CAPARDUS - Capacity-building in Arctic standardization development

Coordination and Support Action under EC Horizon2020

Grant Agreement no. 869673

Project coordinator: Nansen Environmental and Remote Sensing Center

Deliverable 6.2

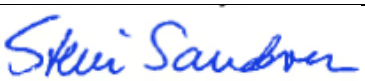
DESIGN FOR AN ARCTIC PRACTICES SYSTEM (APS) AND ROADMAP FOR ITS REALISATION

Type: Report

Start date of project:	01 December 2019	Duration:	42 months
Due date of deliverable:	31 March 2023	Actual submission date:	05 June 2023
		Revised and resubmitted:	22 Nov 2023
Lead beneficiary for preparing the deliverable:		AWI	

Authors: Pier-Luigi Buttigieg, Annette Breckwoldt, Nike Fuchs, Jay Pearlman, Francoise Pearlman, Gesche Krause and Siri Jodha Khalsa

Version	DATE	CHANGE RECORDS	LEAD AUTHOR
1.0	26/03/2020	First version	P.-L. Buttigieg
1.1	22/11/2023	Revised version after external review	P.-L. Buttigieg

Approval	Date: 01 June 2023 Revised: 22 Nov 2023	Sign.  Coordinator

DISSEMINATION LEVEL		
PU	Public, fully open	X
CO	Confidential, restricted under conditions set out in Model Grant Agreement	
CI	Classified, information as referred to in Commission Decision 2001/844/EC	

Executive Summary

One of the key objectives of CAPARDUS was to propose a design for an Arctic Practices System (APS): a digital system to promote the sharing of methodological knowledge about living, working, researching, and sustainably managing the Arctic and its resources. Such a system would address challenges such as fragmented and limited access to Arctic practices, by providing an integrative platform for discovery, access, and collaboration. It builds upon the successful implementation of the IOC-UNESCO Ocean Best Practices System (OBPS), and its emerging federation of providers, which focused on the marine domain.

The case studies conducted by CAPARDUS partners have provided an initial round of insight into the context and role of such a system, captured in this report. The system's core value lies in facilitating the discovery and understanding of diverse practices, safeguarding and protecting contributed knowledge, and enabling control over the sharing of data.

The original plan in CAPARDUS was to gather reporting and feedback from other work packages (WP), including workshops and meetings with partners. However, the COVID-19 pandemic disrupted in-person meetings and hindered the integration of input from local partners and experts as originally planned. The requirements from Indigenous People and their organisations have not been included. Also, requirements from commercial operators, governmental agencies and educational institutions have not been addressed, because it would involve a much more extensive study than the resources and scope of CAPARDUS. As a result

the outputs, insights, and recommendations captured from workshops and documents have been synthesised and condensed into this roadmap for an APS.

In this report, the APS design principles are described, which involve engagement-based co-design, ensuring mutual benefit, careful contextualization of content, reconciling open access and intellectual property rights, multi-modality, capacity sharing, robustness, simplicity of use and development, modularity, and relevance. These principles are important for the APS to meet the requirements of diverse users and promote responsible and ethical use of methodologies and practices.

Further, an expected development path of the APS is described, which isprimarily of technical character, guided by input from selected stakeholders The technical development process includes several stages such as requirement gathering, system architecture design, user interface development, repository implementation, testing, and redesign. This roadmap identifies the need for repeated rounds of requirement setting and refinement, during which the implementation team will rely on surveys, interviews, and workshops with potential users to identify their specific needs and preferences for the APS. Based on such requirements, the components and modules of the system will be determined, but we describe a core set of modules our case studies and user profiles have indicated as essential. In brief, tailored user interfaces (UIs) and user experiences (UXs) will draw content from a secure database storing stakeholders either submitted directly to the APS or harvested from existing systems and filtered through a set of processing modules to identify, structure, and translate content to increase its value to users. User feedback modules will support iterative refinement and improvement, ensuring that the APS meets the needs of its intended users as they change in a rapidly changing Arctic.

In addition to the technical development, an APS will require capacity-development efforts to ensure that users can effectively utilise and participate in the design of the platform. It is recommended that training programs, workshops, and support materials should be developed to enhance users' understanding of the APS and its functionalities. This capacity-development component aims to empower the users to contribute their knowledge while maintain control and authority over it.

In conclusion, this deliverable provides initial guidance on the design and deployment of an APS as a digital knowledge system for sharing and accessing methodological knowledge related to the Arctic region. By embracing the core values and implementing functionalities identified by CAPARDUS participants, a co-designed and co-implemented APS has great potential to facilitate the exchange of knowledge, promote collaboration, and support sustainable development in the Arctic.

Table of Contents

1. INTRODUCTION TO THIS DOCUMENT

The research efforts undertaken in CAPARDUS include a wide variety of participating partners and focused on the inclusion of requirements from researchers, commercial operators, governing and regulatory entities and other knowledge holders.

The objective of this deliverable was to synthesise and condense the outputs, insights, and recommendations of other WPs – as well as earlier outputs of WP6. into a design specification and roadmap for development of an Arctic Practice System (APS), which is envisioned to become a digital system for sharing knowledge between Arctic stakeholders. The specific core objectives of this document therefore are:

- To summarise and scope the challenges of building an APS;
- To identify the core capacities an APS must have to permit broad participation across diverse groups of stake- and knowledge-holders; and
- To propose a path towards deploying a fully-fledged APS, capable of federating assets provided by diverse new partners.

The Arctic Practices System (APS) builds on the IOC-UNESCO Ocean Best Practices System (OBPS; Pearlman et al. 2019, Pearlman et al. 2021), which was implemented to address similar challenges in the marine domain. The OBPS is hosting a forward-facing methodology management system in tune with standards in global ocean observing (e.g. linked to the Essential Ocean Variables or EOVs of the Global Ocean Observing System). In CAPARDUS, an initial design of an APS was formulated through developing an understanding of how stakeholders involved in the project handle and share their methodological knowledge, gleaned through qualitative reflection on workshops and dialogue meetings.The central value of deploying an APS will lie in helping a heterogeneous set of stake- and knowledge-holders discover and understand the practices of others, while protecting and managing their contributed knowledge. Different groups are likely to benefit from an APS, including, researchers, educators, students, decision and policy makers, non-governmental organisations/civil society groups, and funders. Indigenous People and various local communities were not included in the design of the APS, mainly because the COVID-19 limited the possibility to involve them in the work.

Exploitable CAPARDUS outputs

CAPARDUS is a Coordination and Support Action (CSA) under the European Union's Horizon 2020 Programme with focus on capacity-building to explore ongoing processes of developing standards and guidelines, related to topics of relevance in the Arctic. Such topics are exploitation of new technologies (e.g. observing systems), or utilisation and sharing of data to support sustainable development. The capacity-building activities were planned to involve scientists, students, technology providers, economic actors, local communities, regulators and their organisations. Through a series of workshops and dialogue meetings information from the case studies in Greenland, Svalbard, Alaska, and Yakutia were used to identify requirements to an APS. These events were used to show how the social-environmental systems are changing Arctic communities, and the drivers for these changes. Climate change and its consequences in the Arctic leads to new requirements for planning and decision-making based on scientific and economic data, assessments and predictions. A prerequisite for good planning is access to and sharing of data and information of relevance to the actors in the Arctic. To do this an Arctic Practice

System should be developed that is searchable on titles, keywords, and content (comparable to OBPS; Pearlman et al. 2019, Pearlman et al. 2021). An APS should be co-designed and co-implemented to be a tool for co-production of knowledge between scientists, students, technology providers, economic actors, local communities, and other stakeholder groups.

2. DESCRIPTIONS OF KEY TERMS AND CONCEPTS

Stake- and knowledge-holders: This expression acknowledges the variety of engagement with and between equal partners, advisors, experts, trainers, and visitors (Lakola et al., 2020). Those that hold knowledge about a certain issue in the Arctic are as important as those that "hold a stake" in a certain issue, place, process, or other entity. Indigenous People are important knowledge holders and right holders, implying that they can decide how they are engaged in research and how their knowledge is used and disseminated. ICC has produced a report on protocols for equitable and ethical engagement of Indigenous People in Arctic research.

Participation: Following Reed (2008), participation is defined as a process where individuals, groups and organisations choose to take an active role in making decisions that affect them. In this sense, participatory approaches are perceived as the important ways to foster the 'social robustness' of knowledge (Hage et al. 2010). This definition focuses on stake- and knowledge-holder participation rather than broader public participation, if stake- and knowledge-holders are those who are affected by or can affect a decision (after Freeman, 1984). Thus, participation endorses the (often conflictual) plurality of perspectives on a problem, and acknowledges that both the methods of its generation and the facts are always value-laden. The aims of applying participatory approaches can be grouped into four main categories, that is (1) *instrumental aims* that focus on the status and acceptance of the product; (2) *quality aims* which concern either as quality control of the knowledge and used methods, or to fill in knowledge gaps; (3) *democratic aims* envisage that stake- and knowledge-holders are entitled to participate in the production of knowledge that regards them; and (4) *emancipatory aims* that concern processes of mutual learning, creating networks of expertise, and supporting less privileged groups (empowerment). All of these categories are relevant to the work conducted in CAPARDUS.

Co-design: This concept has become a key approach in many fields, including research on climate change and sustainability. It aims to develop specific research methods in order to advance and support processes of social change, and to contribute to their implementation in a collaborative manner. This begins with the formulation of what is to be regarded as a shared problem and includes the agreement on the steps of joint knowledge production. Co-design is hence a response to the idea of integrating different work methods to produce more robust and comprehensive knowledge. Key components of a design process should involve: intentionally involving target users in designing solutions, postponing design decisions until after gathering feedback, synthesising feedback from target users into insights, and developing solutions based on feedback. A co-design approach can therefore combine lived experience and professional expertise to identify and create an outcome or product via steps of co-design, co-production/co-implementation, and co-delivery (e.g. of a report). It builds on engagement processes (e.g. community development) where all participants, from experts to end users, are encouraged to participate and are respected as equal partners, sharing expertise in the design of services and products.

Standards and Practices: Both standards and practices are rarely, if ever, aligned universally, but are developed locally or regionally, and are thus contextual. To some, the terms imply a set of technical

directives developed by international standards organisations, confirmed and monitored for compliance by governance bodies. Others may consider standards to be a set of rules or agreements established by a community that are based on norms and ethical behaviours. In this broad gradation, there is overlap between more formal, top-down standards and bottom-up community developed practices, conventions, and norms. Different kinds of standards can range from culturally and socially negotiated ethics and norms to formally negotiated laws.

CARE principles: The CARE principles (www.gida-global.org) complement the FAIR principles. The latter have become a major priority in data-centric efforts, and focus on facilitating the discovery, sharing, and reuse of data over the web. The CARE principles seek to ensure that data is used ethically, requiring collective benefit, authority to control, responsibility, and ethics. "Operationalizing the FAIR Principles for scientific data with the CARE Principles for Indigenous Data Governance enhances machine actionability and brings people and purpose to the fore to resolve Indigenous Peoples' rights to and interests in their data across the data lifecycle." (Carroll et al. 2021: 1) Persisting power relationships (e.g. power imbalances between Indigenous and non-Indigenous, local and external, government and non-government individuals and groups) continue to hinder collective benefit and trust building, and hence the development of shared solutions (such as an APS). Effective measures to ensure that the use of data and information does not lead to the further marginalisation or harm of Indigenous and local groups are therefore of high importance in technology design. .

Guidelines and Regulations: When used in this document, the term "guidelines" suggests voluntary (and usually non-binding) sets of general recommendations, principles and rules, usually developed with a variety of stake- and knowledge holders on a given topic e.g., Arctic data generation, sharing, knowledge exchange, participatory research and co-design. Regulations are understood to be more formal and binding, typically embedded within a legal and corrective framework. Guidelines and regulations in the Arctic (e.g. with regards to environmental and human protection, economic activities, safety of operations, planning and decision-making) would indeed be useful for settings where data collection and data sharing (including the sharing of practices and other methodologies) are important elements, taking into account that there is no "standard Arctic", only a variety of highly diverse regions and communities.

APS concept: This term links all the components within the design process of an APS, from the first stake- and knowledge-holder mapping exercises to the actual prototype demonstration of how the system works and how it could be used. This concept guides the implementation of an APS and is intended to link people who create a practice with those who use them, help them to protect the ways how they share their knowledge, and thus support capacity development in an interwoven and contextually aligned process.

Data: Data can exist in very different forms, but generally comprises collections of structured signs, symbols, or other representations of an entity, describing quantity, quality, fact, statistics, or other basic units of meaning'. Data can be digitalized or not, qualitative or quantitative. Here, all data that can impact *how* local stake- and knowledge-holders in the Arctic share their knowledge (i.e. not the knowledge itself) is of concern. An APS should seek, harvest and convert data into forms that support efficient and informative sharing, analysis, and/or processing.

3. WHY DO WE PROPOSE AN ARCTIC PRACTICES SYSTEM?

The Arctic is a rapidly developing region, disproportionately impacted by the multiple stressors of climate change as well as dramatic increases in new economic activities, transportation routes and natural resource utilisation. It is also a region where long-established indigenous and local communities have lived, worked, and observed their environments for generations, and who face unprecedented challenges to their cultures and livelihoods. If current rates of greenhouse gas emissions continue, Arctic people will increasingly experience "extremes in temperature, sea ice and precipitation phase far outside anything experienced in the past century and probably much longer" (Landrum & Holland 2020: 1114). That said, Arctic communities experience the consequences of these extremes not as individual events but as the composite of multiple events. As the commercial interests and communities present in the Arctic diversify, the collective ability to share data, information, and knowledge on how to operate – and how not to operate – in this fragile region will be instrumental in protecting and sustaining the Arctic and the livelihoods of its peoples. More holistic observations and syntheses of knowledge are in demand, particularly those which effectively include the perspectives of Arctic indigenous knowledge holders. This includes that the different cultural, social, and economic settings across the Arctic region are acknowledged and are appropriately represented. As each community is different, each region is different, its culture, history and language is unique, a mode towards standardisation and interoperability is needed that helps to foster participation and dialogue across the different knowledge realms and stake- and knowledge-holder groups alike.

Arctic communities and sectors are - by and large - still methodologically isolated and thus limited in harnessing the knowledge needed to address emerging challenges. This isolation leads to the situation that the methods and practices used by one community or sector are often unknown or inaccessible to another. As a result, this methodological isolation leads to missed opportunities to share knowledge and observations from a plethora of different sources and limits the creation and adaptation of new methods across the Arctic as a whole. As a consequence, this lack of information exchange results in missed opportunities to build trust and innovation across observations and subsequent decision-making in the Arctic region. To date, while centrally coordinated frameworks for observing the Arctic emerge, there is a risk that (local) practices that are considered unfamiliar – despite their validity – will not be integrated into or supported by the systems that determine the region's future. This undermines participation of key stake- and knowledge-holders in the region, especially those impacted by practices they have little to no awareness of or say in. This may potentially lead to a marginalising effect on those stake- and knowledge-holders who rely on such practices to inform and support their way of life, compromising drives to realise societal benefit through enhanced observation and informed decision-making. However, connecting these siloed knowledge sources is not a trivial task, but requires co-designing an inclusive, linked system where communities can – in a manner under their control and ownership – preserve and share their methodological approaches. This solution, and the resulting knowledge-base it will build, is a concrete step towards deeper understanding and partnership building across the Arctic.

Access to Arctic practices is currently fragmented and limited, since these practices are held on diverse platforms across disciplines and cultures (for illustration, see Appendix). A sustained resource that offers more uniform discovery and access is needed to link methods that may be related or interdependent as well as people who create a practice with those who use them. This need resonates across a large array of stake- and knowledge holders, and is expressed in high-level considerations of

e.g., of the International Arctic Observing Assessment Framework (IAOAF, initiated in 2017) and its major initiative the Sustaining Arctic Observing Networks (SAON),

In line with the objectives of EU-PolarNet, the IAOAF also articulated how Arctic observing systems bring value to societies, identifying so-called Arctic-specific Societal Benefit Areas (SBAs; see Starkweather et al., 2020 and Dobricic et al., 2018 for context). The IAOAF identifies 12 SBAs[1], further specified into 42 sub-areas and 140+ key objectives. The SAON initiative – co-sponsored by the Arctic Council (AC), the International Arctic Science Committee (IASC), the World Meteorological Organization (WMO) – released a 2018-2028 strategy and implementation document in 2018. These documents called for the creation of a roadmap to create a well-integrated Arctic observing system, which is being iteratively pursued in the SAON Roadmap for Arctic Observing and Data Systems (ROADS). The ROADS process seeks, among other objectives, to increase coordination across Arctic actors and stake- and knowledge-holders by the definition of Essential Arctic Variables (EAVs)[2], measurable by multiple networks using Arctic-viable technology and practices (e.g., Bradley et al., 2021).

As noted above, this deliverable lays out an initial design specification and roadmap for the development of an APS, which complements the considerations in the SAON ROADS process. Each EAV – and the data, information, and knowledge supporting it – will be associated with diverse collections of methodologies (i.e. practices) that must also be made transparent and accessible while protecting intellectual property, respecting cultural norms, and commercial competitiveness. The same principles and architecture will also support more local efforts in the future, allowing the collective documentation of 'how' Arctic activities are and/or should be conducted as a record of the region's complex (encompassing cultural, natural, scientific, ethnological, etc.) heritage.

4. COLLECTION OF INFORMATION ABOUT REQUIREMENTS FOR AN ARCTIC PRACTICE SYSTEM (APS)

4.1 On engagement for designing an APS

Learnings from previous efforts on engaging with the large variety of Arctic stake- and knowledge-holders have generally revealed that project structures in stake- and knowledge-holders' engagement are less supportive than long-term engagement provided by institutions such as national parks. The development of trust requires clear and mutual and tangible benefit for all participants, understood and negotiated by those participants. An often reported view is that well-paid scientists approach IPLCs, use local resources for research purposes, and give nothing tangible in return. If monetary compensation cannot be offered, an equally valuable benefit should be found. When approaching IPLCs and other local stake- and knowledge-holders about the design of an APS, there are some additional key elements to consider before scientific-technical questions can be approached. For example, in order to understand

[1] *The 12 SBAs are: Environmental Quality, Food Security, Fundamental Understanding of Arctic Systems, Human Health, Infrastructure and Operations, Marine and Coastal, Ecosystems and Processes, Natural Resources, Resilient Communities, Sociocultural Services, Terrestrial and Freshwater, Weather and Climate.*

[2] *The EAVs are counterparts of a growing family of Essential Variables, used as interfaces between research, operations, and decision-makers are all levels. Other EVs include the GEO BON Essential Biodiversity Variables (https://geobon.org/ebvs/what-are-ebvs/), the GOOS Essential Ocean Variables, and the GCOS Essential Climate Variables (https://public.wmo.int/en/programmes/global-climate-observing-system/essential-climate-variables).*

who might experience a direct benefit from using an APS, opinions and perspectives from all affected (and not simply targeted) groups must be gathered.

Suggested questions for the core team to consider before the co-design process starts, are:

- Who should be the target group for the system and who should have access to it?
- What other groups will be affected by methodological sharing enabled by the APS? Have they been informed and offered mechanisms to shape the process of APS development?
- Who should be contacted and how?
- How do we plan for and ensure continuous input from IPLC to the development of an APS?
- How can we generate shared ownership of the APS, i.e. to the process of developing it and, later on, using it?

Simultaneously, the following questions address more complex challenges, and should be reflected upon:

- What benefits could diverse communities derive from an APS? Are they equitably distributed?
- How do we communicate these benefits?
- What would convince stake- and knowledge holders to co-develop and use an APS?
- How do we effectively and equitably engage IPLC?
- Can an APS help in bridging the worldviews of its user base?
- Have we identified and secured sustained resources for APS development and operation for all participants?

Stories and experiences from the work of CAPARDUS partners have provided initial insights into some of these aspects of an APS, which will determining its varied user interfaces (UIs) and user experiences (UXs)[3], in order to improve the system's usability[4]. In the following, the considerations from the workshops were focusing on user experience, however, due to the travel restrictions during the pandemic, the actual determination of user needs could not take place, or only in a very limited fashion. To adapt to these circumstances, the system pilot for this work, the OBPS, was used by several participants as an example of the APS concept. Their feedback on this and the broader APS concept in relation to their real-world experience and expectations, was then used to advise recommendations. Further, stake- and knowledge-holders were asked basic questions on how they currently archive and converge methods and practices, and then how an APS would be able to support them. The questions and language used for communication were adapted to be understandable by the recipients, and also structured in a way that uncovers and integrates the local information and knowledge factually needed for the design of an APS.

When one enters into dialogue with different groups it is important to make our assumptions clear. The expectations of various groups for an APS can be very different, depending on the interests

[3] subjective experience, perception and emotional experience that occurs during use for the user

[4] or user-friendliness, objective, only a part of the user experience; the focus here is on making use as efficient and effective as possible

and priorities of the groups. An APS cannot include everything because Arctic topics are very broad and the communities are very different. The initial systems should be targeted to certain topics (e.g. knowledge sharing on resources, traffic, tourism) in order to be relevant. Furthermore, the ingestion of information into the APS must be user friendly and consider that online access to the system is often not possible. Thus, there is a need to describe the operating environment and infrastructure of the participating communities/partners. It needs to be clear that an APS cannot be developed without the various Indigenous and local stake- and knowledge-holders. Yet, this deliverable also shows the obstacles that still need to be overcome along this path. As noted in D3.1, it is vital to adopt a true, ab initio co-design process to avoid alienation of stake- and knowledge-holders. Examples/recommendations included:

- Development of guidelines and standards for tourist activities should be done as a collaboration between the governor, experts and locals with knowledge about the practical aspects of tourism. This will help to decide which sites can be visited, how many [visitors], how often, and which sites should not be visited.

- There needs to be a process for how to consult and properly involve communities in decision-making around cultural heritage tourism. In a recently inscribed World Heritage Site (WHS) in Greenland, UNESCO employed a top-down approach in their community communication where meetings were held to give information rather than asking for input. This has undermined local support for the inscription and the WHS has restricted economic activity of fishermen in the area.

- Further, as reported in an informal survey on requirements for an APS (in January-February 2022, prior to the Arctic Science Summit Week 2022) and D6.1, the importance was highlighted of 1) including Indigenous methodologies and practices, the 2) accessibility of the contents through several platforms, 3) focusing on practices linked to training, and 4) language issues. A future pilot phase of co-design will reveal whether such concerns will be a generic theme and persist in case the APS partnership finds the funding to grow.

- The process of co-design and restructuring must be professionally moderated and facilitated by personnel with regionally relevant experience and understandings, alongside the APS' core implementation team. These parties must seek a careful balance between specificity and generalizability of any solutions proposed and tested: solutions must deliver clear value at a local scale, where the urgency of decision-making impacts lives, while simultaneously allowing extensibility to other scenarios in the region, with different challenges and operational norms.

- It must be acknowledged that there will be difficulties in finding representatives of remote communities with sufficient time and resourcing to commit to the APS co-design, -development and -implementation. Equity mechanisms must be deployed, compensating such stake- and knowledge-holders for lost working time and providing them with the tools and resources they need to participate effectively (e.g. translators, liaisons/dedicated facilitators, transport and accommodation). These requirements will be indicative of additional costs incurred as new communities who are not regular participants in regional consortia are engaged.

The envisioned Roadmap towards an Arctic Practice System is illustrated in Fig. 1.

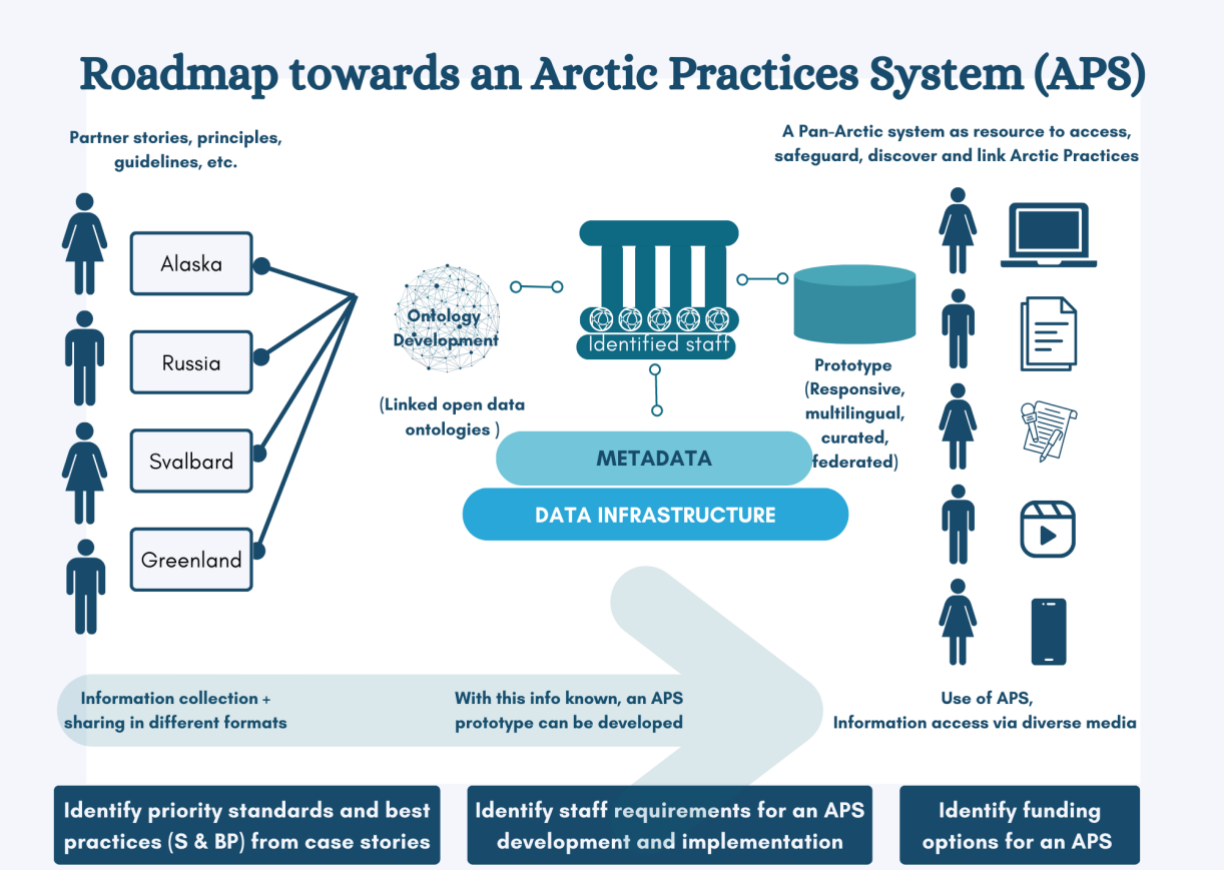


Figure 1: Schematic of an APS development process, resulting in a pan-Arctic practices system.

4.2 Additional major learnings from CAPARDUS' workshops and deliverables

Much of the feedback originating from the CAPARDUS workshops was written-up and assessed (e.g. in terms of usability) in a number of project deliverables. Some of the main outcomes in terms of relevance for the roadmap and APS design were:

D2.1 Report on dialogue with Greenland actors. The report showed that climate change underscores the need for integrated environmental and economic reporting, particularly by communities living in the Arctic. However, the value of community-based monitoring (CBM) and local and Indigenous knowledge (LIK) (including their specific knowledge-sharing practices) is still often not recognized in key decision-making processes that still (too) often rely on international assessments and reports. It was strongly recommended that the actual capture and use of local knowledge be made more transparent and that mechanisms be established to make such contributions sustainable and effective through sustained and equitable participation. This deliverable, among others, identified a clear need to improve cooperation among local hunters and fishermen in Greenland and the international management bodies of greatest importance to their lives and livelihoods (e.g. the North Atlantic Marine Mammal Commission (NAMMCO) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

D2.2 Report on BBN model for halibut fisheries in Greenland. The technical guidelines for the integration of local knowledge in Bayesian Belief Network models (with halibut fisheries in West Greenland as an example) focus on the rapidly changing biodiversity of the Arctic, and its impacts on the region's societies. Models based on Bayesian Belief Networks (BBN[5]) were explored to analyse and predict such multifaceted changes. These models are especially suited to build scenarios with low volumes of digitised or recorded data, as they allow expert and local knowledge to be directly incorporated. Concerns were raised about accurately representing and responsibly managing such knowledge (of the fishers), as well as linguistic and contextualization barriers. D2.2. noted that avenues for local knowledge holders to contribute to the implementation must be well communicated, and evaluated by the level of sustained IPLC participation. This is also central to the genuine pursuit of *Etuaptmumk* ("Two-eyed seeing").

D3.1 Report from the first workshop and dialogue meetgins in Svalbard. The report gives a summary of activities from 2020 to 2022 revealed that bridging the value of environmental observation, cultural heritage, and sustainable tourism development will need to have strong CBM and citizen science (CS) elements to involve the wider public in Arctic observation and societal interaction. Noting that tourism motivated by cultural and/or environmental interest can be regenerative, which can then bridge observations via CBM/CS to Societal Benefit Areas (SBAs, see below). Media helps to deliver/share knowledge over common devices such as smartphones and rendered as podcasts and storytelling in a form of edutainment and adventure, especially when merged with scientific observations.

D5.1 Alaska case study report on interviews with CBM programs for coastal hazard monitoring: The report focused on CBM related to the coastal hazards of coastal erosion and permafrost thaw, as well as harmful algal blooms. With interviews and document analysis, a range of CBM information types used to plan for and respond to coastal risks and hazards were identified, contextualised, and their pathways towards decision processes considered. The report offered insights into another region facing urgent threats from hazards, and which has established networks of CBM and cooperation, and also highlighted the important role (and challenges) of standardisation in connecting community observations with (regional?) decision processes. The approach aimed to develop a concept map to understand how CBM programs produce and share information; some critical discussion on the benefits and drawbacks of greater standardisation for different actors were also included.

D.6.1 Report on the Arctic Practice System co-design work. The potentially beneficial characteristics for an APS – to link people who create a practice with those who use them, and thus support capacity development was explored. The report describes the responses to the workshop and online surveys carried out in 2022. The workshop in Svalbard (6-9 August 2022) was a productive opportunity to engage with a mixture of natural, social and political scientists, and an excellent occasion to exchange information and ideas. The most significant outcomes of the survey and discussions were a clear priority for an APS where practices are easily discoverable and accessible. The APS should support both community practices and standards. It should be the foundation for sharing practices and forming networks of like-minded users. The complexities of Intellectual Property Rights and Privacy need to be handled appropriately both for government regulations and for Indigenous Peoples rights. An APS pilot built upon the OBPS Repository has been used to evaluate key attributes of an APS design. This has pointed to needs for support of multiple languages and for adapting the current operational elements for ease of use under diverse cultural and natural conditions. This looks feasible, but there needs to be

[5] e.g. https://www.ipbes.net/bayesian-belief-networks

Arctic-related use cases as discussed at the workshop to validate the requirements[6]. As a highlight, the survey pointed to the level of interest in the APS from the meeting participants through their answer to two questions: 80% said they would deposit their practices into the APS, and 50% said they would like to participate in the design study. The collaboration potential seen in the Svalbard CAPARDUS workshop can be pursued in advancing the APS as an opportunity for the Arctic.

D9.2 Gender and Diversity Action Plan. The following actions from this plan are relevant also for the design of an APS: to improve gender balance at all levels of personnel assigned to the project, including at supervisory and managerial levels; to take the gender dimension into account when approaching local communities including decision and policymakers, actors in the private sector, and other stake- and knowledge-holders; and to build awareness of the gender balance within the consortium and among the participants in dialogue meetings, workshops, research schools and other events organised by the project.

D9.3 Plan for dissemination an dexploitation. The plan included a few main items intended for exploitation: 1) a comprehensive framework for Arctic standards, 2) the documentation of knowledge and know-how from local communities and operators in the Arctic, and 3) the prototype APS itself. Standards are the common language among stake- and knowledge-holders when dealing with technology and the transition of technology into commercial products and services. Equipment manufacturers, data producers, citizens and governments all benefit from the creation of open standards, which is why it becomes increasingly important that the digital ecosystem for data be designed and managed in a way that ensures sufficient public access, transparency, accountability and quality assurance (UN Science Policy Forum, 2018). Not an easy task at all. Yet, a comprehensive framework for Arctic standards is ultimately expected to be useful for all stake- and knowledge-holders who are involved in the development of "recommended practices", "guidelines", "regulations", etc. in their respective fields. Hence, CARPADUS' objective was to work with local communities and related partners and operators to document knowledge and know-how so this knowledge can be shared between the communities and be maintained in written and searchable form over longer time periods. Increasingly, IPLCs depend on easy access to new information and new technology to complement their own knowledge for adapting to the climatic change. Due to the effects of the pandemic, however, the detailed requirements for an APS could not be explored for different local communities and other user groups to the expected extent. The concept for a fit-for-purpose APS could therefore not entirely develop, be discussed at the originally planned dissemination events, nor fully documented in the roadmap.

5. DESIGN CONSIDERATIONS TO INITIATE THE CREATION OF AN APS

In this section, we provide design considerations for establishing an APS. As we have stated elsewhere, we emphasise that these recommendations serve only as a starting point: to develop this concept into a more comprehensive and robust solution, it needs a broader consultative co-design process that represents a greater diversity of stake- and knowledge-holders. The diversity and selection of these

[6] "*I think it is important that the people working locally should address local actors to inform, discuss, and have dialogue meetings, workshops etc. to involve the different actors in the process, and establish trust and ownership." (Workshop participant)*

stake- and knowledge-holders should be able to identify a diversity of methods that support the observations made in the relevant scientific context in a way that generates societal benefits across the region. The particular methods and related benefits should be identified and defined by the respective stake- and knowledge-holder groups and confirmed as helpful. While the Arctic is more complex than the ocean ecosystems, lessons from the UN Ocean Decade can provide guidance on some of the key challenges to be experienced in the APS roadmap and design. These include, for example, tracing of methods, linguistic barriers, interoperability across "silos" and the relations between methods with similar objectives (Pearlman, et al. 2021).

5.1 Provisional Vision

Multi-sectoral know-how on Arctic practices is safely preserved, rapidly accessible in understandable forms, responsibly managed, and collectively used to advance our understanding, protection, and sustainable development of the Arctic and its peoples.

5.2 Core values

The design of the APS will evolve as new partners with varying capacities and interests join its co-design; however, we anticipate that the following core values will remain stable throughout its successive rounds of design and development, guiding their outputs.

Multilateralism: VariousPartners in/contributors to the APS may be interested in sharing methodological know-how to support dialogue, promote reciprocity of value, avoid conflict, and sustainably manage the Arctic for future generations. With a wide range of geographic and cultural diversity, please explain in practical ways how such convergence can occur…. and does this also include future users of the system.

Transparency and openness: As far as possible and respecting the rights of all contributors, partners in the APS will facilitate the understanding of their methods to promote trust in their observations, decisions, and other outcomes of their practices.

Equity: Recognising the diverse capacities across the Arctic, partners in the APS will co-design and –develop mechanisms and resources to allow their methods to be understood and reused by as diverse and broad a user base as possible.

Responsibility & Ethics: Methodologies and practices are valuable assets, and their responsible and ethical use is necessary for trust to flourish between all partners contributing to the APS. Contributions should clearly define conditions for reuse, and users should state how they met them. Further, partners in the APS have complete control over what they share and when.

Etuaptmumk: A Mi'kmaw term often translated as "Two-eyed seeing", is a concept championed by Mi'kmaq Elder Albert Marshall which promotes the linking and complementation of scientific traditions,systems, and methods of Indigenous and western knowledge to achieve innovative advancements (Bohensky & Maru, 2011; Pedersen et al. 2020; Reid, et al. 2021; Doering et al. 2022; Leonard, et al. 2022; Yua et al. 2022). The processes for convergence to these core values in the APS design and implementation is discussed in the following section.

5.3 Design principles

Deliverable 6.1 proposed six principles upon which an APS should be designed, derived from experiences in deploying the IOC-UNESCO Ocean Best Practices System (OBPS; Pearlman, et al 2022; Pearlman et al 2019; Buttigieg et al 2019). A refinement of these is listed below:

1. **Engagement-based co-design:** Broad stake- and knowledge-holders (including academic researchers, industry, indigenous organizations or knowledge holders and others) should be engaged throughout the creation and evolution of APS and Arctic practices from initial concepts to implementation and use. It is imperative that such engagement does not perpetuate "parachute science" or other extractive, one-off, or shallow modes of consultation, but is based on sustained and meaningful participation of all those engaged.
2. **Mutual benefit**: Closely linked to reciprocity, the benefits realised by each contributor, user, or other participant in the APS (both in general and through each specific class of supported actions) must be clear to and deemed fair by them. In this pursuit, the acknowledging and harmonising of diverse value systems through consensus building will be key.
3. **Contextualisation**: The APS should be able to retain the context of the practices (as metadata) to understand if a practice is appropriate for another specific purpose.
4. **Open Access and Intellectual Property Rights**: An open-access policy must be balanced against community rights for information control (cf. the need for a system to respect Indigenous data sovereignty; e.g. Racine 2022; National Inuit Strategy on Research 2018; Kukutai & Taylor 2016).
5. **Multi-modality**: To achieve geographic and culturally attuned coverage, practices should be accessible in different languages, modalities (e.g., documents or videos or audio recordings) and sourced from all regions.
6. **Capacity sharing:** Educational tools should be integrated into the design of the APS to accelerate how new participants learn Arctic practices.

Subsequent CAPARDUS activities have confirmed the relevance of these principles across the project's use cases. Additionally, we propose the following principles to ensure that the design of the APS (as it evolves) is able to accommodate novel opportunities and face unexpected challenges.

7. **Robustness**: An APS would federate independent resources, which would require a robust core infrastructure to be in place to weather the addition, change, or removal of components as Arctic observing and management systems evolve.
8. **Qualified simplicity**: From its user interfaces to its back-end implementation and foundational technologies, the APS should strive for simplicity and efficiency. Ease of use and maintenance should be prioritised, and any features which do not clearly contribute to achieving the vision of the APS deferred.
9. **Modularity**: Closely tied to robustness, the APS should be built as a collection of modules, each with defined inputs/outputs linking them together. In this manner, changes or accommodations of, e.g., digital sovereignty or regional regulatory frameworks (which may preclude certain technologies or capacities) can be nimbly implemented with minimal overhead.
10. **Relevance**: The informational value and user-friendliness as well as that of the APS should supersede the usage of Google, Youtube and ChatGPT in order to make it relevant for users.

6. CORE COMPONENTS OF AN INITIAL APS

6.1 Architecture

Given the understanding and contextualisation provided above, the general specification of core APS components is articulated below. We deliberately do not identify any specific software or technological product, as many tools and products are suitable and the final choice is in the hands of the implementation team(s) deploying an APS. It is essential, however, that all such choices are 1) generally aligned to the recommendations herein and 2) interoperable with one another, such that any parallel implementations of APS components can be easily and rapidly reconciled into an integrated system.6.2

6.2 Front-end elements

Front-end elements are those that the users of an APS will interact with, such as websites, smartphone Apps, software interfaces, and other user interfaces. For the front-end component, it is especially important to include the needs of future users in the design of the user interface. In the case of use by representatives of local communities in the Arctic, it is also essential to recognise that the highly diverse cultural and linguistic landscape requires a more individualised matching of users' needs. The case studies of the individual workshops already indicate how different the needs can be and what information should be collected in further coordination processes.

6.3 Multiple, tailored user interfaces & experiences

As our user profiles have revealed (Appendix), potential APS users will interface with the system in a wide variety of ways. Some will be comfortable with the website-based interfaces and portals deployed in the OBPS. However, others are more likely to respond to chat-style interaction via WhatsApp, Signal, Telegram, or other peer-to-peer (P2P), voice-over-internet-protocol (VoIP), session-initiation protocol (SIP) solutions (Appendix, Profile 4). For others, barriers to interaction can be lowered by offering functions to harvest, structure, and recall content in e-mail correspondence voluntarily shared in the APS (presumably in secure and encrypted storage (Profile 3). With the new possibilities being offered by Large Language Models (LLMs) and solutions such as OpenAI's ChatGPT, the feasibility of converting such stores of relatively unstructured information into useable content has dramatically increased (of course, with multiple caveats and risks). However, the capacity to parse, understand, translate content to and from the indigenous languages of the Arctic is still sorely lacking and warrants dedicated research (including ethical and legal analysis) and development effort. Aside from textual content, an APS must also interoperate with multimedia channels such as Alphabet's YouTube and/or social media including Meta's Facebook (Appendix, Profile 2) to identify and harvest content. Relevant content can be processed, translated, and made more discoverable to a wider user base, should appropriate UI/UXs be co-designed with sub-group therein.

Leveraging the content management approach and interoperability architecture described in the section on Back-end elements (below), partners within the APS have the basis to gather and deliver content in user experiences tailored to their stake- and knowledge-holders. Ideally, partners will not have to disrupt relationships with existing UI/UXs they use, but will have a means (under their control) to link content to the processing and archiving environment of the APS to enhance its discovery. Formal research into potential user stories and profiles should guide implementation of multiple sub-regional, thematic, and community UI/UXs, managed by implementation partners as close to user communities as possible. These will – where needed – filter and moderate content while deploying additional software modules

to improve user friendliness and utility. A related approach has been successfully trialled by Ocean InfoHub (https://oceaninfohub.org), which supports implementation partners in Latin America and the Caribbean, Africa, and the Pacific region in creating and maintaining their own portals to a collectively managed knowledge base. Across all these interfaces, the design principle of qualified simplicity (see above) must be underscored to ensure that users can efficiently engage with the modules of the APS relevant to their needs, intuitively and with minimal overhead.

6.4 Back-end elements

To power all front-end elements of the APS, a robust and modular back-end architecture is vital. Back-end operations include all those operations that the end-user is typically never exposed to, including data harvesting, exchange processing, analysis, and system diagnostics. The need for localisation of software and data (e.g. for IPLCs, commercial organisations, research institutes; see Appendix, Profiles 2, 5) is likely to be high in order to allow users and developers of the APS to align to the CARE and FAIR Principles, exercising control over their holdings, and what to make visible, to whom, and when. Further, many potential user and developer groups exist in areas with low-bandwidth or poor internet connectivity (e.g. Appendix, Profiles 2 and 4), presumably with similar limits to digital storage and computing capacity. Thus, the constellation of APS backend will *require*, as a default and native feature, interoperable capacity sharing and the underpinning trust in both the communities operating these and the technology handling content.

6.5 Flexible content management & analysis capacities

As the content in the repositories constituting the APS is likely to be diverse, the system as a whole should be prepared to convert/transform, share, and analyse content flexibly and across a distributed set of independent "nodes". The modularity principle (see above) is a key enabler, as capacities to manage and analyse content can then keep pace with the variety of the content itself.

While the localisation, redundancy, access to, and management/governance of each of the APS' backend components is a matter to decide during consultation and co-design, the following capacities will be required by the system to address needs detected during CAPARDUS:

- Archiving systems supportive of fine-grained version control and provenance tracking. Each object stored in these systems should be assigned a dereferenceable, web-accessible permanent identifier (e.g. a DOI, W3ID) that provides rich, content-negotiated metadata (to be delimited during co-design) on access.
- Advanced rights management and access control systems, with granular configuration to support diverse implementations of the CARE Principles, co-designed with IPLCs.
- Curation and quality control processes, either human-driven or automated. This will allow data to be corrected (with provence tracking), and quality control flags/tags added to indicate uncertainties. These processes are key to accurate data processing and machine learning / AI approaches to help the co-implementers handle content.
- Structured and web-accessible FAIR metadata archives describing and allowing discovery of physical and/or digitised collections. Each of these would be extracted from each uploaded object or populated by human input.
- Containerised software capable of one or more of the following:

- Multi-lingual and –character set support, translation, and interpretation, especially focused on underrepresented or non-digitised languages and scripts;
- Content conversion from localised into globally adopted (or at least APS-wide) data formats and serialisations;
- Content discovery across networked repositories;
- Content classification, using appropriate semantic standards and labels (e.g. BioCultural Labels, Traditional Knowledge Labels, and Sustainable Development Goals, Targets, and Indicators);
- Natural language processing (NLP) such as functions to identify and extract content from websites, social media posts, e-mails, and peer-to-peer communications deliberately shared with the APS (Appendix, Profile 5);
- Image-centric/video-centric feature detection and recognition (Appendix, Profile 2);
- Speech and audio processing and entity recognition. This is particularly needed for content uploaded as audio files, which will include multiple languages. This capacity is also suited to passively collecting (when authorised to) content from in-person knowledge transfer (Appendix, Profile 1, 3);

- Advanced and integrated user, licence, permission, and rights management capacities to ensure sensitive or restricted content is appropriately managed. Such content may be restricted due to commercial, military/security, or cultural concerns. Industry standard secure storage solutions as well as emerging recommendations for cultural assets (e.g. https://ardc.edu.au/resources/working-with-data/sensitive-data/indigenous-data/)

6.6 Methodology-focused interoperability architecture

To interlink the network of repositories and systems composing the APS, and allow sharing of their diverse content and capabilities, a robust interoperability architecture is required. Such an architecture would provide templates and guidance on how the diverse content types hosted by APS co-implementers can be shared across federated systems. Through such conventions, APS partners will be able to work together to make Arctic practices more transparent and accessible (with appropriate constraints, where needed) to regional and international partners. This architecture will almost certainly be web-based, with accommodations for low-connectivity or offline systems (see above).

One of the APS' precursors, the Ocean Best Practices System (OBPS; https://www.oceanbestpractices.org/), uses such an architecture to embed itself within the Ocean Data and Information System (ODIS), projecting (meta)data about its content into the web using globally adopted standards, understood by major search providers such as Google and Microsoft. This allows its holdings to be integrated and made discoverable by systems such as Ocean InfoHub (OIH; https://oceaninfohub.org/) and many others (see Figure 2). A similar approach is being used to federate polar data sets by initiatives such as the POLDER federated search system (https://search.polder.info/about/), co-sponsored by the Arctic Data Committee (ADC), or others such as the POlare Observing Assets Working Group (https://www.polarobservingassets.org/).

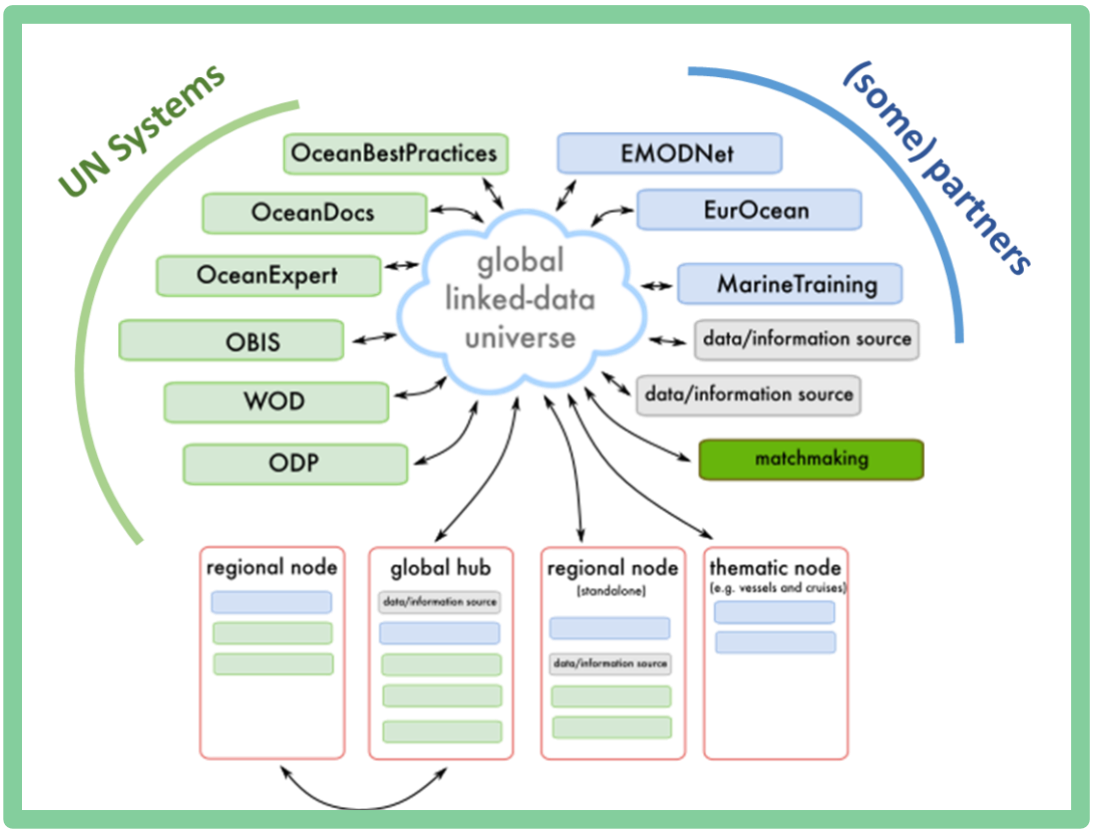


Figure 2: The interoperability approach employed by the Ocean InfoHub (OIH; https://oceaninfohub.org/) and Ocean Data and Information System (ODIS), within which the Ocean Best Practices System (OBPS) is embedded.

The creation of an interoperability architecture and specifications compatible with systems like POLDER and Ocean InfoHub - with accommodations to describe the content managed by the APS - would offer the most direct mode of interlinking partners and interoperating with a growing list of related initiatives. Special care must be taken to ensure the architecture equitably supports all APS partners, accurately represents the content being shared, and allows the expression and integration of priority (meta)data aligned to actionable or operational standards(e.g. the Polar Code for vessels).

6.7 Networked, trusted repositories

The core of the APS will consist of a network of archives or repositories trusted by one or more Arctic communities. Actual utility and user experience will be explored through a co-design process at the outset, with potential compromises as outcomes. These repositories may be of various types and contain documents, images, artefacts, audio (visual) recordings, and other content in physical or digitised form, according to the cultural backgrounds of respective needs and users. The information may also be housed in existing community-operated systems: As noted in D3.1, Wikipedia is used by several stake- and knowledge-holders as an easily accessible, familiar, and visible resource for archiving Arctic expertise. Each repository on the network can be managed independently and determine independently what and how much content to share via the APS. At least to some degree, each repository that is part of the APS must be able to share or make content available over the Internet, even if this is delayed due to transferring non-digital content to a digitisation or data transfer facility. This content would describe and/or provide access to the repository's holdings, services, and policies within the parameters defined by the community. We recognize that Internet connectivity is not a given in many Arctic communities,

so regular transfer/updating of content (e.g., through physical storage media to a cooperating web-enabled system) must be possible

6.8 Usage analytics, feedback & continuous improvement

As the APS is deployed, how user groups interact with its interfaces and modules will be the primary source of intelligence to guide its refinement and evolution. Well-designed usage analytics approaches and user consultation mechanisms will include the user base of the APS in post-deployment rounds of co-design.

The mechanisms that are used to gain deeper understandings of APS user communities will vary considerably across partners; however, examples of generic mechanisms may include:

- Periodic focus groups with representatives of target user groups;
- Automated gathering of search terms, as a basis to support discovery through natural language interactions;
- Consultation and review by external UI/UX specialists, alongside those knowledgeable about the user community/communities being engaged;
- Generic and specific feedback mechanisms, designed to suit user communication norms;
- Cross-partnership usage diagnostics and analytics, providing insight into how networked repositories in the APS are sharing content, as a foundation to deepen and expand their interoperability.

7. ROADMAP TOWARDS THE REALISATION/IMPLEMENTATION OF AN APS

Implementing an APS (hereafter called ‘the project’) based on co-design (cf. above) will undoubtedly reshape many of the approaches proposed earlier in this document. Nevertheless, this section presents a tentative roadmap to implement what we believe to be the minimal design, while accommodating revision, by acknowledging that co-design is an on-going process. We outline a general approach, define personnel and minimum resourcing needs, and finally anticipate a set-up of three phases of creating and testing a prototype APS, each encompassing steps that can be used/translated into minimal milestones and deliverables.

7.1 Deployment Approach

Framework: Co-Design

To enable/support the operationalisation and applicability of any type of APS requires a co-design approach (as noted in the introductory sections, above) in order to advance and support processes of social change, and to contribute to their implementation in a collaborative manner. From the onset it is thus to be ensured that the products and services an APS may support are applicable and meet the requirements of a user-relevant product. This requires robust and trusted long-term participation on all sides that accommodates the (sometimes conflictual) plurality of perspectives and different types of knowledge, and facilitates mutual learning, creating networks of expertise, and supporting local and Indigenous communities in their empowerment-efforts.

Advisory committee & focus groups

To advise and help steer the project, an advisory committee with trusted representatives from all communities and subregional interests pertinent to the scope of the APS will have to be assembled. This assembly process requires time and dedicated funding, also to engage with the representatives in such a way that they will remain 'on board' during and beyond the project's life-time. It should include funding to compensate members whose professional roles do not already support their involvement. This committee will be instrumental in scoping the mission and operations of the APS co-implementers, ensuring alignment with prevailing and emerging frameworks in the Arctic. To support the committee's work, dynamic, ad hoc focus groups can be established to delve into specific issues or challenges, producing recommendations related to the development of the APS.

Personnel recommendations

- **Project manager:** A dedicated project manager will be essential to coordinate the personnel and partners who are co-designing and -implementing the APS, updating the implementation plan and strategy in response to changing needs, contexts, and opportunities.
- **Liaison persons or 'boundary spanners'** (Hatch et al. 2023): Connecting to the intermediaries of the respective stake- and knowledge holders, dedicated relationship managers, with deep knowledge of the heterogeneity of the Arctic region, experience of its diverse communities and nations, and professional intercultural communication skills will be instrumental in supporting sustained and meaningful interaction and cooperation throughout the APS co-design and -implementation.
- **Facilitators for consensus building:** During co-design processes, skilled facilitators are required to accompany partners with diverse objectives, knowledge, interests, world views, and modes of cooperation on a potentially rocky road towards consensus. Facilitators should be able to adapt methods to accommodate partner modalities of trust and consensus building, to allow effective and inclusive co-design and -implementation of the APS.
- **Content steward(s) / Librarian(s):** As repositories are networked and/or come online, personnel to steward these collections, and direct curators to maintain and align content across the APS partnership, will be critical.
- **Content curators:** Under the direction of these Librarians, the curators will continually assess the state of their repository holdings, ensuring that content released to the APS conforms to expected regulations and conventions, and is suitable for distribution under any assigned licences or restrictions. Familiarity with Indigenous data sovereignty principles and requirements will be an important area of expertise for content curators.
- **Digital solution architect:** A solution architect will create a detailed implementation plan for the core technologies underpinning the APS, in facilitated consultations with the partners.
- **Full stack developer(s):** Under the direction of the solution architect, full-stack developers will engineer the core system modules and extensibility framework to 1) deploy the minimal viable form of the APS, and 2) demonstrate how this can be independently extended by partners in independent development streams. This is a different area of expertise that is involved with co-design and co-implementation. Experience with consumer applications (e.g. Smartphone apps, whose importance

was noted in D3.1) would be key. It is an important role as long as the process is iterative and the developers work under the direction of the collective.

- **UI/UX developer(s):** To tailor user interfaces (UI) and user experience (UX) towards matching user requirements while ensuring close compatibility with the technical architecture of the APS, professional UI/UX developers will be needed to draw and learn from the facilitated consultations to co-create effective and intuitive interaction models for each community.

Infrastructure

- **On-premises hardware:** Many of these APS co-implementers are likely to use local hardware to host and control their collections, before choosing what to share with the federated/allied partners. The costs and nature of these systems will vary widely, and capacity sharing with trusted, sub-regional and/or international partners will be key to interconnect these systems.
- **Cloud-based, containerised solutions:** Cloud-based solutions that have been well-containerised (e.g. using Docker, Singularity, or other container management systems) for portability, which are aligned with the APS interoperability architecture, and which can be rapidly shared and deployed by partners, will be key to both innovation and robust engineering of the APS. The capacity to co-create and/or use such solutions will likely have to be shared across less digitally equipped communities (and those with less stable power supply), and supported by simple and transparent documentation on their functionalities, security measures, and other relevant attributes.
- **Digital and in-person meeting facilities:** Two-way consultation and frequent, constructive, and focused interaction processes are key to building the trusted relationships needed to co-develop and -implement an APS. Thus, hybrid systems to ensure the involved partners have open, trusted, secure and respectful communication channels, are essential to the work of all personnel in the project.

Proposed phases, expectations and timelines for the realisation of an APS

Following the objectives of this document, the lessons learned to date within the CAPARDUS project, and the elements outlined above, we suggest the following phases towards aligned co-design and -implementation of a prototype APS. We articulate broadly defined expectations/steps for each phase (below, to be translated into e.g. milestones), albeit the respectively chosen co-design processes, local context, and local consultations (e.g., incl. preferences, specific existing skills) are difficult/impossible to predict prior to the co-design process and may - as noted above - affect these phases and their individually listed steps. All of these steps/expected results are to be seen on the backdrop of the concepts and principles outlined earlier in this document. The development and deployment of at least some of the APS core design and functionality should synchronise – as far as feasible – with the implementation of the SAON 2018-2028 Strategy and implementation plan. However, the timelines needed to build trust with local stake- and knowledge-holders may not be compatible with that of SAON or other similarly scaled initiatives in the region.

In the following outline of phases, all potentially envisaged steps towards co-design, co-production and co-delivery, this extended time (more than often originally planned) needs to be taken into consideration. From the onset and throughout, technical training and sharing capacity with local users of the APS needs to be established and maintained. This co-design process cannot assume that people are going to be invested in a shared system without a lot of effort and engagement, and that all liaison persons/boundary spanners can effectively represent the communities they are trying to reach. For this, they require deep

and sustained processes of engagement that reach the community level. Liaisons are asked to speak for a diversity of people and their involvement cannot take the place of long-term engagement and interaction at the scale of expected use of the APS. If the goal is for Arctic communities to use this system, there thus has to be an effort included in its design to hold regular workshops, training events, and interaction at the community level. The liaison for each community could then help represent these exchanges within the broader design system. In addition to the extended time, this would likely be expensive; however, without this consultation, the system may be perceived as an imposition, rather than a collective solution wherein each agent has control and receives the benefits they negotiated. In general, projects as limited undertakings are less conducive to generate and maintain trustful relationships, and background circumstances are highly individual for each region, each nation, each community. The following description thus serves merely to draft an understanding on how such a process could look like, with the embodied requirements to adapt to the specific (groups of) partners interested in implementing an APS.

Phase	Description/Expectations	Time
Phase 1 Initialisation & proof of concept	● Setting up project coordination and management ● Co-design strategy and methodology ● Assemble initial co-design requirements, implementation, and advisory groups	M0 - M12
Reflecting on & learning from the process	(by core implementation team and advisory committee)	M12 - M15
Phase 2 (Deployment of operational systems & next feedback round)	● Results of co-design consultations with consensus on initial implementation ● Collect and analyse example content ● Iteratively develop common exchange conventions & monitoring capacity ● Assemble a distributed and open source digital architecture for methodological management	M16 - M30
Reflecting on & learning from the process	(by core implementation team and advisory committee)	M31 - M34
Phase 3 (Maintenance & refinement)	● Implementation plan for the prototype APS ● Monitoring and evaluation of use of the system ● Ongoing engagement process ● Begin iterative expansion of the APS federation	M35 - M48 (or longer)
Evaluation	(by core implementation team and advisory committee)	M40 - M46 (or longer)

Phase 1: Initialisation & proof of concept

Project coordination & management

- Create an overview on needs for capacity-building in standardisation processes following co-design principles;
- The establishment of credible and inclusive project management and coordination mechanisms is a prerequisite to the co-development of an APS.
- Convene the core team which will see the co-design and implementation of the APS through to delivery; decide on who will be in the APS implementation team.

- The project manager, relationship manager, facilitators, librarian, and digital solution architect will initialise – through consultation with the early co-design and –implementation team – the creation of a detailed project plan, scoping early actions to create deploy demonstrations of the APS in a modestly scoped sub-region to initialise the project.

Assemble initial co-design, implementation, and advisory groups

- Once the core APS management and coordination team has been established and a demonstration area identified, a co-design process will begin, where representatives from interest groups in the pilot region will be assembled to express their needs, aspirations, and understandings of the APS vision. The input of this group – with core perspectives provided by the advisory committee – will inevitably restructure any initial plans laid forth in this document and by the core project team. This is a desired outcome, and an opportunity to identify the robust core of the APS as it is tuned to meet local / sub-regional needs.
- As stake- and knowledge-holders are assembled (incl. the advisory committee), a "listen first" mode of project coordination and management is key: this is likely to be a lengthy process, but setting this norm is key to avoid misunderstandings and top-down dynamics that may damage trust at the outset (cf. D2.2).
- The aspects and considerations of 'bringing back the knowledge', in an enriched form, to communities that generated it need to be implemented from the onset.
- Pilot co-design phase: possibly identify the leads of the Essential and Shared Arctic Variables (E/SAVss) and engage them in the first co-design process; SAON/ROADS has a well-defined model where expert panels with special emphasis on including Indigenous communities' work identify SAVs, being piloted by Arctic PASSION and RNA CoObs.
- First round of consultation with interest and potential user groups, including a demonstration of a potential prototype APS; followed by a deliberation process on user-level to discuss, confirm or decline co-design details, usability, options and relevance through future users.
- If consultations with potential users lead to a consensus and validation of the approach and outline, these then must be repeatedly refined and agreed in a transparent, structured, and well-moderated way before implementation.
- Complete first stake- and knowledge-holder mapping, potentially re-define stake- and knowledge-holders after analysis of this concept phase; re-visit selected stake- and knowledge-holder groups for re-initating co-design process and to define the specific requirements.
- Set-up next generation APS and keep close feedback loops with users-to-be.

Phase 2: Deployment of operational systems and next feedback round

- Implementation of feedback round from reflexive turn.

Collect and analyse example content

- Presentation and assessment of preliminary outcomes through advisory committee;
- Once the initial co-design process in the defined pilot region has stabilised, the team will begin to gather and analyse methodological content most relevant to the stake- and knowledge-holders represented in the previous step.

- A precursor of this step has been completed via the creation of a CAPARDUS testbed for content aggregation based in the OBPS APS Pilot, called Polar Collaborations, where 158 documents are registered (status December 2022). The technical personnel of the core team, supported by local partners and the advisory committee, will use this collection as a basis to identify which technologies, content description standards, and conventions are necessary to fulfil the vision of the APS in the pilot region.
- Proposed modes of interacting with and sharing any content offered by (co-)implementation partners must be carefully considered and fully understood by all involved, to ensure that no unintended consequences are encountered.
- Lightweight and internal-use demo versions of the APS will be tested with partners/co-developers before rolling it out to larger interest groups for partner feedback, as the basis of content handling mechanisms. We fully expect that not all technologies or description approaches will be appropriate across all content types. A modular and carefully managed suite of processes to expose content in a manner that contributors wish it to be shared will thus be a core feature of any APS.
- Importantly, D2.1 (Dialogue with Greenland actors) noted that tools are already available to share Local and Indigenous Knowledge and Community-based Monitoring outputs, while these are not in practice used by international environmental management bodies today. In the co-design and -implementation of any APS, the existing tools used by local stake- and knowledge-holders must be integrated and empowered (rather than marginalised or competed with).

Iteratively develop common exchange conventions & monitoring capacity

- Based on recommendations in D2.1, make visible the actual extent of the Arctic that is monitored via CBM or similar local initiatives. Use arcticcbm.org as point of departure;
- Jointly deliberate on both restrictions and opportunities (various media, systems used, …);
- Monitoring is key – this is how to detect if content is shared that should not be shared; monitoring could be done by the content stewards and content curators;
- For new technical capacities or when new partners are connected to the APS federation, a responsible pre-release screening should be conducted on the backdrop of the above-mentioned guidelines and standards for trusted collaborations.

Assemble a distributed and open source digital architecture for methodological management

- This must come after the first tranche of content (cf. content in the Arctic community portal of the OBPS) has been assembled: the tooling should follow the material being managed (rather than the material being forced into the capacities of existing tools);
- Innovation is key (not only, but especially) in this phase, particularly in understanding and accurately representing Indigenous and local conventions and modes of expression;
- Open source (i.e. source code that is made freely available for possible modification and redistribution) is fundamental to trust-building in the team and advisory committee; security and privacy mechanisms and encryption technologies/processes need to be transparent and independently verifiable;

- Extending the prototype APS through new co-design and -implementation processes will be demonstrated here.

Phase 3: Maintenance & refinement & conclusive feedback round

- Implementation of feedback round from reflexive turn.
- The assemble and implementation phase of the prototype APS is completed at this point, and the APS realised. The engagement process continues, as new needs and adjustments during continued curation and work with the APS are expected to arise.
- Monitoring and evaluation (of the use, not the content of the system) process, how users are using it and if it is living up to its intended purpose and if not, why. I believe if the local training/capacity sharing processes are put in place, then this step would be easier because it would involve reconvening current and potential users at the community level to get feedback and provide additional exchange of ideas and training;
- With respect to the engagement process (e.g., for user options), it is important to plan with long time periods, as building the right communication channels/platforms, and allowing equitable participation from a variety of users-to-be, will take time and many iterations (rush too often created the ground for parachute science);
- Acknowledge that the implementation phase might be over, but the co-designing and co-producing work continues, just like the engagement processes.
- End: Beginning of use of completed APS?

Begin iterative expansion of APS federation & in-depth process evaluation:

- With the beginning use of the completed APS, new interested and trusted partners can be brought to the federation/collaboration.
- Open steps are required here (which in the end is no end): as new communities are engaged, the requirements for the APS will change.

8. CONCLUSION

In conclusion, the development of an APS is intended to counteract the persisting lack of exchange and integration of practices and, more generally, knowledge between different communities and sectors in the Arctic, and to lead to opportunities for learning and collaboration. The proposed APS would serve as a platform for sharing and accessing diverse Arctic practices across disciplines and cultures. It aims to support capacity development, facilitate knowledge transfer, and promote inclusive participation, while protecting rights and ownership of knowledge. This deliverable emphasises the need for further engagement with IPLC and other stake- and knowledge-holders to understand their needs and ensure the APS meets their requirements. Existing initiatives like the IAOAF and SAON can support this development, and the integration of SAVs as a guiding principle in the APS design is suggested. Comparable to the OBPS for ocean-related practices, the goal of the APS is to improve the effectiveness, safety and efficiency of Arctic-related knowledge-sharing activities in a scientifically sound and socially responsible manner. The APS can thus be useful for the Arctic by supporting: the sharing of practices, collaboration, capacity building, and policy development. Drawing from the experiences and consultations of various partners in the CAPARDUS regions, and ultimately generating

recommendations and requirements for an effective methodology management system in the Arctic, an APS developed like outlined in this roadmap would not only support scientific observations but also document and preserve Arctic activities and heritage. Overall, the APS can therefore help to promote sustainable development and conservation in the Arctic by providing a platform for knowledge-sharing and collaboration among stakeholders in the region.

9. REVIEWER'S COMMENTS

From the deliverables table, it seems like the original planned deliverable D6.3 was removed, and just D6.2 has been done, which only seems to use the results from WP6 (and it is not clear what exactly was used). It is very unfortunate that apparently the other important work that has been done in CAPARDUS has not been used here, which would have been helpful (and critical) in developing the roadmap document. In particular, D1.5 and D1.2 are providing important information that should be included in the design of the roadmap document.

(1) From the Inuit point of view, it is very problematic to mix Indigenous Peoples and local communities, which has been done in deliverable 6.2. and some of the other deliverables. Please see the policy paper done by the Inuit Circumpolar Council (ICC) on this matter (https://www.inuitcircumpolar.com/project/ policy-paper-on-the-matter-of-localcommunities/). It is similarly important to recognize that Arctic Indigenous Peoples are not stakeholders and should not be reduced to knowledge holders. They are rights holders, as recognized through the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) and other documents. This is important because it includes the right to self-determination and governance. Please also refer to the documents referenced below.

(2) On participation, it is important to establish if, and then recognize how Indigenous Peoples want to be engaged. The very first step is to establish if they are interested in this work to begin with (i.e. proposal development stage). This is outlined in ICC's Circumpolar Inuit Protocols For Equitable and Ethical Engagement (EEE protocols) (https://www.inuitcircumpolar.com/project/circumpolar-inuit-protocols-for-equitableand-ethical-engagement/), as well as in documents such as the National Inuit Strategy on Research (NISR) of the Inuit Tapiriit Kanatami (https://www.itk.ca/nationalinuit-strategy-on-research/), which have been included in the CAPARDUS document repository, but it is not clear that they have been followed in the development of the APS roadmap. There are also similar documents prepared by/with Saami Council. In particular, I recommend that this document is included and followed in developing the APS and further steps:

Herrmann, T.M., Brunner Alfani, F., Chahine, A., Doering, N., Dudeck, S., Elster, J., Fjellheim, E., Henriksen, J.E., Hermansen, N., Holmberg, A., Kramvig, B., Keskitalo, A.M.N., Omma, E.M., Saxinger, G., Scheepstra, A., van der Schot, J. (2023). Comprehensive Policy-Brief to the EU Commission: Roadmap to Decolonial Arctic Research. University of Oulu, Helmholtz-Centre for Environmental Research-UFZ, The Indigenous Voices (IVO) research group – Álgoálbmogii jienat, Arctic University of Norway UiT, Saami Council. Áltá – Kárášjohka – Leipzig – Oulu. https://doi.org/10.25365/phaidra.400.
URL: https://phaidra.univie.ac.at/o:1653557

(3) The capacity development efforts stated (training programs, workshops and support materials) will not be sufficient. There would be the need for sustained support and funding to organizations who lack capacity, such as Indigenous Peoples organizations, to work with the tools over an extended period of time. The tools will need to be maintained and continued technical support will be needed on an ongoing, sustained basis. Please also see the NISR implementation plan for some background on what Canadian Inuit describe is needed to properly implement a research plan (https://www.itk.ca/wp-content/uploads/2018/09/ITK_NISR_Implementation-Plan_Electronic-Version.pdf). To develop (research) standards would be a related exercise.

(4) There are very big gaps with regards to the described user profiles and documented standards and best practices, which will make it difficult to have the system usable throughout the Arctic. For example, Canada, which has extensive and sustained CBM programs funded by the Canadian government, as well as very well-organized Arctic Indigenous (in particular Inuit) governance, is completely missing in the user profiles. Using well established systems and involving existing and well-structured governance would make it more likely that the development of standards can be successful.

(5) Similarly, working with Permanent Participant organizations would have been important, since they represent Arctic Indigenous Peoples across the different Arctic countries. In particular involving Saami Council and the Inuit Circumpolar Council would have been advisable, since they both represent Arctic Indigenous Peoples associated with European countries. But this would also have required funding (including budgeting for person-months) to Indigenous organizations to work on these tasks. When considering participation, the word ‘equitable’ and implementing what it means (i.e.: funding and a proper structure to allow for equitable participation from the very beginning, i.e. pre-proposal developing stage) is very important.

(6) The proposed phases of the realization of the APS are missing a development phase, where the proposal is developed, partners and Indigenous coleads are being identified, and partnerships are being formed. In the case of Indigenous Peoples, this is an extremely crucial step, takes a lot of time, and also needs funding to build trust and relationships. Currently, the co-design process is set to begin when the APS management and team has already been established. From the Indigenous perspective, this is too late.

Overall recommendations:

(7) As stated in the document, the development of the APS should be closely aligned with SAON and the ROADS process. It is true that the timelines may not align, but if ROADS is fully established, the framework can be used to establish the APS. The APS activities can also build on relationships established during Arctic PASSION. However, the roadmap also should use a multi-pronged approach, and include considerations of governance and strategic steps to address these aspects (please see the comments on governance on this).

(8) It is important to scale the APS down to a realistic form, e.g. focus on standards/one standard covering very specific topics/one very urgent need. This is already recognized in the document but what is outlined is still too broad. It is recommended to focus on one specific example, and this

should be very closely developed with the partners in question (ideally, Indigenous partners should be co-leading the work).

(9) The Roadmap repeats some well-established criteria to involve Indigenous Peoples but is missing a clear path forward that actually implements these criteria. Please see the specific comments above on this. In particular, Indigenous governance, and the issue of colonialization needs to be recognized with regards to the Indigenous participation in this work. Some of this is covered in CAPARDUS publications, but it is not taken onboard in this document.

(10) It is recognized that an "APS cannot be developed without the various Indigenous and local stakeand knowledge- holders". However, the way the documents/reports have been written, it becomes clear that this still represents a very colonial view of Indigenous Peoples – the Indigenous coauthorship is clearly missing, which means that the very first step of "co-creation" has already taken place without proper/sufficient Indigenous input.

(11) As mentioned, equitable Indigenous engagement is needed, but this means particularly Indigenous co-leadership in the development (co-design) of the APS, which already starts in the proposal-predevelopment stage. It is somewhat unlikely that representatives in remote communities can take this on, this requires the support of well-established Indigenous organizations working at the needed levels, which have the required mandate (please also see the comments on Indigenous governance).

(12) Again, it would be important to align this document more with D1.2 and D1.5 (please keep comments and necessary revisions on D1.2 in mind), which outline a aspects that seem to be missing here, including governance structures and how they can/should play a role in the APS.

10. REFERENCES

Bohensky, E. L. and Maru, Y. (2011). Indigenous knowledge, science, and resilience: what have we learned from a decade of international literature on "integration"? *Ecology and Society* 16(4): 6. http://dx.doi.org/10.5751/ES-04342-160406

Bradley, A., Eicken, H., Lee, O., Gebruk, A. and Pirazzini, R. (2021). Shared Arctic Variable Framework Links Local to Global Observing System Priorities and Requirements. *ARCTIC* 74(5), Supplement 1 : 69-86.

Bull, J., Beazley, K., Shea, J., MacQuarrie, C., Hudson, A., Shaw, K., Brunger, F., Kavanagh, C. and Gagne, B. (2020), Shifting practise: recognizing Indigenous rights holders in research ethics review, *Qualitative Research in Organizations and Management*, Vol. 15 (1): 21-35. https://doi.org/10.1108/QROM-04-2019-1748

Carroll, S.R., Herczog, E., Hudson, M., Russell, K. and Stall, S. (2021). Operationalizing the CARE and FAIR Principles for Indigenous data futures. *Sci Data* 8: 108. https://doi.org/10.1038/s41597-021-00892-0

Dobricic S., Monforti Ferrario F., Pozzoli L., Wilson J., Gambardella A., Tilche A. (2018). Impact assessment study on societal benefits of Arctic observing systems - IMOBAR. EUR 29400 EN, Publication Office of the European Union, Luxembourg, 2018, ISBN 978-92- 79-96697-2, https://doi.org/10.2760/713084, JRC113327.

Doering, N. N., Dudeck, S., Elverum, S., Fisher, C., Henriksen, J. E., Herrmann, T. M., Kramvig, B., Laptander, R., Milton, J., Omma, E. M., Saxinger, G., Scheepstra, A. J. M. and Wilson, K. (2022). Improving the relationships between Indigenous rights holders and researchers in the Arctic: an invitation

for change in funding and collaboration. *Environmental Research Letters* 17(6): 065014. https://doi.org/10.1088/1748-9326/ac72b5

Freeman, R.E. (1984). Strategic Management: a Stakeholder Approach. Pitman, Boston.

Hage, M., Leroy, P., and Petersen, A. C. (2010). Stakeholder participation in environmental knowledge production. *Futures*, 42(3): 254-264.

Hatch, M. B. A., Parrish, J. K., Heppell, S. S., Augustine, S., Campbell, L., Divine, L. M. , Donatuto, J., Groesbeck, A. S., and Smith, N. F. (2023). Boundary spanners: a critical role for enduring collaborations between Indigenous communities and mainstream scientists. *Ecology and Society* 28(1): 41. https://doi.org/10.5751/ES-13887-280141

Huggel, C., Caplan-Auerbach, J., and Wessels, R. (2008). Recent Extreme Avalanches: Triggered by Climate Change? *Geology Faculty Publications.* 45. https://cedar.wwu.edu/geology_facpubs/45

Kukutai, T. and Taylor, J. (2016) (eds.). *Indigenous Data Sovereignty -Toward an agenda*. Centre for Aboriginal Economic Policy Research (CAEPR) Series. https://doi.org/10.22459/CAEPR38.11.2016

Landrum, L., and Holland, M. M. (2020). Extremes become routine in an emerging new Arctic. *Nat. Climate Change*, 10, 1108-1115. https://doi.org/10.1038/s41558-020-0892-z.

Latola, K., Scheepstra, A., Pawlak, J., and Saxinger, G. (2020). *White Paper on Status of Stakeholder Engagement in Polar Research*. EU-PolarNet.

Pearlman, J., Bushnell, M., Coppola, L., Karstensen, J., Buttigieg, P. L., Pearlman, F. , Simpson, P., Barbier, M., et al. (2019). Evolving and Sustaining Ocean Best Practices and Standards for the Next Decade. *Frontiers in Marine Science* 6:277. https://doi.org/10.3389/fmars.2019.00277.

Pearlman, J., Buttigieg, P. L., Bushnell, M., Delgado, C., Hermes, J., Heslop, E., Hörstmann, C., Isensee, K., et al. (2021). Evolving and Sustaining Ocean Best Practices to Enable Interoperability in the UN Decade of Ocean Science for Sustainable Development. *Frontiers in Marine Science* 8:619685. https://doi.org/10.3389/fmars.2021.619685.

Pedersen, C., Otokiak, M., Koonoo, I., Milton, J., Maktar, E., Anaviapik, A., Milton, M., Porter, G., et al. (2020). ScIQ: an invitation and recommendations to combine science and Inuit Qaujimajatuqangit for meaningful engagement of Inuit communities in research. *Arctic Science*. **6**(3): 326-339. https://doi.org/10.1139/as-2020-0015.

Racine, P. (2022). *Indigenous Data Sovereignty and Open Data in Environmental Sciences. In Indigenous Data Sovereignty and Open Data in Environmental Sciences.* National Center for Ecological Analysis and Synthesis. https://doi.org/10.5281/zenodo.6908484

Reed, M. S. (2008). Stakeholder participation for environmental management: a literature review. *Biological conservation*, 141(10): 2417-2431.

Starkweather, S., H. Shapiro, S. Vakhutinsky, and M. Druckenmiller (2020). *The Observational Foundation of the Arctic Report Card – a 15-Year Retrospective: Analysis on the Arctic Observing Network (AON) and Insights for the Future System*. Arctic Report Card 2020, R. L. Thoman, J. Richter-Menge, and M. L. Druckenmiller, Eds. https://doi.org/10.25923/ahj5-z336.

Stoffel, M. and Huggel, C. (2012). Effects of climate change on mass movements in mountain environments. *Progress in Physical Geography: Earth and Environment* 36(3): 421–439.

Yua, E., Raymond-Yakoubian, J., Aluaq Daniel, R., and Behe, C. (2022). A framework for co-production of knowledge in the context of Arctic research. *Ecology and Society* 27(1): 34. https://doi.org/10.5751/ES-12960-270134.

APPENDIX: EXAMPLES OF USER PROFILES

The following examples of potential APS user groups were composed by the CAPARDUS partners and WP participants with the strongest link to each, typically described in their respective WP deliverables. Each reveals considerations for the design of an APS, which have been integrated in the sections in the main document.

Profile 1. Coastal hazards in Greenland

In this profile, potential APS users are developing approaches to respond to and build resilience for multiple, cascading coastal hazards. Examples include flooding of coastal settlements caused by water displaced by rock avalanches, a phenomenon that may be linked to climate change (e.g. Huggel et al., 2008; Stoffel & Huggel, 2012)

User types:

- Public authorities
- Scientific organisations
- Citizens (esp. evacuees)

Currently, public authorities rely on national and international scientific organisations to 1) investigate the chain of events which leads to hazard impact, and 2) propose approaches for prevention, preparedness, and response to natural hazards. Often, however, the respondent noted that these authorities do not find the scientific results sufficient to inform their decisions. Citizens/evacuees rely on lived experience.

Public authorities transfer knowledge, guidance, and notices of decisions to citizens through press releases, outreach through social and other non-press media, and participation in public meetings. These communications occur prior to, during, and after the hazardous event.

The respondent noted that citizens want greater involvement in decision-making processes, especially those concerning possibilities of returning to flooded settlements and resuming public life. They maintain that authorities should rely more on citizen experiences and know-how, rather than solely on scientific research and recommendations.

Citizens find that their knowledge and know-how is undervalued and underused by public authorities: Too few opportunities exist for them to participate in the processes that can effect change and/or take into account their experiences.

Profile 2. Fisher and hunter communities in Greenland

In this profile, potential APS users are custodians of traditional methods and developers of new approaches to fish and hunt in Greenland. Many of these communities are remote, and have unreliable access to the internet, with variable bandwidth when present.

User types:

- Fishers
- Hunters

Currently, methodological knowledge is primarily exchanged through word of mouth, Greenlandic and Danish television broadcasts, in-person training provided by co-practitioners, and generational transfer within families and larger social groups (e.g. via traditions). Where access to the internet is available, resources are found through generic web searches or through media sharing platforms, with Meta's Facebook and Alphabet's Google and YouTube services mentioned explicitly. The respondent noted that a considerable amount of methodological knowledge is developed through trial and error.

The respondent felt that the knowledge and know-how their community possesses is not sufficiently taken into account by authorities, particularly regarding climatic and ecosystemic changes, alongside their impacts on day-to-day life.

The respondent noted that the exchange of practices could be improved by both web-based and in-person measures. These included the availability of short instructional videos and more opportunities to meet and deepen social ties with other practitioners, while exchanging methodological advice.

The major obstacles to sharing practices and know-how were identified as language barriers, limited access to WiFi, the high-cost of communication, and large geographic distances between potential partners.

Profile 3. Central and Municipal Governments in Greenland

In this profile, potential APS users are personnel working in both central and municipal governments in Greenland.

User types:

- Central government staff[7]
- Municipal government staff

Currently, these users exchange methodological know-how through directives (and further instruction) from superiors, email correspondence and/or phone conversations with knowledge holders, and occasionally web searches. Their primary reference material comes from information materials and instructions issued by the government, supported by knowledge transferred during meetings and conferences.

The respondent noted that in-person attendance at national and international training courses, as well as exchange visits, would be desirable to increase methodological transfer. However, they noted that linguistic barriers, geographical distance, and cost are significant impediments.

Profile 4. Indigenous reindeer herders, hunters, and fishermen in Yakutia:

In this profile, potential APS users are members of indigenous communities in Yakutia, engaging in traditional livelihoods.

User types:

- Reindeer herders
- Hunters
- Fishers, primarily fishermen

Currently, these users exchange methodological know-how through human-to-human interaction, be it intergenerational, intra- and inter-familial, or within a community of practice (e.g. other herders). Occasional use of telephony via Iridium satellites was also noted, as well as peer-to-peer messages and multimedia communication solutions such as Signal and WhatsApp. Traditional exchange of knowledge

[7] cf. Deliverable 2.1.: This Deliverable identified, as examples, staff or volunteers of: Qeqertalik Municipality; the PISUNA Natural Resource Committee in Attu, Disko Bay; Ministry of Fisheries and Hunting; Ministry of Science and the Environment; KNAPK (Association of Greenland Fishermen and Hunters); ICC Greenland; Ilisimatusarfik / University of Greenland; Greenland Climate Research Centre; Greenland Institute of Natural Resources; Oceans North Greenland; UArctic; and the eight EU-funded Arctic projects with community engagement activities (INTERACT, Nunataryuk, Arctic PASSION, JustNorth, EcoTip, Face-It, ArcticHubs, and Charter)

is key to structuring and maintaining this transfer, with trial and error driving cases where no knowledge is available. The respondent also identified the local indigenous peoples organisations in the Republic as a source of information.

The respondent noted that an increased capacity to share experiences across the user types noted above is desirable, both within and beyond Yakutia. They also raised concerns of non-indigenous and extra-regional groups hunting, fishing, and extracting other resources from the local environment.

The respondent noted that methodological sharing was hindered by language barriers, limited and costly access to the internet, and the present geo-political situation.

Profile 5. Cultural heritage research in Svalbard

In this profile, potential APS users are members of scientific and governing bodies in Svalbard, concerned with the domain of cultural heritage.

User types:

- Scientific communities
- Governing bodies and official
- Directorate for cultural heritage research

Currently, these user types have well established channels of communication such as scientific publishing, research/policy consultations, as well as regulatory and licensing processes. The responded noted that these processes are supported by several existing systems, and interoperation with these systems would be necessary to engage with an APS.

The respondent noted that methodological know-how in cultural heritage research is found in standard guidelines, both regionally and at the EU level, accessible to the user types above. Knowledge is acquired primarily through the scientific literature and guidelines provided by regulatory authorities. Methodological knowledge is spread to other stakeholders through outreach activities by these user types, such as public-facing dissemination through museums, public distribution channels online (websites, social media, etc), and the like.

The respondent noted that while the systems that are in place provide ample functionality, there is a lack of comprehensive discoverability, targeted information products, story maps/story-telling interfaces, and related user experiences. As an example, a virtual reality experience of a historic mine scheduled for demolition was proposed, to reconcile cultural preservation with natural restoration and erosion.

Regarding impediments to sharing methodology, the respondent noted that the financing of data and information resources to support comprehensive dissemination was the major obstacle. Additionally, directorates of cultural heritage occasionally have regulatory barriers to fully open sharing. Further, existing national repositories to support sharing of content generally preserve content which has been produced through opportunistic interests (e.g. films, documentaries) rather than through consolidated efforts to share practices.

Profile 6. Tourism in Svalbard

In this profile, potential APS users are members of tourism services and facilities, as well as the respective governing and regulatory bodies in Svalbard.

User types:

- Operators of tourism services
- Authorities governing tourism
- National and sub-national Governors and their offices
- Researchers investigating the impacts of and routes to sustainable tourism

Currently, these user types obtain information on permitted and recommended practice from the Governor's office (for regulations) and from the operators (e.g. Visit Svalbard) regarding all aspects of tourist activity, their guidelines, and approaches to develop sustainable tourism in the region. The research community also provides methodological insight through seminars and presentations to the other actors noted above.

The respondent noted that methodological information is distributed through a set of individual sources. The Governor's office and related authorities, operators, and researchers publish such information through dedicated channels (e.g. through their websites, in journals and whitepapers) and provide information on request.

The respondent noted that there is a need to improve the efficiency and transparency of information sharing, as not all actors are aware of changes to sustainable tourism practices, regulations, and recommendations in a timely or complete fashion. Further, they identified a need to upload experiences and reports related to the safety of expeditions, which is of relevance to all actors in this profile. Further, they noted that tourism organisations typically focus on the promotion and advertisement of expeditions and services. This requires that systems like the proposed APS would have to implement functions to identify and extract methodological information from promotional text, should these organisations not create dedicated channels for this material

The respondent noted that the competitive context of the tourism sector is perhaps the major impediment to sharing methods openly. This reduces the motivation of these actors to allocate resources to the development and maintenance of common information systems.

---------- END of DOCUMENT----------

This report is made under the project

Capacity-building in Arctic standardization development (CAPARDUS)

funded by the European Commission Horizon 2020 program

Grant Agreement no. 869673.

Project partners:

No	Acronym	Participant Legal Name	Country
1	NERSC	STIFTELSEN NANSEN SENTER FOR MILJO OG FJERNMALING	NO
2	NORDECO	NORDISK FOND FOR MILJØ OG UDVIKLING	DK
3	Ilisimatusarfik	Ilisimatusarfik, Grønlands Universitet, University of Greenland	GL
4	AWI	Alfred-Wegener-Institut Helmholtz-Zentrum fur Polar- und Meeresforschung	DE
5	IEEE	IEEE France Section	FR
6	NINA	STIFTELSEN NORSK INSTITUTT FOR NATURFORSKNING NINA	NO
7	UCPH	KOBENHAVNS UNIVERSITET	DK
8	NIERSC	Scientific foundation Nansen International Environmental and Remote Sensing Centre	RU
9	ARC-HU	Arctic Research Centre, Hokkaido University	JP