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ARICE: Arctic Research Icebreaker Consortium:

A strategy for meeting the needs for marine-based research in the Arctic

Deliverable 2.7. Update of inventory of specific opportunities for technology transfer and innovation between Arctic science community and industry

 05/10/2022

Submission of deliverable

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1.- Science industry dialog for ARICE

The main goal of ARICE's WP2 is to maintain a fluid dialogue between the industrial community and the Arctic scientific community. Ultimately, such dialogue allows the development of the industry to respond to the challenges of sustainability, responsibility, and effectiveness in industrial operations in the Arctic.

During the period since the publication of D2.4 "Inventory of specific opportunities for technology transfer and innovation between Arctic science community and industry" in 2020, this dialogue has continued, providing tools for the possible development of a long-term relationship between the scientific and industrial community in the Arctic.

2.- Science-Industry Meetings

To date, WP2 has hosted, joined, or partnered on the organization of three high-level science-industry meetings. These are:

WOC Sustainable Ocean Summit (SOS), 2020 (online)

Hosted online from 08 to 11 December 2020, the SOS 2020 convened the third meeting between ARICE ILP, the maritime industry and the science community. The session was titled "Arctic Sustainable Development: Impacts of Changing Environmental Conditions on Shipping Operational Risk" and it discussed how shipping operational risk caused by changing environmental conditions can be predicted to ensure safe and sustainable marine activities. Further details on the session can be found in D2.6.

Besides, another session dedicated to data collection was also relevant to the science-industry relation in the Arctic. It was titled: "Implementing the Vision of Ocean and Climate Data Collection by Industry: SMART Ocean-SMART Industries in Support of SDG 14 and the U.N. Decade of Ocean Science". The discussion determined how the industry could become more involved in the collection of data that serves scientific objectives in a specific way. This point is particularly important with regards to how industry can provide data aimed at specific "knowledge gaps" in order to eventually achieve better science in the Arctic.

The recommendations were as follows:

1. WOC recommitment to advancing the SMART Ocean-SMART Industries program development.

2. Develop a hub or “clearinghouse” for industry as part of expanding its efforts to broker interaction with the science and technology community in order to engage the help that industry needs to participate in data collection and sharing.

3. Encourage, challenge and assist ocean companies to at least evaluate their potential for engaging in (or expanding efforts in) data collection and sharing. WOC will develop a submission for the 1st “Call for Action” for the UN Decade of Ocean Science.

Oceanography International (OI), 2022 (London, UK)

The fair was held from March 15 to 17, 2022 in London, UK. 500 exhibitors and more than 10,000 visitors had the opportunity to visit this exhibition, the first after two years of cancellation due to COVID. The exhibition had all the equipment that can be added or arranged in autonomous vehicles. ASV and AUV have been developed extensively in recent years and their use in any sea conditions and capabilities have increased considerably. This is an important advance in terms of the miniaturization of registration equipment, which must be included in the limited payload of autonomous vehicles. Therefore, there will be future applications in recording equipment that can be used by the maritime industry in support of data collection for science, especially in the Arctic.

SMM, 2022 (Hamburg, Germany)

The fourth (and last) meeting between science and industry was convened at the leading international maritime fair (SMM) held in Hamburg from 06 to 09 of September 2022. ARICE WP2’s team collaborated with other organizations from the EU Polar Cluster and was present on a booth during the whole trade fair. The EU Polar Cluster’s presence and actions on-site consisted of:

1. On 07/09: a 10-minute speaker session introducing the EU Polar Cluster and its key projects (including ARICE)

2. On 08/09: the fourth meeting between industry and science, as a one-hour stage session titled “Operations in ice-covered waters. How can the maritime industry benefit from cooperation with science?”. The session moderated by the WOC, gathered 2 speakers from science, and 2 speakers from the maritime industry (cruise ship, shipyard)

3. A questionnaire aimed at the private sector about prioritizing themes for EU polar research. On-site, the questionnaire gathered 11 responses. It kept being advertised after the SMM and got more responses.

Further details on the session can be found in D2.8.

Technology Developments to Advance Antarctic Research: A workshop, 2022 (NFS, National Academies)

The National Academies of Sciences, Engineering, and Medicine organized an online workshop to solicit broad community ideas and inputs regarding how technological innovation can:

1. advance, facilitate, and transform Antarctic research and facilitate improvements to science support logistics;
2. increase the reach of scientific investigations in Antarctica while reducing the logistics and environmental footprint of these operations; and
3. facilitate broader, more diverse participation in Antarctic research.

A number of presentations and discussion themes focused on particular disciplinary sciences and cut across multiple disciplines, especially regarding technologies on: autonomous sensors and platforms; data transfer and communications; communications and connectivity; transportation and logistics, and; energy sources and consumption, including low power and battery developments.

The discussions were not only framed on the use of new sensors or innovative technologies, but also on how to attract talent and new researchers in the technological field and be able to materialize innovative ideas. This is also a major challenge for research organizations.

3.- Major outcomes of the science-industry dialog

Deliverable 2.5 “Minutes of the second annual meeting between the ARICE ILP and the Arctic science community” regarding the discussions with the ILP (Industry Liaison Panel) provided a general idea of what industry and science understand as joint needs for a sustainable science in the Artic region

These priorities continue to be in line with what was expressed in the conclusions of the other events that have taken place:

1. **Need for more data collection**. For both science and industry, it is a priority that can respond to the needs of both parties.

2. **Need for safe maritime Arctic operations**. From the point of view of maritime operations, the industry needs practical applications to be able to carry out its operations safely (detection and greater knowledge of the evolution of ice, planning of safe routes, etc.). All aspects of safety in maritime operations also have a direct implication in environmental management.

3. **Ships of opportunity**. Make the ships that work in the Arctic a tool that can help achieve the two previous objectives. Train and adapt data collection equipment and technologies to the capacities and possibilities of ships in the industrial sector.

Finally, Deliverable 6.5 on "Key technologies for an improvement of ship-based and autonomous measurements in the Arctic Ocean" provided some of the needs in terms of technology in the field of marine research, such as:

1. The development of increasingly independent autonomous systems. Whether submarine or surface, these platforms will be key in marine and atmospheric research. The miniaturization of the sensors to install in reduced equipment payloads is crucial as well for the installation in drones.
2. The application of artificial intelligence and the capacity of communications is essential to allow the use of multiple platforms and receive their feedback in real time.
3. The development of technologies to improve battery life and reliability will be key to facilitating longer and more complex missions, providing more energy capacity to have more sensors. In this sense, it will apply to both autonomous teams and observatories.

4.- Technology transfer opportunities

4.1.- Inventory of technology transfer and innovation opportunities

The work carried out in D.2.4 "Inventory of specific opportunities for technology transfer and innovation between Arctic science community and industry" aimed at translating the needs from industry and science into opportunities for technology transfer and innovation arising from the relation between these two communities. Since the publication of D.2.4 in

2020, new expectations have been generated in terms of technology transfer between science and industry in the Arctic field. In other words, in addition to the opportunities previously identified in D2.4, some new ones have been reported in the inventory. These opportunities have been classified based on what was expressed by the industry in recent events (cf Section 2). **The updated tables are shown below, with the new additions marked in light blue.**

4.1.1. Safe maritime operations in the Arctic

Industry Interest	**Technology need**	**Support science activities**	**Technology available**	**TRL**
Ship design. Fuel consumption	New reliable and CO2 reduced propulsion systems	New propulsions systems development	Fuel cells, batteries, LNG,…	5-8
Ship design. Fuel consumption	New and efficient energy recovery systems for reducing oil consumption	Identification of points and systems suitable for energy recovery	Energy recovery systems from winches, antiroll tanks,…	5-10
Risk assessment/tools for ship design and navigation Route planning (short term) Optimal use of infrastructures/shipping resources	Forecast conditions for weather, ocean and ice (short term) Mission planning algorithms and methods	Develop a risk assessment toolbox accessible in near real time. Field campaigns and historical data combined for model validation and development. Framework for optimal use of infrastructures / shipping resources	Weather and sea ice forecast services at different spatial scale, from few hours to 5-7 days	4-5
Route planning (long-term) Navigation services planning	Forecast conditions for weather, ocean and ice (monthly, seasonal)	Develop risk assessment methods Integrated navigation services	Integrated satellite observations and sub-seasonal, seasonal forecast models	3-7

	Mission planning algorithms and methods	Cross validation by ships collecting data of ice and iceberg positions along route(s)		
Route planning. Marine mammal avoidance	UW Acoustics with telemetry position and species identification	Validation of equipment and technology	UW Acoustics	4-5
Respond to POLAR CODE on pollution	Test new technologies for pollution measurements, effects and mitigation in real conditions	Stakeholder engagement and interactions to identify promising technologies, present and (expected) future standards and management strategies	Results on scrubber water, new fuel oils, bilge water, lubricants, cargo residues and treated sewage and food waste, underwater noise. Same risk areas models Multi-Iper-spectral and opto-acoustic techniques for atmospheric pollution	1-4
Respond to POLAR CODE on pollution	New technologies for detection and management of oil spills	Adaptation of existing technologies. Oil spill plume detection and forecast	Computational techniques	8-10
Present new POLAR CODE regulations on waste management and support sustainable tourism growth	Waste management plan Transfer on ships consolidated land technologies On-board detectors to secure and document that waste management policies are in compliance	Adaptation of existing technologies/developme nt of new methods suitable for ship conditions Transfer of experience acquired in remote areas or space Demonstrations of water treatment processes and waste treatment processes Mapping of areas where impact (pollution and	Water and waste systems for separation and compacting, biological treatment, etc. Map same risk areas	5-8

		‘time presence’) is different levels of impact		
Reduce overall risks and support ship design	Effective survival equipment	Test in real conditions Define special certificates on survival equipment	Different equipment including Tents or storm shelters, Thermal protective aids or similar, sleeping bags, Foam sleeping mats, Emergency food, Group survival equipment container etc.	6-9
Ship design to respond to POLAR CODE	New materials for low temperature	Test in real conditions Define special certificates on POLAR materials (e.g. ISO type)	Winterization of materials	7-8
Respond to POLAR CODE work to improve/ameliorate its standards	Documentations and standards	Stakeholder engagement and interactions to identify management strategies Test present certifications and standards	Integrated ecosystem assessment for the Arctic, including policy tools	2-3
Risk management and ship design	Standard ship interfaces based on Data Distribution Standards	Test systems on board for real world applications	Research and some commercial products are available	6-9
Risk management and route planning	Automatic instruments for data acquisition, e.g. of sea ice and snow variables of interest	Test systems on board for real world applications	Use of drone technologies for ice measurements	5-7

Navigation services planning	High bandwidth communications and cloud-based services for near real-time, high resolution transfer, storage and analysis of data	Define secure protocols	SeonSE platform from e-GEOS and similar. See also ARCSAR project	
Risk management, route planning and navigation services planning	AI-based methodologies for automatic classification of ice properties from satellite images	Applications and testing	Products from ESA or national agencies	6-8

4.1.2. Need for data collection

Industry Interest	**Technology need**	**Support science activities**	**Technology available**	**TRL**
Define shipping coating requirements	Mapping biodiversity status along navigation route	Assess changes at different spatial and temporal scales	End to end ecosystem models	2-3
Route planning (short term)	Forecast conditions for weather, ocean and ice (short term)	Develop a risk assessment toolbox accessible in near real time. Field campaigns and historical data combined for model validation and development.	Weather and sea ice forecast services at different spatial scale, from few hours to 5-7 days	4-5
Route planning (long-term)	Forecast conditions for weather, ocean	Develop risk assessment methods	Integrated satellite observations and sub-	3-7

	and ice (monthly, seasonal) Mission planning algorithms and methods	Integrated navigation services Cross validation by ships collecting data of ice and iceberg positions along route(s)	seasonal, seasonal forecast models	
Underway measurements	Easy to install and management "FerryBox"	Water underway sampling	Underway measurements	5-10
Route planning (long term)	Coastal and traffic areas bathymetry	Equipment developments in acoustics applicable to commercial vessels	Ferrybox, multibeam echosounders	4-8
Route planning (medium term)	Ice flows and dynamics	Field campaigns and historical data combined for model validation and development.	Satellite images, short scale products (drones)	2-6
Underway measurements (sea water)	Easy to install and management "FerryBox"	Water underway sampling	Underway measurements	5-10
Underway measurements (air)	Easy to install and management "Air FerryBox"	Air underway sampling	Air collectors	5-10

4.1.3. Ships of opportunity

Industry Interest	**Technology need**	**Support science activities**	**Technology available**	**TRL**
Ship design	Standard ship interfaces based on Data Distribution Standards	Test systems on board for real world applications	Research and some commercial products are available (Box 1a)	6-9

Risk management and route planning	Automatic instruments for data acquisition, e.g. of sea ice and snow variables of interest	Test systems on board for real world applications	Use of drone technologies for ice measurements	5-7
Navigation services planning	High bandwidth communications and cloud-based services for near real-time, high resolution transfer, storage and analysis of data	Define secure protocols	SeonSE platform from e-GEOS and similar. See also ARCSAR project	

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