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Deliverable 7.8

Report on performances and use of the ARICE system and compliance with standards

Submission of Deliverable

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Author list	Vito Vitale, Giulio Verazzo, Mauro Mazzola, Marie-Noelle Houssais, William Lafarge, Veronica Willmott
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1. Abstract

ARICE has developed a system of tools to improve data access and to understand the capacities of research icebreakers.

The 3D Virtual Icebreaker platform allows users to explore and understand the capacities of these research platforms. The “3D Virtual Icebreaker” can be accessed through the following link: https://vessels.arice-h2020.eu.

To maximize the results in terms of public reachability, the platform was designed to meet the needs of both experts and the general public described within the site as “Explorers” and “Fans”. This distinction separated the website in two paths, the first more focused on the scientific information while the second one providing also educational and training material. The overall aim is to provide a unique access point gathering a coherent and standardized information on the research vessels, using multimedia new technologies, like 360° movies and 3D graphics to make the experience more involving and very close to a "virtual visit".

The platform gathers information from all the ARICE Icebreakers and provides advanced functionalities such as an interactive map with real-time ship positions and layers, interactive 3D model of the Icebreakers with their scientific equipment, a 360° photo virtual tour with precise surface measurement tool, a map with present and past cruises of the ships, a multimedia section as well as an educational and informative video section. The portal is planned to act in the future as a collector of all the other ARICE data management resources.

The data tools developed for the data management system includes a metadata catalogue, a map viewer, and a Cruise Summary Report database.

The intention of this report is to describe the design and the reasoning behind the development of the 3D virtual icebreaker, also giving examples of possible uses. And at the same time also briefly provide a summary of the data tools that have been developed for the Data Management System, giving space to the detailed description of the most recently developed tool, the Cruise Summary Report database. The prospect of searching for information along different levels and the connection of the different tools is briefly illustrated.

2. Introduction

Research vessels are very expensive and complex observation platforms that require significant investments not only for their construction but also for their management and use over the years. They play a fundamental role in the observational system of our planet, allowing us to investigate and monitor the seas, which as we know cover 2/3 of the Earth's surface. In the polar regions, the distribution of land masses makes their role even more important if possible: in the northern hemisphere, the central part of the Arctic and all areas above 80° N are a single enormous expanse of sea water and ice (the Arctic ocean), while the southern hemisphere is characterised by the presence of a continent, Antarctica, surrounded by an ocean and limited by the convergence zone around 60° S of latitude. If for the scientific

community the importance of research vessels is very clear, it is extremely important to disseminate this message effectively and correctly to society, the media, and political decision-makers. Visiting a ship, being able to closely observe its complexity but also appreciate which and how many activities and measures can be made thanks to it, is certainly the most immediate and effective way, but for obvious reasons it is limited to the people who can access the ship. Creating occasions and events for visitors to access the ship is not at all easy due to the operation of the ships themselves, which takes them away for long parts of the year.

Visiting and getting to know the ship is not only a matter that concerns the outreach towards the general public and other stakeholders; it is important also for researchers to plan new research projects and to promote a multidisciplinary use of this observational platform. This contributes to maximizing the use from a scientific point of view and satisfies the need for an increasingly integrated and holistic look at our system.

The current scenario for a user, researcher, or general public, wishing to learn more about polar research ships, is not particularly exciting. The level of presentation of the ships is very heterogeneous and fragmented on different websites, and this even if only limited to the vessels that are part of the ARICE consortium. The lack of standards in presenting information makes it difficult to make comparisons, even for basic information, between the different vessels, being difficult even for expert users to understand the potential of one vessel compared to another, and to decide which one is the best for their research.

This is the rationale behind ARICE's idea of creating an innovative IT platform, the 3D icebreaker, which could overcome fragmentation, provide standardized information for the various research vessels participating in the consortium and become a front-end for the project data management system. In this report we present the strategy adopted and the tools / functionalities developed to date. The platform was presented during a hybrid event held in Bologna, Italy, on the 17th of June 2022. The platform is still under development as the information from the various ships and instruments is currently being acquired.

3. The 3D virtual icebreaker

3.1. Concept and methodology

Our aims in designing the IT platform called 3D icebreaker to:
(i) "bring" the ship closer to the user, whether this is a researcher, user, or general public;
(ii) make the nature of an observation platform as clear as possible;
(iii) provide the researcher / user with information and tools to plan the activity by allowing a virtual access to the platform;(iiii) to connect the 3D icebreaker with the data management functionalities.

These four aims have constrained the development of all functionalities in the platform.

Figure 1 - *The 3D icebreaker entry portal.*

The entry portal (Figure 1) highlights that the platform is devoted to two broad categories of stakeholders: (i) those interested to use the ship, or the data collected by this observation platform (Explorers); (ii) those curious to know more about the activity, characteristics and available resources (Fans).

The "Explorers" portal

If the user moves to the "Explorers" section, the user will be able to see the entire list of research ships included in the platform and at the same time their current position and current cruise (Figure 2).

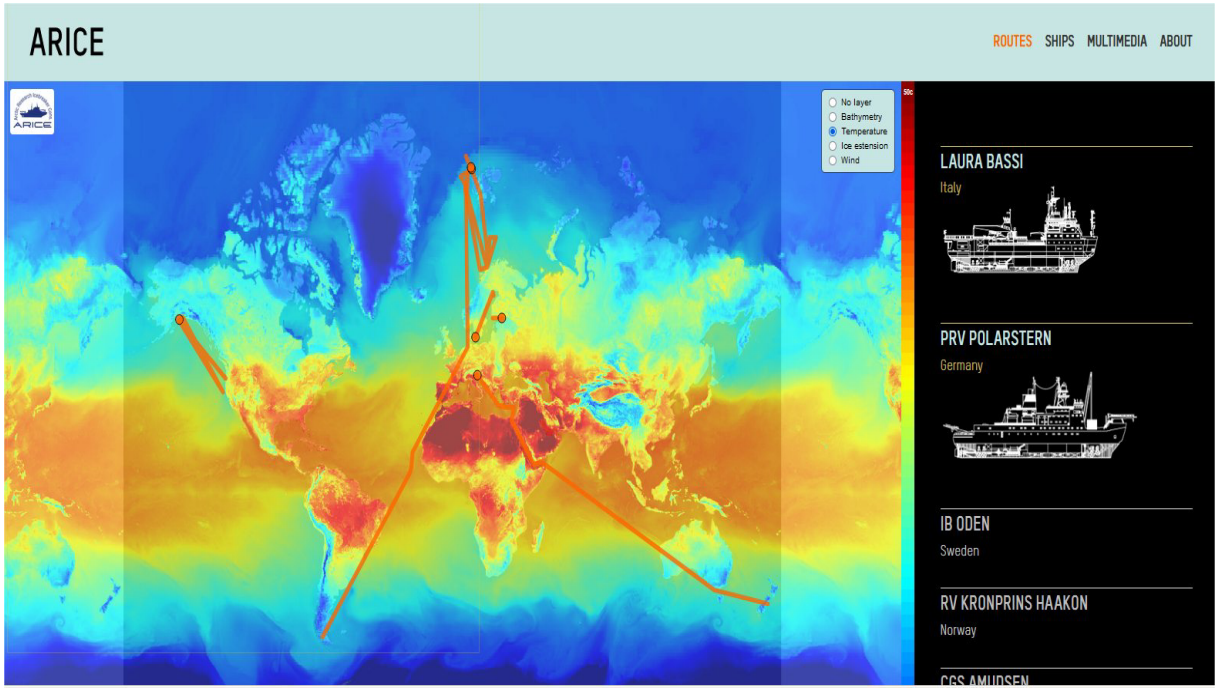


Figure 2 - *The main page of the 3D icebreaker ("Explorers") . The information later presented is the air temperature at surface in °C.*

The map shows different information layers, bathymetry, temperature, ice cover and wind. These information layers and their representation graphics are the result of the close collaboration that ARICE has started with EMODnet and in particular EMODnet physics. Thanks to the agreement and collaboration, the 3D icebreaker platform can present products that have been developed by EMODnet Physics. For now, the information on the position of the ships is picked up by the network through services that are public. But in the near future these data can be directly provided by research vessels in Near Real Time (NRT). The description of the actual cruises is in progress, as behind every single point and line there is a remarkable work of collecting and harmonizing the data to be presented on a regular basis.

The expert user is immediately put in contact with the observation platform and its status. But if the user moves towards the "Fans" section, the user is primarily led to a series of basic information both on the ARICE project and on contents related to research vessels, their role and their potential in the observation system of the polar regions (see section 4).

Both sections, "Explorers" and "Fans", present a coherent set of information capable of satisfying the visitor needs. The 3D icebreaker does not intend to replace the original sources of information.

The "Fans" portal

The "Fans" portal gives access to information and material not linked to a specific icebreaker (Figure 3).

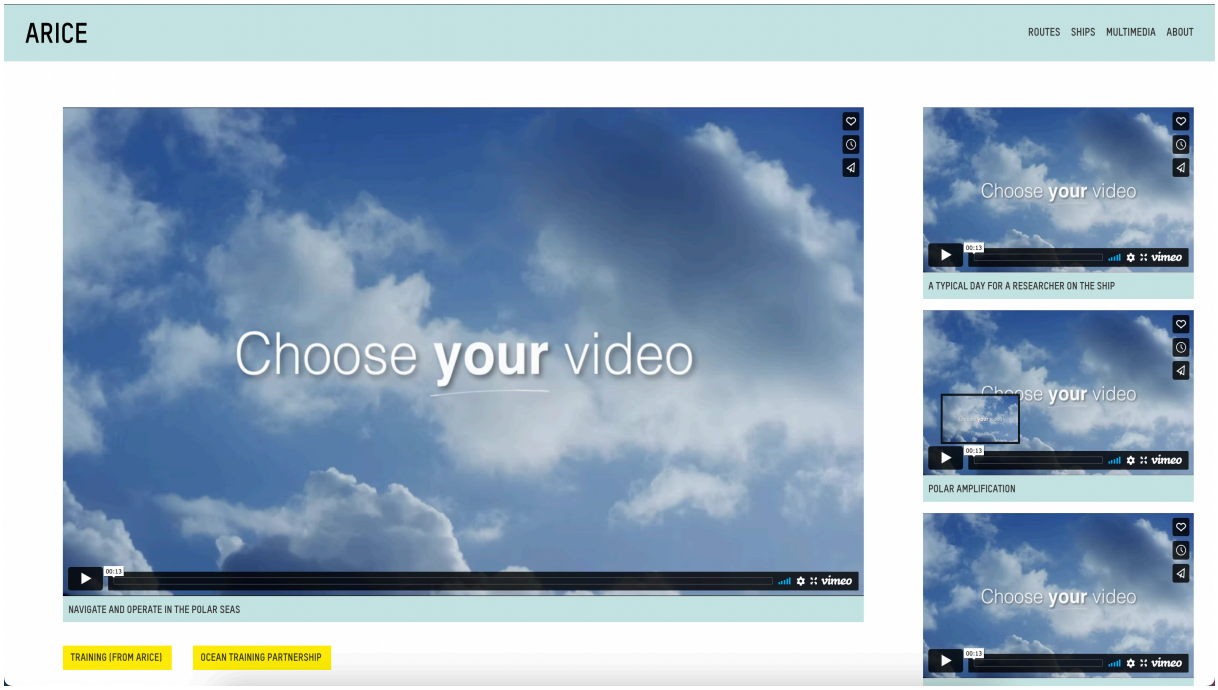


Figure 3 - *The outreach page of the "Fans" section*

(i) a series of videos of a maximum length of 5 minutes should introduce the non-expert user to the major scientific and technological issues related to research vessels and their use and role both to study the Arctic region and to monitor their status with respect to climate change.

(ii) a series of buttons at the bottom of the page refer to both the outreach and dissemination resources produced by ARICE and to other resources on the web that are considered particularly relevant for the development topic. In this case the connection is in any case made in an active and not passive way: if necessary, a selection of the most relevant resources and information is proposed, to avoid the non-expert user from being lost. The link to the original resource gives the user the possibility to decide and operate in full independence and autonomy with respect to our suggestions. The illustrated scheme can easily grow in both video content and links to new resources without having to modify and / or develop new technical elements (Figure 4).

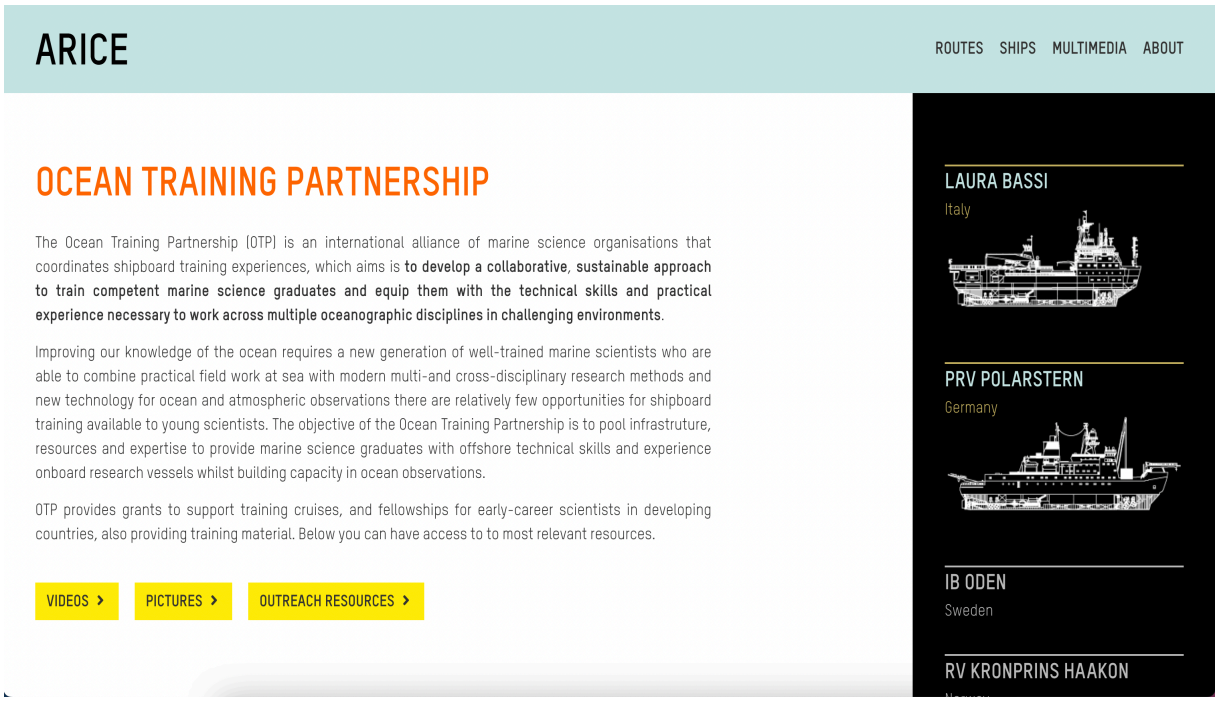


Figure 4 – *Information and tools selected from the Ocean Training partnership web site*

Now we are currently working on a first set of 6 videos on the following topics:

1) Navigate and operate in the polar seas
2) A typical day for a researcher on the ship
3) Polar Amplification
4) Sea ice decreasing
5) Why Polar Regions are important
6) Polar Regions and global sea level

3.2. Information for a single ship

The main objective of the platform is, as previously mentioned, to bring the user closer to research vessels operating in the polar regions. For this reason, the information is mainly organized according to the ship category, and the user is prompted from the beginning to indicate and select the ship he is interested in. For example, if the user selects the "Explorers" route, on the main page he finds the list of ships on the right, and by selecting one, access the next level of information and services. For now, only the sections ROUTES and MULTIMEDIA have been added to the SHIPS categories, but the platform can easily add more categories if needed. This mode offers the possibility of highlighting the training and outreach in the "Fans" path, and the user can then select the category of ships to move forward in the exploration.

By selecting a specific ship, the user will access a page with a standardised ship information.

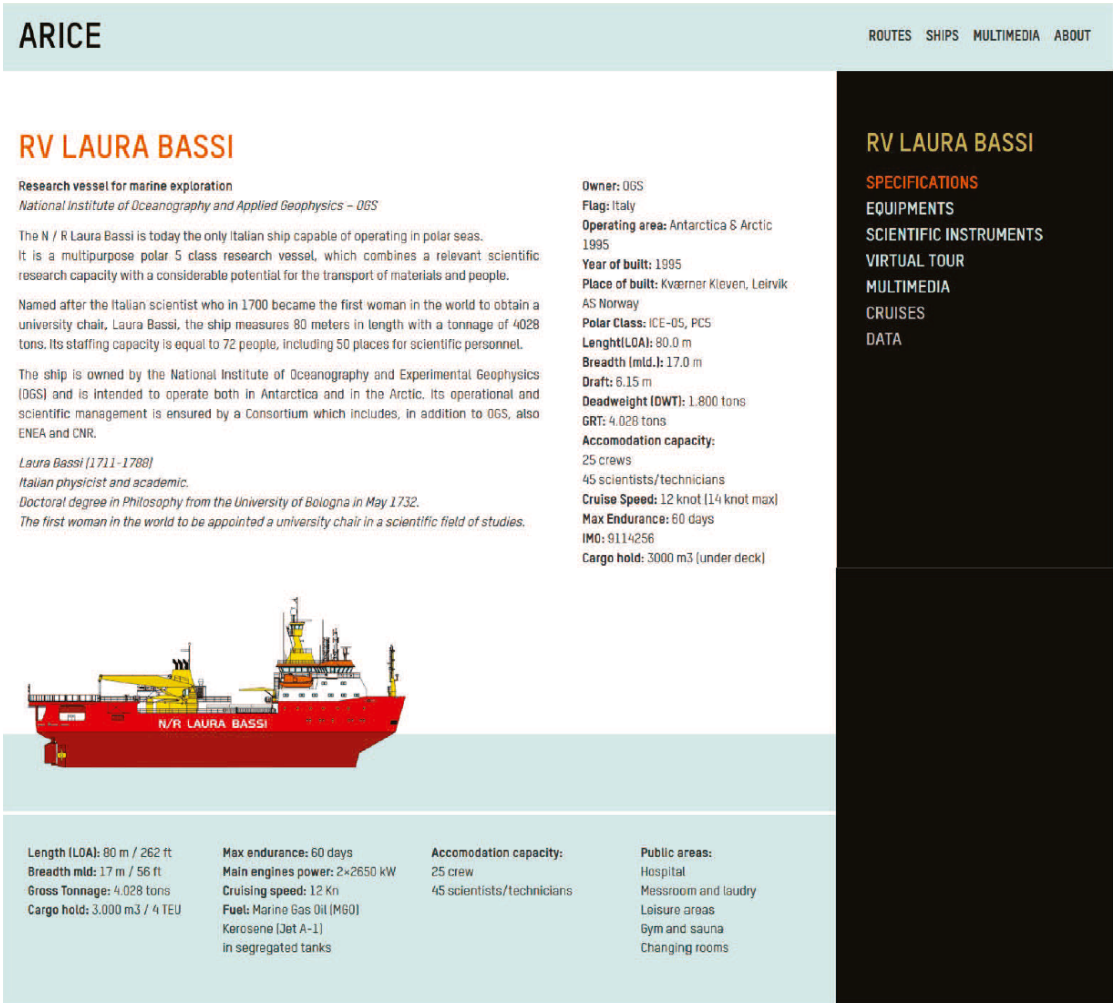


Figure 5 – *Information for Laura Bassi Research vessel*

Some information is repeated in the lower part under a stylized graphic of the ship, grouped into 3 categories, dimensions and tonnage, autonomy, engine and accommodation. Added to these are new information related to public areas. Figures 5 and 6 show the information provided for Laura Bassi and Polarstern, respectively.

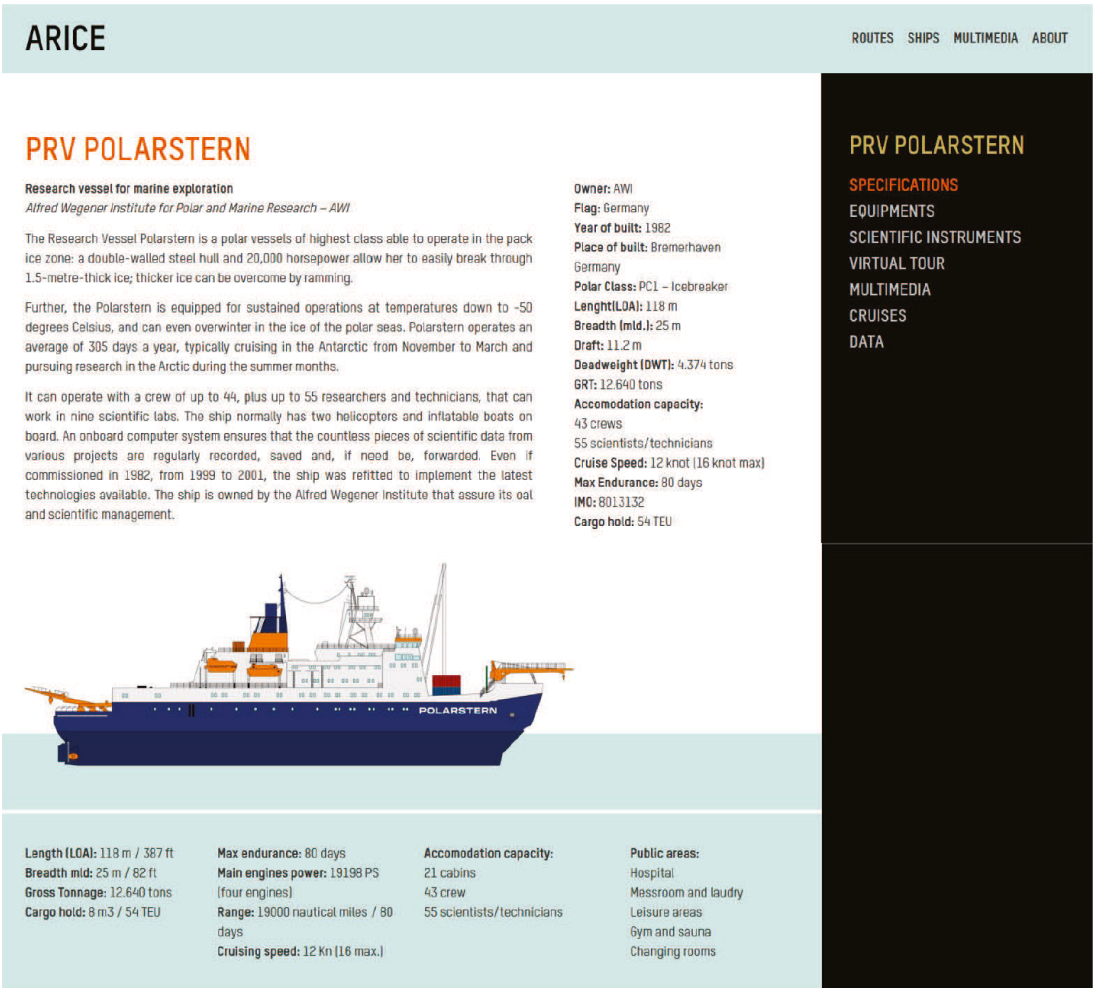


Figure 6 – *Information for POLARSTERN icebreaker*

The right side shows a menu to start the exploration and knowledge path of the ship both in the specifics of its operational and technical characteristics and in the detail of its research activities. The path begins with the presentation of the ship platform through a 3D model (equipment option). A series of points of interest for the chosen ship, generally between 7 and 10, are presented with a short text and a photo (Figure 7). The scientific equipment option allows the user to access the functionality that is also found in the menu.

Figure 7 – *The 3D model for Laura Bassi and description of points of interest*

3.3. Scientific instruments

The scientific equipment is described following a similar 3D modelling concept.

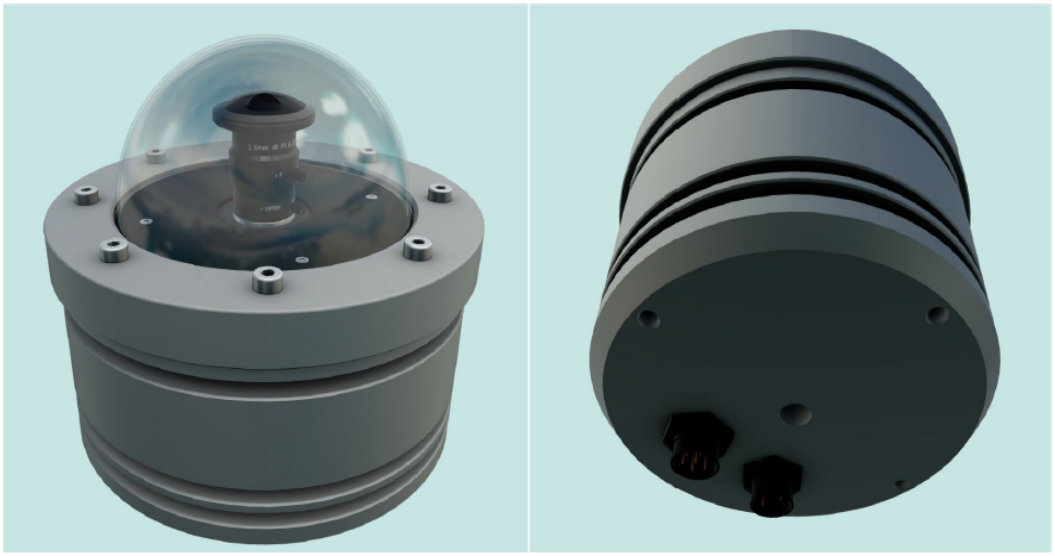


Figure 8 – *The 3D model of the all sky camera*

To highlight the similarities between research vessels, showing how they can operate for the same scientific purposes and monitor the same parameters, the 3D icebreaker platform describes the instrumentation as an example to make that measurement. The instrument is described in a simple way to "bring" the user closer to the activity that takes place on the ship. This section is identical for all ships that are present on the platform.

Figure 8 shows as example the 3D model for the ALCOR all sky camera used to observe and monitor the cloudiness conditions. Figure 9 shows the “all sky camera” description.

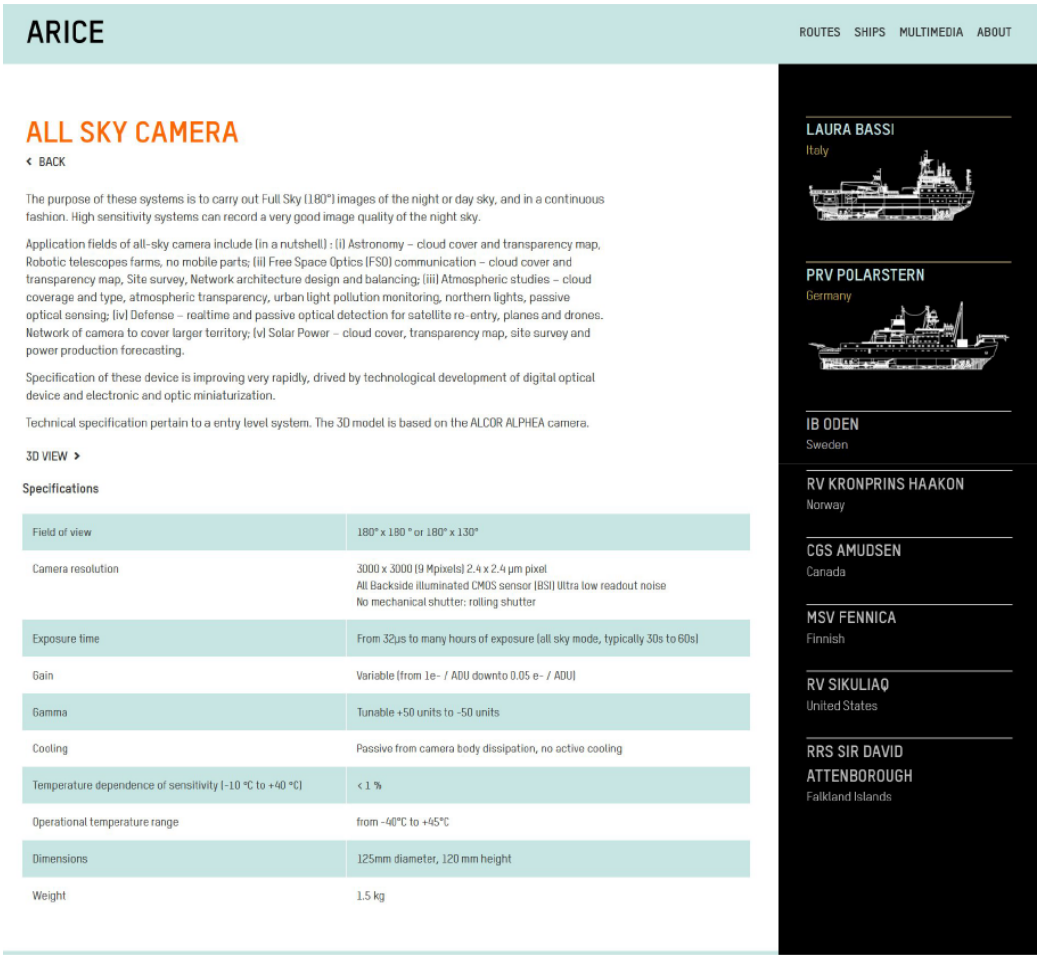


Figure 9 – *The information page about the all sky camera*

The scheme adopted also makes it quite natural to link the instrument and the single parameter with the measurements made, both present in the catalogue of historical data and the NRT measurements of the cruise in progress.

3.4. Virtual tour and related functions

Mobile mapping is a technology developed in the late 1980s and early 1990s. A mobile mapping system consists mainly of three components: mapping sensors, a positioning and navigation unit for spatial referencing, and a time referencing unit. These systems capture 2D or 3D geometric environmental information using an imaging sensor that is attached to a moving platform. In the past, the size and weight of the systems required installation on a land vehicle, a vessel, or an aircraft. The applications were therefore limited to the outdoors and in any case restricted by the considerable costs and the need for highly experienced staff, post-processing costs and accuracy limits.

The very rapid development of technology, especially in regards of the imaging system, has led to systems that can easily be worn and used by a human operator, opening the doors to indoor applications. The development of the detection systems of the point cloud which then reworked allows to obtain the 2D or 3D image, generally based on laser technology, and the possibility of integrating the same with high resolution digital cameras, has raised the precision and accuracy of detection and the ability to reproduce even the smallest details.

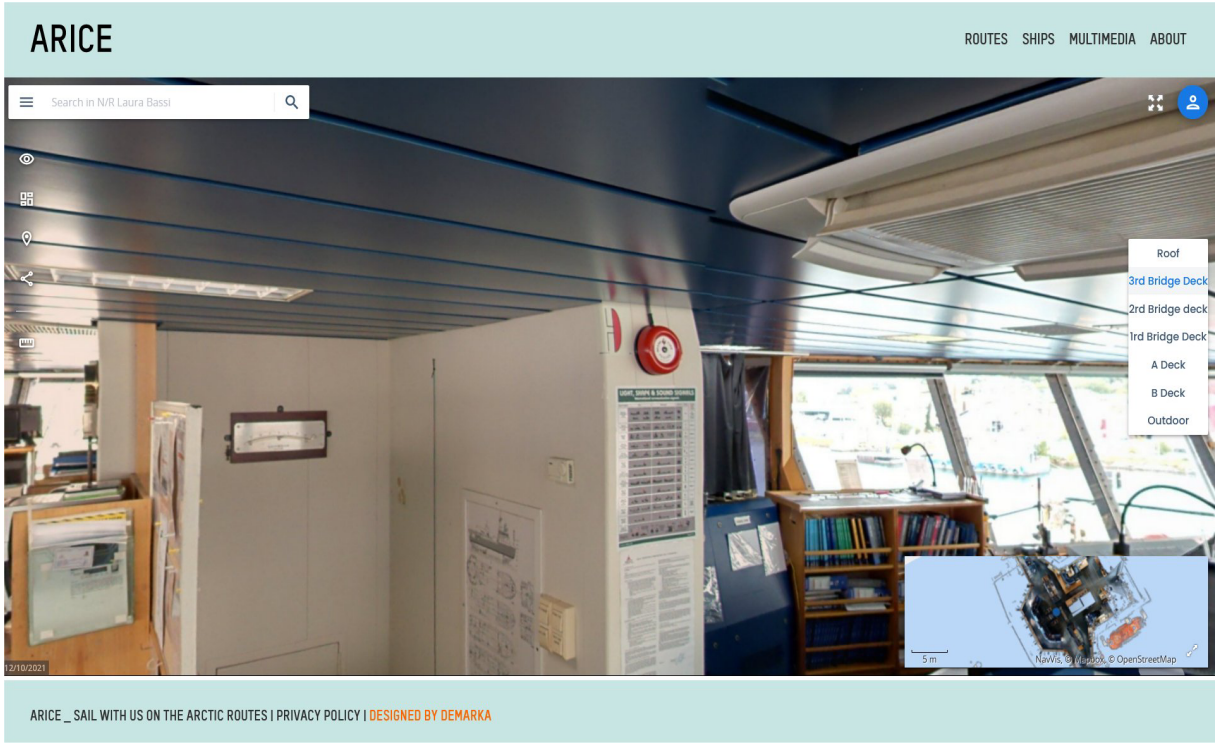


Figure 10 – *The starting page of the virtual tour of Laura Bassi. In evidence on the right side the sections of the tour and on the left functionalities*

If the application of 3D mapping in the field of engineering design and architectural planning has been well established for years, much more recent is the development that aims to use this technique as a tool to transfer physical reality into the digital world and recreate sensations similar to those the user would achieve if he/she were on board the ship.

This approach has already been developed for Polarstern in recent years thanks also to the collaboration of AWI with the German Maritime Museum in Bremerhaven. The 3D icebreaker has taken this approach and further developed it in a key of greater usability and simplicity, making an appropriate choice in the density of the points that reproduce the 3D model and the virtual tour. In Figure 10 the initial screen of the virtual tour prepared for Laura Bassi, it is possible to appreciate the functions available. In particular, the measuring tool is very useful for researchers that need to prepare a cruise and the instrumental set up (Figure 11).

Figure 11 – *The Mark and measure function activated looking the Laura Bassi dry lab.*

This virtual tour function, which is accessible by pressing the small meter that can be seen in Figure 10 at the bottom left, allows the user to evaluate linear dimensions, areas, and volumes available with great precision. For a researcher who wants to start planning an activity and check where to install instrumentation, it is possible to understand the space available and optimise its use, even without having ever set a foot on the ship. This function could favor the approach of new potential scientific users to the various ships, an integration between different groups and the development of ideas for even complex projects.
Menu categories up on the right allows to move very fast to all other information and content in the 3D icebreaker.

3.5. Next step: cruises; historical and NRT/RT data

The 3D icebreaker platform allows the access to information on past cruises and shows the measurements in progress in NRT for some parameters. The graphic functionality that shows the Arctic map on the main page will also be used to show past cruises (currently in development). For each cruise it is possible to include information and link the data available through the catalog and the ARICE data management system. For cruises it is possible to connect to the tool developed to provide information according to the standard defined at the time by SeaDataNet. If the current one is selected from the various research cruises available, the ships and instruments that make data available in NRT are given the opportunity to see them in graphical form.
Access to the same data in NRT will also be given from the section that directly concerns the instruments and parameters observed. In this way we are counting in the future development of the platform to reach ARICE's ambitious initial goal: to make the 3D icebreaker platform the web portal for data and information on ships.

3.6. The legacy perspective

Previous sections describes the 3D virtual icebreaker platform and its functionalities, reasoning its development and justifying the choices made.
In our approach it is good to reiterate that having separated the development of information and documentation functions from those strictly of data management, has allowed us to give greater prominence to the former and to be able to effectively use multimedia tools (3D graphics, virtual tour) that are increasingly establishing themselves as tools to "bring the user closer" to objects even at a distance. For a medium such as research vessels, which by their nature can be visited and seen only in ports, this means significantly expanding the number of users who can "visit" the ship(s). Also, from the researcher's point of view, these tools can favour a better use, and a greater audience of users, also favouring integration and multidisciplinary research.
Now we are committed to filling this platform with more information content, with the aim to eventually have information and a 3D model for all ships and up to 10 parameters / instruments. The complete development for all ships of functionalities such as virtual tours, access to past cruises and / or data acquired in current cruises, requires effort and resources that must be sought since they are not foreseen in the ARICE project.
Which brings us to the question of the legacy and future of this platform once the project is finished. CNR is ready to support its functionality for the next 3 years, thanks to projects and resources already acquired. These resources will allow to keep the platform active as it is and to bring limited development in the functionality related to cruises and data.
The choices and agreements that will be made by the partners of the ARICE consortium will instead determine the level of contribution that they will be able to give to the further development of the 3D virtual icebreaker platform, the creation of virtual tours for all ships, the integration of additional ships from polar search, the ability to connect and view data in NRT.

4. The ARICE Data tools

As shown in D7.6 [1], the general goals considered for the ARICE Data Management System include:

(i) seamless access to the data generated by ARICE cruises;
(ii) to develop and adapt strategies and tools for efficient data access and data dissemination, to help a wider use of data acquired by research icebreakers;
(iii) to contribute to the general goal of improving the availability and readiness of data and information about the status of Arctic Ocean.

While the web portal with Icebreakers augmented reality virtual tour and 3D models can contribute to the second of the three objectives listed above, helping to respond to the needs of a much broader general audience, other tools are necessary to accomplish the other two overarching targets, giving to ARICE DMS the capability to serve both scientific and experienced stakeholders as well as a broader general audience.

Following this need, other three tools have been developed since summer 2020, each assuming a specific function https://arice-h2020.eu/data-tools/ . Those are:

(i) a metadata catalogue for data discovery,
(ii) a map viewer to access and view actual data, and
(iii) a cruise summary report catalog collecting information about polar and subpolar cruises.

Technical details for the first two have been provided already in D7.6, and for the third are provided in the following section 11.

We like here just to provide information on how they have been implemented in the current ARICE web page, the amount of information collected, and how it appears/can be used by the users. The three more specific data tools are accessible through the same menu option, while the 3D virtual icebreaker is accessible through a specific separated option

4.1. Map Viewer

The map viewer, as well indicated in D 7.6 [1], is powered by ERDDAP and Geoserver. It allows data visualization and downloading of scientific parameters collected by ARICE Icebreakers. The map is available in three different projections, default, Arctic and Antarctic. At the moment of writing this deliverable, 264 datasets are populating the map viewer, collected from three sources: Polarstern, Amundsen and Arctic Net. The source for historical Polarstern data has been Pangea, while data related to Canadian infrastructures is harvested from the Canadian Polar Data Catalogue. Datasets can include up to about 10 meteorological/atmospheric parameters as well as up to 5 parameters related to seawater, the most part temperature profiles arising from CTD measurements. For Polarstern datasets, the cruise route is at disposal and presented in the dataset if selected (Figure 12). For datasets related to Amundsen and Arctic Net data are reported as single point measurements.

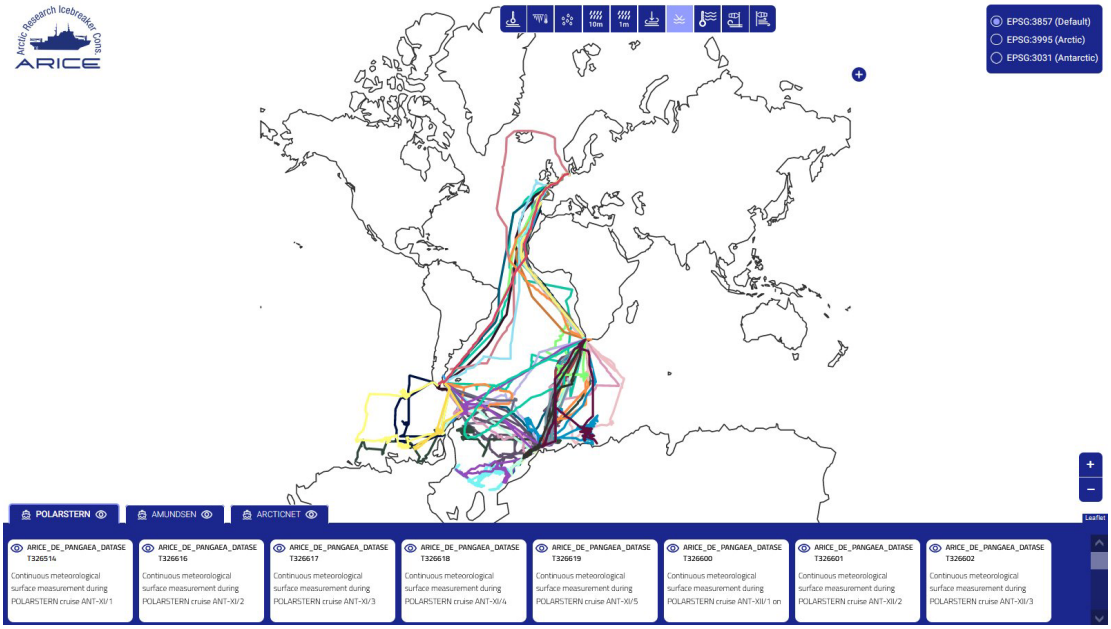


Figure 12 – *The Map viewer: several Polarstern data sets have been selected*

When the data set is selected a large button open on the left side of the screen (Figure 13) giving the possibility to plot data and also to connect with the metadata catalogue where all information on dataset and observed parameters can be obtained. Each parameter in the data sets can be graphically displayed (Figure 13). Graphs can be iteratively managed to see single values, perform zoom for deep visualization etc. Data can be downloaded from map viewer (option on the upper left of the graph – Figure 13), or data repository accessed from the metadata provided by the metadata catalogue. The graph can also be saved in a jpg format. For each parameter, graphical solutions, as well as default axis limits have been defined in such a way to make possible to maintain always the same shape presented in Figure 13.

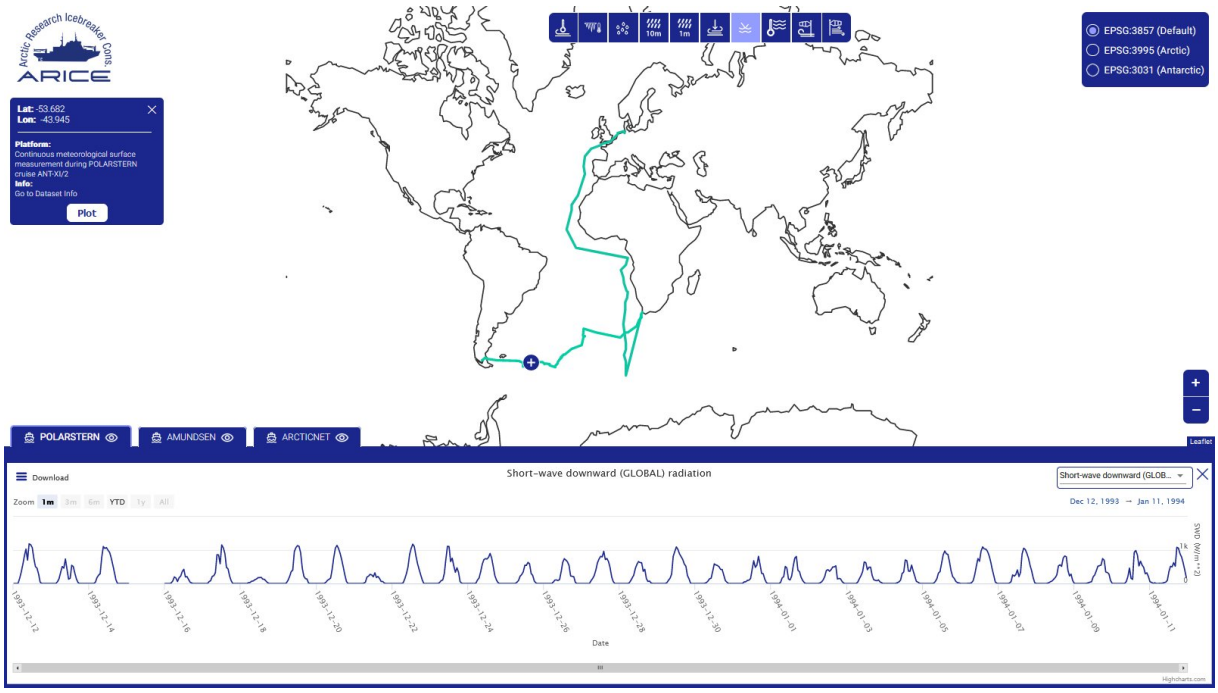


Figure 13 – *A datasets selected and shortwave global radiation plotted. Note the box on the left that able both to activate the plot as well as to connect to metadata catalogue (info). Also note possibility for fixed zoom or select the time scale. Finally on the left top the Download function.*

4.2. Metadata catalogue

It is powered by Geonetwork Opensource [1]. It collects metadata from existing catalogues such as Pangaea and Polar Data Catalogue and also hosts metadata of the projects supported by ARICE and/or the projects supported by PONANT in the frame of the call launched with the support of ARICE. It allows data discovery and interoperability. It uses the ISO19115 metadata format and common vocabularies.

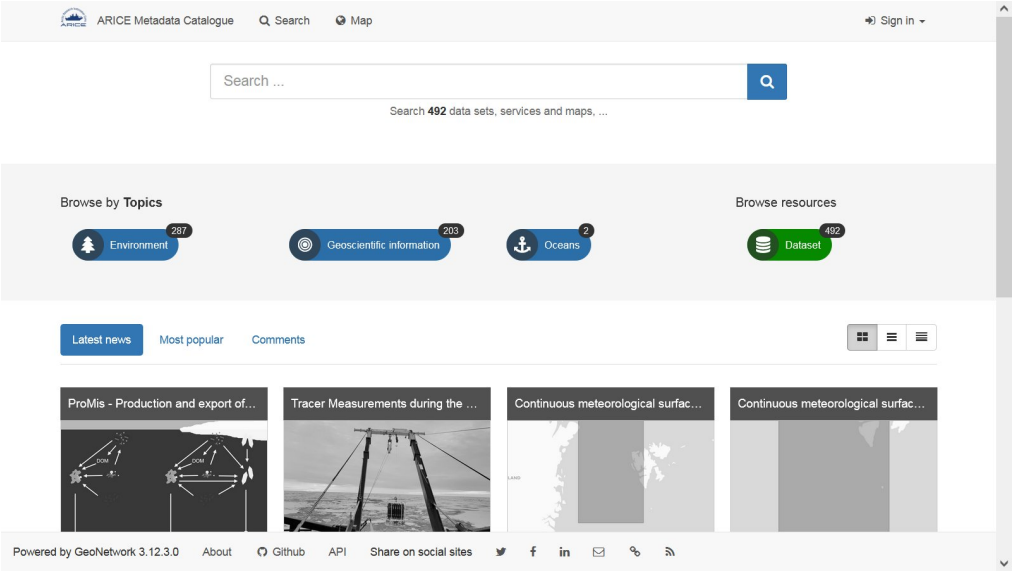


Figure 14 – *The home page of the metadata catalogue*

As shown in Figure 14, at the moment the catalogue is populated by 492 records, 264 of them presented also on the Map Viewer. As indicated above metadata catalogue can be reached by the Map viewer. In the future we plan to activate the possibility to make possible also navigation in the opposite direction.

4.3. Polar Cruises Summary Report database

There is an increasing need and demand from the science community, policymakers, and stakeholders for timely access to information and data on the Arctic Ocean. An inventory of scientific cruises is a useful tool to describe the context of data collection at sea and how these data potentially contribute to improved knowledge of the Arctic Ocean and surrounding seas.

SeaDataNet [2], a pan-European infrastructure for ocean and marine data management, manages the inventory of Cruise Summary Reports (CSR) in all European waters and the global ocean [3]. SeaDataNet CSR inventory stores more than 60 000 CSRs. In the frame of the ARICE project, a specific polar CSR inventory is currently being implemented to describe the context of data collection at sea and how these data potentially contribute to improved knowledge in the Arctic Ocean. The technical details of this latest tool developed during the summer of 2022 and after the submission of D7.6 [1] are extensively reported below.

5. The Cruise Summary Reports database

SeaDataNet, a pan-European infrastructure for ocean and marine data management, manages an inventory of Cruise Summary Reports (CSR) in all European waters and the global ocean. CSR are the usual means for reporting on cruises or field experiments at sea. It provides a first-level inventory of measurements and samples collected, using various types of platforms, such as research vessels including icebreakers, ships of opportunity, coastal structures, moorings, gliders, and more. An online tool "CSR back-office" is available for chief scientists to create and update CSR entries by submitting CSR XML files to SeaDataNet in CSR format or by completing an online form. They are advised to contact their National Oceanographic Data

Centre (NODC) to check whether they have to report directly to the SeaDataNet CSR online back-office or to their NODC, which will then transfer their CSR entries to SeaDataNet. SeaDataNet CSR inventory stores more than 60 000 CSRs. The CSR Synoptic Arctic Survey – Oden 2021 - VACAO is an example of a cruise funded by ARICE which has submitted a summary in the inventory.

Within the ARICE project, a specific polar CSR inventory is currently being implemented, using the SeaDataNet CSR database, standards and interface. The polar inventory contains a subset of the SeaDataNet global inventory which has been extracted based on geographical criteria (namely polar and subpolar ocean areas). Relevant CSRs are selected using a list of ocean sub-regions in polar areas of the C19 SeaVoX vocabulary. To search a cruise, the polar CSR inventory keeps the same search facets as in the global SeaDataNet CSR inventory. However, an additional search facet is under development in the catalogue allowing us to select the ice capability of the vessel through two options: Ice capable vessel, which includes all categories of icebreakers, and open water vessel. By offering a customised discovery service, this polar CSR inventory complements the Metadata catalogue and the Map viewer Data tools of the ARICE website. It also provides information on cruises useful for the ARICE 3D Icebreaker tool by providing a URL to access the cruise list for each icebreaker in the tool.

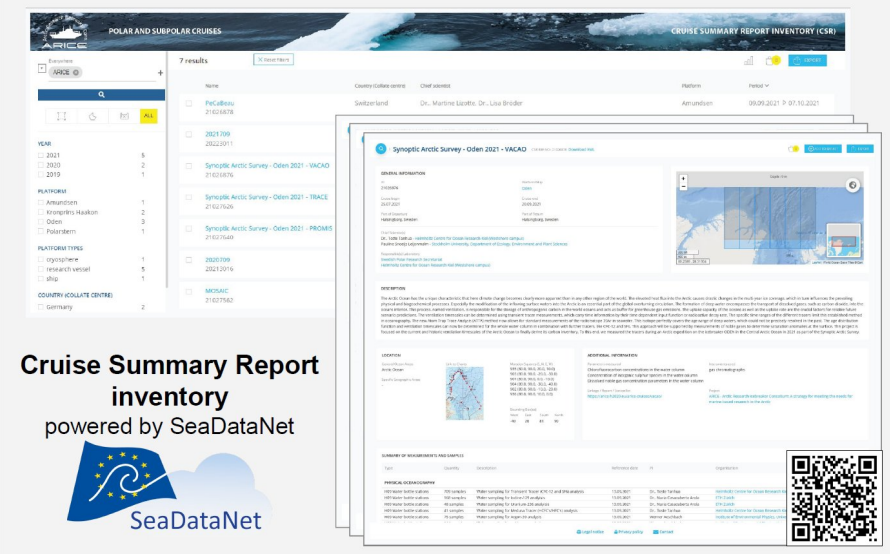


Figure 15 – *The home page of the Polar Cruise Summary Report*

Because the marine community has large volumes of oceanographic data stored in various repositories and catalogues, it is imperative to adopt and use an ontology and common standards for interoperability. A SeaDataNet CSR profile provides metadata on cruises and complies with international data management rules by using the ISO 19139 geographic metadata and INSPIRE. It is based on XML schema especially designed for storing CSR profiles in the inventory. The CSR content is supported by common vocabularies for many metadata tags. Common vocabularies consist of lists of standardised terms that cover a broad spectrum of disciplines of relevance to the oceanographic and wider community.
For the general information, the vocabularies used are:

- C17 (ICES platforms code) for platform/ship,
- L06 (SeaVoX Platform categories) for platform class,
- C38 (SeaDataNet ports gazetteer) for the port of departure/return of the vessel.

For the location, the vocabularies used are:

- C19 (SeaVoX salt and fresh water body gazetteer) for general ocean areas,
- C37 (Ten-degree Marsden squares) for the Marsden squares.

For data, the vocabularies used are:

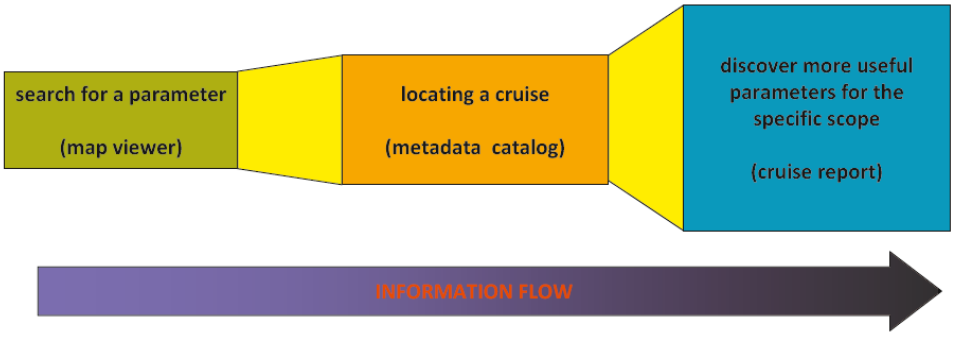
- P02 (SeaDataNet Parameter discovery vocabulary) for parameters
- C77 (SeaDataNet Cruise Summary Report data categories) for data type
- L05 (SeaDataNet device categories) for instruments.

In addition, two metadata tags use information from two other inventories hosted by SeaDataNet, which are EDMERP for European research projects and EDMO for European organisations.

6. Connection between data tools and 3D virtual icebreaker

As indicated 4 tools to discover scientific expeditions and data in the Arctic Ocean have been developed. These tools offer the possibility to approach the information content present in the ARICE DMS from different levels, increasing the flexibility of its use. Whether a user only knows the acronym of a cruise or is looking for a specific parameter in a specific time period or specific geographic area, he can search the DMS using the right tool. But in addition to the advantage of making the approach to DMS simpler and more flexible, the tools developed, if used in a synergistic way, can lead the user to significantly increase the amount of information available to him. Figure 16 provides a couple of simple examples to support this statement.

In addition to what the examples in the figure show, the use of the 3D icebreaker can also allow a scientific user to better understand how the measurements are effectively carried out and to appreciate any problems that may arise from the specific observation platform / specific ship.



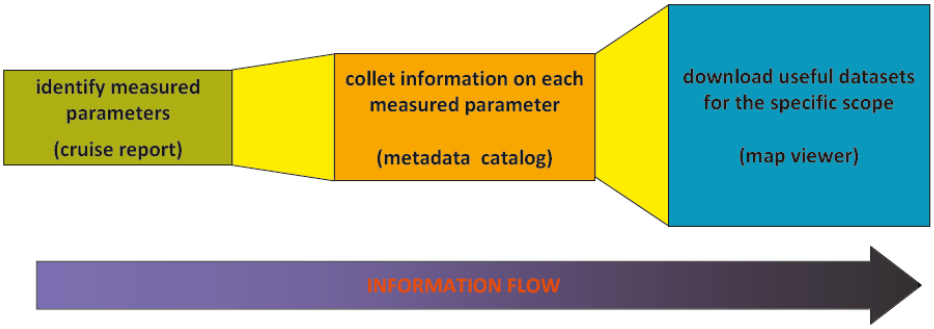


Figure 16 – *Examples of how the synergistic use of the developed tools can lead the user to retrieve much more information than initially sought for.*

Also considering what has just been said about the possible synergistic use of the different tools, future development of the ARICE DMS will move along two directions:

- consolidate and enlarge both metadata catalog and datasets at disposal; secure regular cruise summary reports from the research vessels as well as ship of opportunities like the Commandant Charcot, introducing if/when necessary little addition to mandatory information to facilitate synergy; strengthen the connection with the Arctic and polar data landscape, also considering satellite observations.
- Increase and extend functionalities of developed data tools with the aim to make the synergy depicted above more efficient in generating more information and "added value" from the use of the ARICE DMS

7. References

[1] D7.6 - Data Management System and documentation (https://arice-h2020.eu/about/work-packages/wp7-enhancing-virtual-and-remote-access-to-data/)

[2] SEADATANET - https://www.seadatanet.org/About-us

[3] CRUISE SUMMARY REPORT STANDARD - https://www.seadatanet.org/Metadata/CSR-Cruises