recommendations identified in this report. Designers should conduct cognitive walkthroughs to understand what works and what does not on our lo-fi and newly created ones, and reiterate until satisfied. If time allows, we also recommend A/B testing with end users to understand which of the lo-fi prototypes works best and why, before settling on one to refine into a med-fi with some functional features implemented. The med-fi prototypes should be tested using usability tests and heuristic evaluations by experts within the maritime field before refined into a hi-fi prototype based on the feedback. This prototype should be completely functional and ready to handoff to the development team before being deployed to real end users to test and evaluate in the field.

Study and Research Summary

Grace is a new MDA platform that has the ability to recognize patterns resembling suspicious marine activity. To design this interface, we conducted a usability test with end users, looking into established MDA platforms (GFW and SK) to understand how helpful the features are in these platforms and whether the design of these platforms can convey the information effectively through its design. These questions helped us learn how MDA platforms currently support user experience with these interfaces, highlighting areas that are strong but also areas that need improvement. Knowing this, we can implement the strengths into *Grace*, like adding the helpful features from these MDA platforms into *Grace*, making features visible when possible, and implementing features that facilitate learning like an information *i* button. We can also develop solutions that improve weaker areas we found in these MDA platforms into *Grace*, like requiring users to input specific criteria before loading the information on the interface to make it run faster, designing a more intuitive and visible cue for the *Filters* feature, and avoiding certain elements that look like icons when they are not clickable. Understanding the strengths and weaknesses of existing MDA platforms helped us determine the design requirements and design concepts for *Grace*, and we designed three lo-fi prototypes based on these concepts which can be used as initial design ideas for *Grace*.

APPENDIX A

A.1) Global Fishing Watch Interface



A.2) Global Fishing Watch Pop-Up Modal of Vessel Information

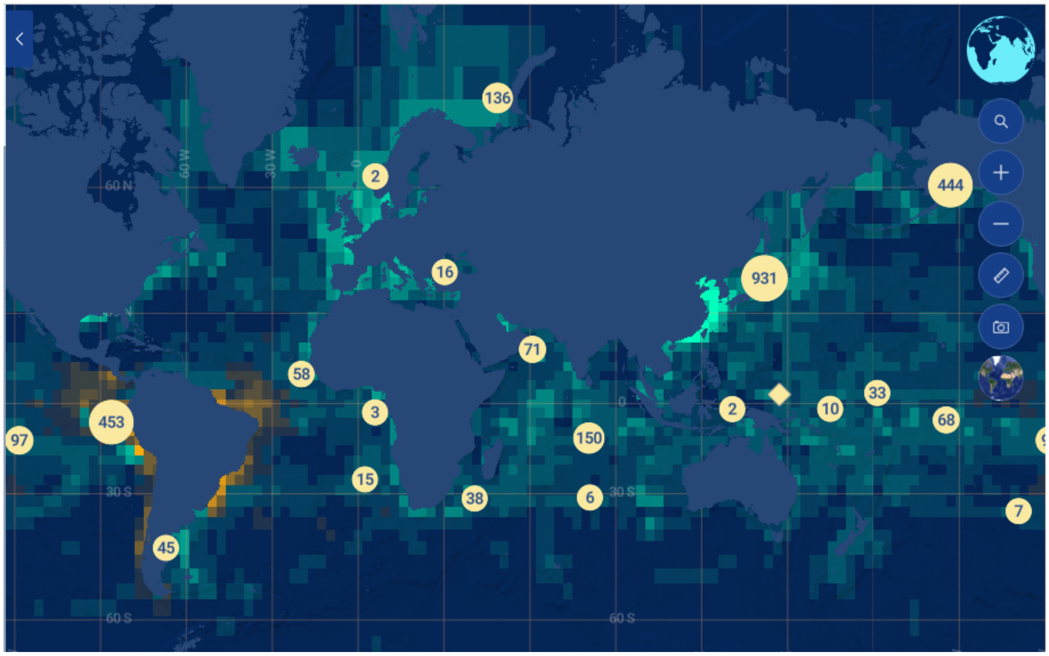
Apparent fishing effort between Aug 6, 2022 and Nov 4, 2022

4,198 hours

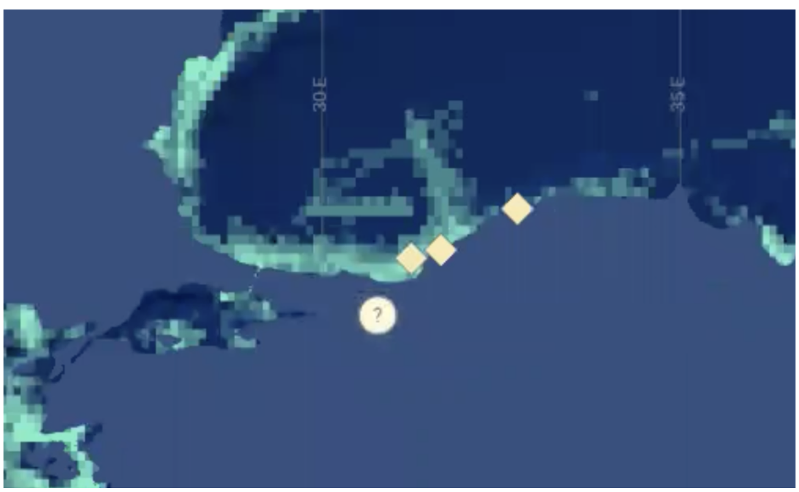
VESSELS	FLAG	GEAR	SOURCE	HOURS
TAIXIANG1	CHN	Drifting longline	AIS (Fishing Ves…	277
Tai Xiang 10	CHN	Drifting longline	AIS (Fishing Ves…	261
Tai Hong 6	CHN	Drifting longline	AIS (Fishing Ves…	259
Imula 0013 Jfn	LKA	Drifting longline	AIS (Fishing Ves…	245
Imula 0682 Chw	LKA	Drifting longline	AIS (Fishing Ves…	225

+ 45 more

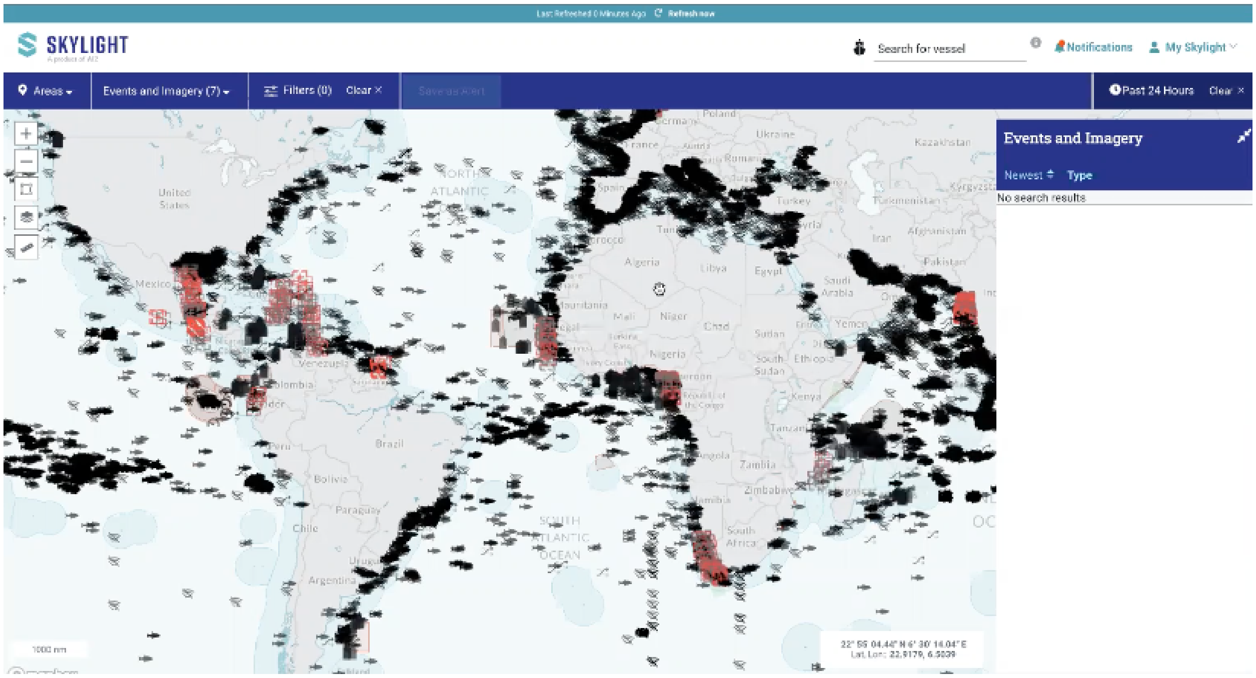
A.3) Global Fishing Watch Encounters Result



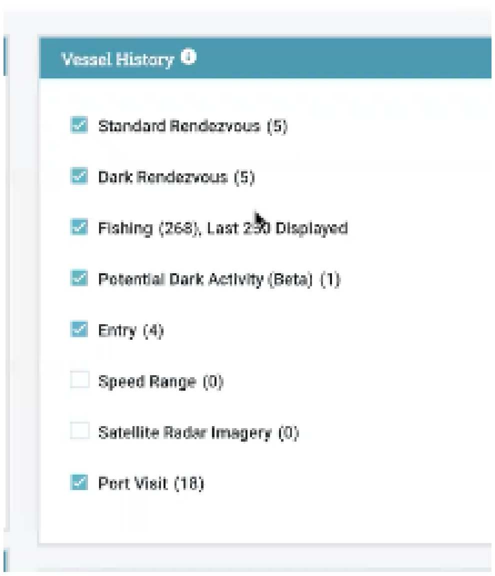
A.4) Question Mark Bubble



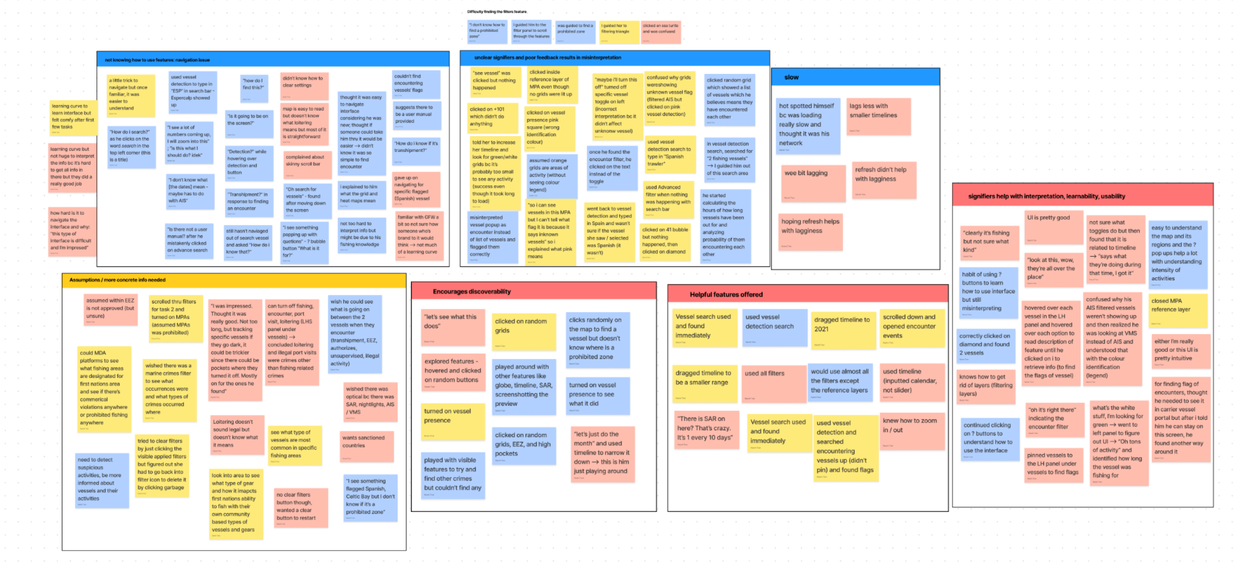
B.1) Skylight Interface



B.2) Skylight Events & Imagery Dropdown



C.1) GFW Affinity Diagram



C.2) Average Time to Complete Tasks on GFW and SK

Participants	familiarity	navigating	interpreting	
a	3	1	1	
b	1	2	2.5	
c	2	3	3	
d	5	2	3.25	
avg	2.75	2	2.4375	
%	0.55	0.4	0.4875	
GFW Participants	a	b	c	average time (s)
task 1	90	80	90	86.66666667
task 2	600	120	600	440
task 3	360	540	120	340
SK Participants	d			
task 1	10			
task 2	125			
task 3	25			

D.1) Usability Test Raw Data: Interview notes + coding sheets

https://drive.google.com/drive/folders/1Oq1vmPVLLStdGnXnZklEdcBFfW_mnFHH?usp=sharing

D.2) Initial Interview Raw Data

https://docs.google.com/document/d/1KODh5HPQ3yfYBRIdxVbwBCflrJ6vfU5eclLqHXjXibI/edit?usp=sharing

D.3) Competitive Review Raw Data

https://docs.google.com/document/d/1Z3nqiw9kJmBORQpE821GrjiUfdjSGQykGqfJ0mcSOoY/edit?usp=sharing

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