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ArcGIS Online Arctic Marine Accident/Exercise Collection

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ABSTRACT

Arctic sea ice reaches its minimum extent in September each year. September sea ice is shrinking at a rate of 12.6% per decade(NASA, 2022). As the Arctic sea ice continues to decrease, more vessels are able to access the Arctic Ocean. With the growth in ship traffic operating in the Arctic Sea regions increases, the need to prepare for potential marine accidents in these remote and extreme areas as well as learn from previous errors is critical. The aim of this work is to create a user-friendly dashboard interface where a collection of both marine accidents as well as rescue exercises are displayed and able to be filtered and searched through as well as get a 'deep dive' into each specific case to understand the event in detail. To facilitate this, the use of ArcGIS Online Dashboards and ArcGIS Storymap applications are utilised to create a comprehensive collection of cases in the Arctic region. These two powerful tools provide an intuitive and flexible way to present data with various forms of multimedia and interactive maps. Engaging visuals and Storymaps better inform the user or audience about the event.

KEY WORDS: GIS; Storymap; Accident; Exercise; Safety

INTRODUCTION

In the last decade the Arctic has seen a dramatic increase in the amount of marine traffic operating in polar waters. Work done by the Arctic Council and Protection of the Arctic Marine Environment (PAME) reported in 2019 that the number of cruise ships in the Arctic region had increased by approximately 35% since 2013(Arctic Council, 2019). As well as this increase in cruise ship numbers the numbers of fishing, cargo and other vessel types transiting in the region has increased by 25% between the years 2013 and 2019(Arctic Council, 2020). In Figure 1, this upward trend in cruise ships visiting the various regions of the Arctic is also seem in the other categories of boats as well. This growth in vessels has resulted in a greater need for preparation and planning in the areas of navigational safety, Search and Rescue (SAR) operations and mandatory framework for safety & protection of ships sailing in these areas. Due to the region's remoteness and harsh weather environment it makes it more difficult for SAR personnel to monitor and manage maritime accidents and deal with them effectively.

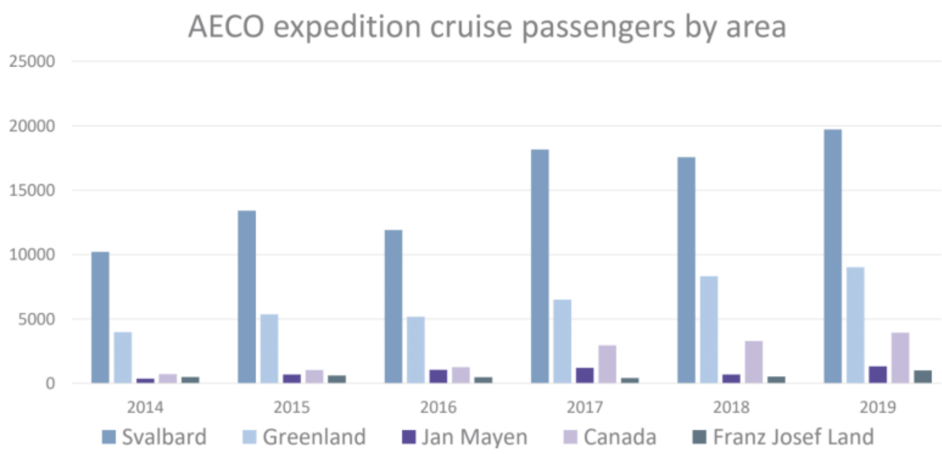

Figure 1. Annual Arctic Cruise Ship Traffic Breakdown 2014-2018(AECO, 2019)

The aim of this project is to create an online platform using the ArcGIS Dashboards and ArcGIS Storymaps applications to compile a collection of both previous accidents and Mass Rescue Operation (MRO) exercises with a 'deep dive' into what happened and the learnings. At present finding information on these accidents is scarce and scattered as there is no one place to find information and search.

Safety of ships in polar waters is an area of significant importance to Arctic countries as prevention of an accident is the first line of defence before a mobilisation of SAR crew to deal with an accident occurs. To ensure the safety of vessels navigating both in the Arctic and Antarctic, the 2011 Arctic SAR Agreement along with the Polar code were established. The Arctic SAR agreement provides a structured responsibility for the areas of coverage and response for the Arctic member countries. The Polar Code was created in 2014 by the IMO and was based on the previous code, Safety of Life at Sea (SOLAS) convention which was established in 1974. Before the Polar Code it was the main international maritime safety treaty. The new code provided the necessary standards of safety required of vessels operating in the polar areas while the SOLAS convention provides the legal framework for its implementation. In combination, they lay out a comprehensive system to best ensure the safety of crew, passengers, and the physical environment. Since the 2011 Arctic SAR Agreement rescue crews from all across the Arctic conduct mass rescue training operations to ensure that they are familiar with the process of dealing and responding to a potential accident at sea. The rescue operations simulate a variety of scenarios that may occur and personnel train in their response with large number of simulated casualties needed evacuation as well as utilizing the most modern safety equipment. These multi country drills help crew work as a large team to deal with substantial emergencies along with adverse weather and sea condition. By engaging in these on a yearly basics then familiarity and effective response is developed if indeed a situation arises.

EXISTING COLLECTIONS & DATABASES

Existing work in this area in the field of academic research has been done by the co-author of this paper, Dr Nataly Marchenko of The University Centre of Svalbard (UNIS) through the

MARPART and MAREC projects. The 2014-2020 MARPART project was a research project that aimed to improve the safety of navigation in the Arctic region through the collecting and analysis of data on wrecks, accidents and rescue operations in the area. The project collected data from over 20 countries which was compiled into a database for use by industry, researchers and policy makers to learn from(Nord University, 2020). The 2018-2021 MAREC project focused on the inter-organizational coordination of mass rescue operations in complex environments in particular the coordination of response resources involved in mass rescue operations(Marchenko, 2022). This papers work is a direct follow on from the work done by Dr Marchenko with a more in-depth case collection as well as the use of comprehensive ArcGIS Storymaps and Dashboards features. In Figure 2, an example of the GIS work done in the MAREC project by Dr Marchenko which formed an initial start point for how to carry out the work in this project.

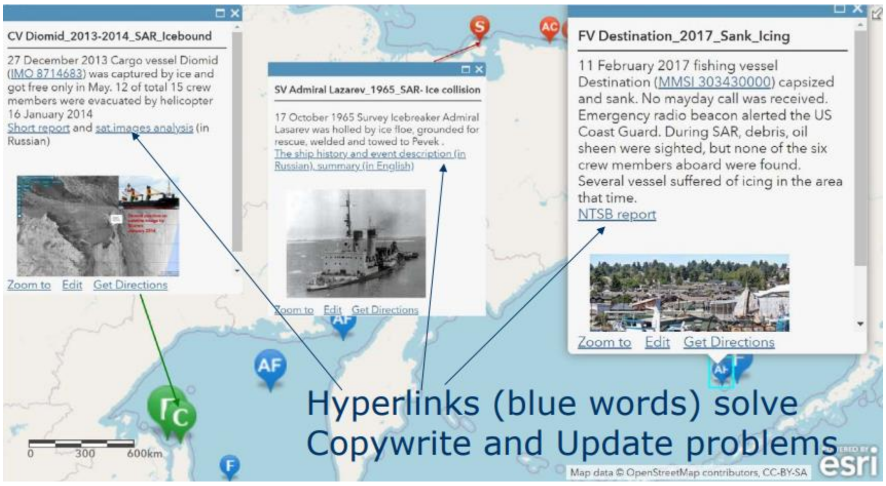

Figure 2. ArcGIS Online Interface from the MAREC Project(Nord University, 2018)

Databases publicly available on the web about the Arctic waters include BarentsWatch which is a Norwegian Government open information system and resources for the monitoring of the Arctic waters around the Barents Sea(BarentsWatch, 2022). It provides a multitude of maps and shapefile layers available for download and viewing by anyone that contain information about the environment, coastal areas, marine activities and ice conditions. The Baltic Marine Environment Protection Commission online website HELCOM is another tool that is used in the specifically in the Baltic Sea(HELCOM, 2023). The viewer which is based on ArcGIS Online and shapefiles, allows users to view information with the choice to turn on and off eight major category headings. One of these categories is shipping and includes a layer for shipping accidents that is relevant to this paper. The symbology used in this tool is categorised by the ship accident type rather than vessel type. Each accident type has both a unique colour and distinct shape. Information on specific ship accidents is available to view and also download on various governmental sites. In Norway the relevant authority is The Accident Investigation Board of Norway (AIBN) where a course of events and causes is investigated with a view to an avoidance of accidents and improving the safety of life at sea(AIBN, 2023). Similarly, in Canada the Transportation Board of Canada published investigative reports into marine accidents that occur within its waters as well as Canadian vessels that are involved in accidents(TSB Canada, 2023).

OBJECTIVES

The aim of this project is to create an interactive interface using the ArcGIS Online Dashboards tool to have a collection of marine accidents and exercises to search through before getting a full comprehension of the case in question through the Storymaps tool. ArcGIS Online Dashboards is an ESRI product that allows users to create powerful, user-friendly panels to display their geographical information combined with other media and shapefile layer information. Through maps, tables and charts that can all be linked together the data can be displayed to show what the designer wants. High customizability lets filters be applied as well as threshold limits to highlight trends or add insight into a particular field in the data. This type of interactive and visually appealing form of displaying information is being used more and more by industry as well as academics to effectively communicate date to a vast range of audiences as their end users.

Similar to the ArcGIS Dashboards product, the Storymaps application lets the creator document an event or data collection through the use of many forms of aesthetic multimedia. Templates can be used in the creation process as well as adding many maps, text and videos. Completed stories are able to be published and embedded into a companies, or any other institutions website which provides a more interactive and engaging way to understand data. The objective of the project as stated earlier is to use these two tools in combination with each other to have both a case collection as well as detailed information on the specific events.

METHODS

The first process was to define the scope of the project. As this is part of a Master's thesis, there is a time limit on its completion so the collection could not be a full scale case collection of the entire Arctic. Therefore, the most relevant areas were chosen. These were determined by availability of information on the cases as well as proximity to the region where the MarEmAr project was operating, namely the area around Svalbard, the Barents Sea, Iceland, and Greenland were chosen to build the case collection.

To start collecting data, first a process of systemisation needs to be established. Systemised data makes sure that the dataset is uniform and consistent. By defining these lists of parameters, it streamlines the process for processing and analysing. All of this gathered information doesn't need to be utilised immediately on the shapefile or Dashboard but in having it on-hand then if required it can simply be turned on and all cases will have this information. In the systemisation of the data before collecting some of the main categories were defined. These include the ship type and accident type for the marine accidents and the exercise type for the SAR exercises. Ship types can be divided into five distinct categories. These are passenger, fishing, cargo, research, and all other vessels outside of the four aforementioned. With regard to the accident type, there are six categories. As this collection is with an Arctic context there is a lot of ice induced accidents, these include ice bounding, collisions with ice, glacier induced impacts. These can all be grouped together under the bracket of ice accidents. The other five accident categories are grounding, engine issues, fire, collision, and all other accidents.

Collection of the actual data is the critical step in building this collection. Limited or restricted availability on the information about an accident that occurred, or SAR exercise limits the ability to collect and analyse fully. Complete marine reports carried out by governmental organisations were found to be not a frequency. After extensive research the collection size was determined to be 28 marine accidents and 19 exercise cases.

In Geographical Information System (GIS) maps the symbology plays a crucial role as it is a visual way to convey information about the features or parameters that the data has in a fast and effective manner. The created layers from the data collected for the marine accidents and exercises use relevant symbology to give a user an easy understanding of what they are looking at. In the case of the marine accidents, there is a two tier level of symbols. The first is the type of ship conveyed with a relevant symbol, the second relates to the severity of the accident. Based on a scale of 1-5 with one being the least severe and five being most severe the size of the ship symbol changes. In the case of the exercise cases, the symbology uses only colours to differentiate the different exercise types but also adopts the same scale severity as the marine accidents to easily quantify how large the training exercise was.

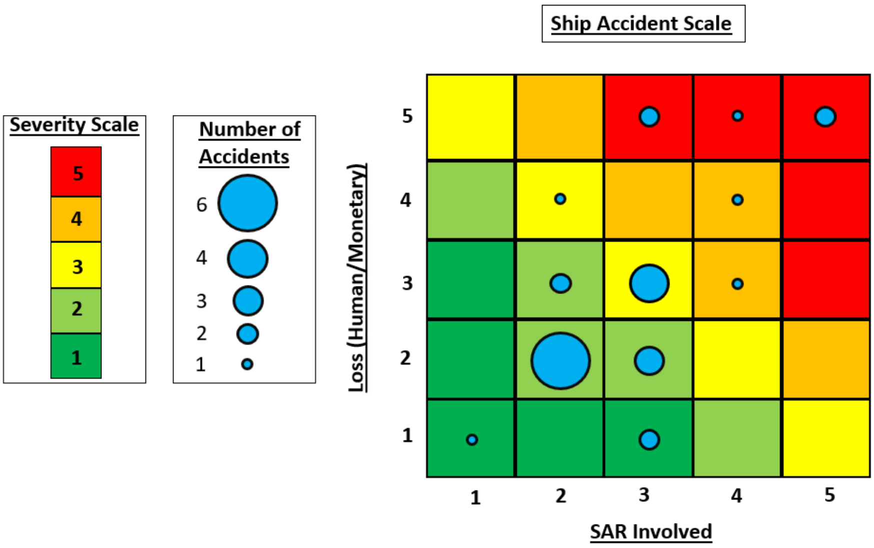

Figure 3. Severity scale chart for Marine Accidents

The severity/size of the accident or exercise scale was created specifically for the project. For both it was a 5x5 grid with an X and Y axis where the relevant details let the case fall into a scale category. In the case of the marine accidents, it was a subjective quantification based on knowledge while the exercise cases were denoted a number based on a set number of personnel involved and duration of the exercise. In Figure *3*, the accident severity scale as well as a summary of where cases were spread across the chart is shown. The quantifying of scale for the exercises was defined by different criteria. On the X-axis was the personnel involved, while the duration of the exercise in days was the Y-axis, with the number of days corresponding to the scale number. A detailing of the exact personnel numbers for each scale is shown in Table 1.

Table 1. X-axis scale for exercise cases classification.

Scale	Personnel Involved
5	500+ Persons
4	250-500 Persons

3	100-250 Persons
2	50-100 Persons
1	<50 Persons

When an individual case is selected in the ArcGIS Online shapefile, the resulting pop-up can be a powerful tool to show information that a table or other features can't. In doing this there must not be repetition of information that may be shown on the dashboard elsewhere. For example, the pop-up showing the accident type and then this also being shown on the information table. Simplicity and easy of understanding are the two main concepts to remember in the co figuration of the display. In the case of the project, the ship/exercise name as well as the month and year are shown along with a brief synopsis of the event with a picture and a link to the 'deep dive' Storymap.

In the Dashboard which holds the case collections, filters provide users the option to quickly filter through the dataset and find the relevant accident type. Three filters were used for the created Dashboard, the ship type, accident type and exercise type. When applied the filter displays only the selected feature information in the shapefile. The table feature on the dashboard helps show information that the pop-up doesn't display. Tables for both the accident and exercise cases were inputted into the dashboard and configured so that in selection of a case on the table flashes and zooms to its location on the map along with showing the pop-up.

Figure 4. Screenshot from collection showcasing legend icons and scale.

In the building of Storymaps, using a devised template structure with the same headings allows creation of new Storymaps that look and feel unique while remain consistent in structure and thus familiar to comprehend and understand for the user. In creating each Storymap, to have the same heading with regards to finding the information makes it faster than starting from scratch each time. A template structure helps keep remaining focused on the key points of each case and ensures that essential elements are not left out.

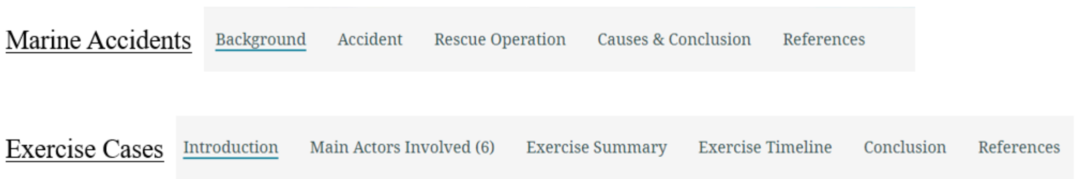

Figure 5. Storymap heading layout for each case collection.

CASE/EXERCISE INTERFACE & COLLECTION

Table 1. Accident and exercise full collection table; MS: Motor Ship, PV: Passenger Vessel, RV: Research Vessel, FV: Fishing Vessel.

Marine Accidents			Exercise Cases		
Year	**Name**	**Accident Type**	**Year**	**Name**	**Exercise Type**
1959	MS Hans Hedtoft	Ice Accident	2012	SAREX-Greenland	Evacuation
1986	MS Syneta	Grounding	2013	SAREX-Greenland	Evacuation
1986	MS Sudurland	Other	2014	Svalbard Exercise	Evacuation
1989	PV Maxim Gorkiy	Ice Accident	2016	LIVex-Greenland	Oil Spill
1997	PV Hanseatic	Grounding	2016	SAREX-1	Evacuation
2006	RV SKA 11	Grounding	2016	OSR exercise in Tryghamna	Oil Spill
2007	RV Aleksey Maryshev	Ice Accident	2017	SAREX-2	Survival
2008	FV Frøyanes Senior	Fire	2018	ARGUS-18	Evacuation
2009	MS Petrozavodsk	Grounding	2018	SAREX-3	Survival
2009	FV Remøy	Ice Accident	2018	OSR Exercise	Oil Spill
2012	PV Polaris I	Ice Accident	2018	LYR Airport	Fire Drill
2012	FV Kamaro	Engine Issues	2019	ARGUS-19	Evacuation
2014	PV Juvel	Grounding	2019	SAREX-2019	Survival
2015	FV Norma Mary	Fire	2020	Arctic SAR TTX	Survival
2015	FV Soley Sigurjons	Fire	2020	SAREX-2020	Survival
2016	PV Ortelius	Engine Issues	2021	Arctic Guardian	Collision
2016	PV Inuk II	Ice Accident	2021	AMRO Svalbard 2021	Evacuation
2016	FV Saputi	Ice Accident	2022	ARCSAR LIVex	Evacuation
2017	Helicopter Mi-8	Other			
2018	PV Aurora Explorer	Collision			
2018	FV Northguider	Grounding			
2018	FV Frosti	Fire			
2019	RV Lance	Ice Accident			
2019	PV Malmo	Ice Accident			
2019	PV Rembrandt Van Rijn	Grounding			

2019	PV Sjøveien	Engine Issues			
2022	PV Virgo	Grounding			
2022	PV Ocean Atlantic	Grounding			

The finished collection and dashboard interface seen in Figure 6 is comprised of 47 accidents and exercises which were geographically shown using the ArcGIS Dashboards application where the ease of use was of top priority. Features to streamline and narrow the search to areas of the user's particular interest with filters and interactive tables are also seen with a sample configured pop-up. The importance of a brief yet informative description to convey the accident or exercises essence helps get a quick overview before clicking on the hyperlink to the actual Storymap of the case. Limited repetition and overlap of information between the table and pop-up window was attempted throughout. For example, the ship type and accident type given more detail in the pop-up window than the information table. In the case of the Saputi seen in Figure 6 it is listed in ship type as 'Fishing', while the pop-up it is denoted as a trawler. The accident type follows in a similar process it is listed as 'Ice Accident' while the description on the pop-up says the exist accident being striking sea ice. Another feature in the dashboard is that only accidents/exercises within the current map extents are listed in the tables. This combined with the bookmarked map extents allow to see just the accidents in the area of interest. The there is three map extent areas. These are, Svalbard, West Greenland and East Greenland & Iceland.

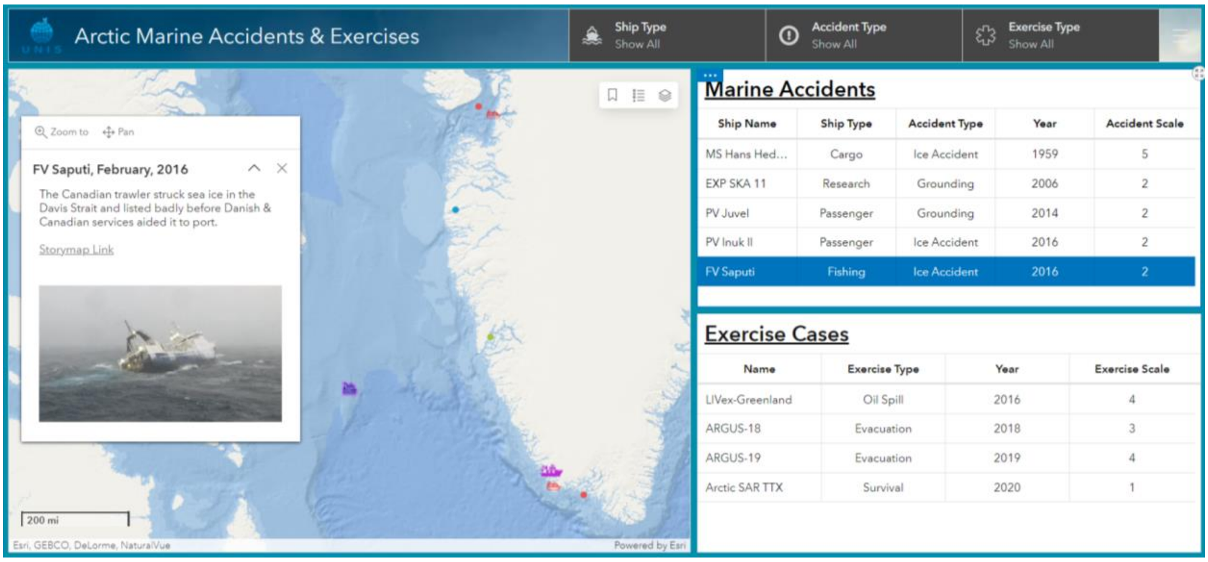

Figure 6. Dashboard interface with example pop-up

The in-depth analysis of the case through the Storymaps after clicking the hyperlink given in the dashboard pop-up leads the user to get a greater understanding and information on the event. Although there is a defined process to completing the Storymaps through uniform heading layouts, the content within these vary. A large part that dictates this is the information available to be obtained on the accident or exercise. Some of the large cases have much literature and reports given precise times and geo-locations, while with others the information is scarce and not release into public domain. While a limiting factor in some regards, it makes for a unique yet familiar format in the whole collection. Where possible the Map Tour feature was used to go through step by step the events with a created map, highlighting points of interest with more information. Another way used where possible was the timeline. In the case of some accidents or exercises there is a short timespan where a lot occurs, and the timeline function helps concisely and effectively tell this story. Figure 7 is an example of utilizing both Map tour and timeline along with visual multimedia to effectively detail the unfolding of the mass rescue exercise.

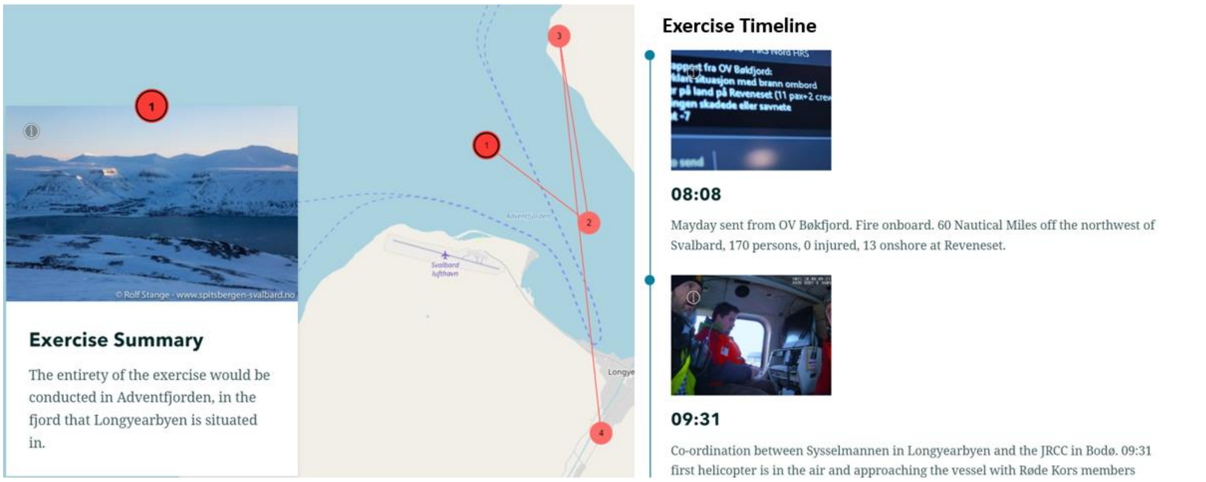

Figure 7. Storymap features implemented in cases where possible, map tour (left) and timeline (right).

CONCLUSION

This paper showcases an interactive and engaging location to host a considerable collection of cases in both marine accident and exercises. As there is no such location at present where this information has been collected and brought together it poses a much use to both marine professionals as well as SAR personnel. The combining of Storymaps to give a whole analysis of the case worked particularly well with the ability to include multimedia and visualisations in. The created project is limited in its size due to time constraints but as it is comprised of shapefiles therefore additional cases could be added if this project was taken forward in the future. Other ways to show or share the data with an inclusion into existing websites such as BarentsWatch apotential option. Further additions could be an expansion of the extents to include the Canadian Arctic as well as American and Russian Polar regions.

APPENDIX

The supplementary material that encompasses the created dashboard and whole Storymap collection is available to view, filter and explore at the following location, https://www.arcgis.com/apps/dashboards/716c03b195ef48dd857fd9c9516c78cd

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