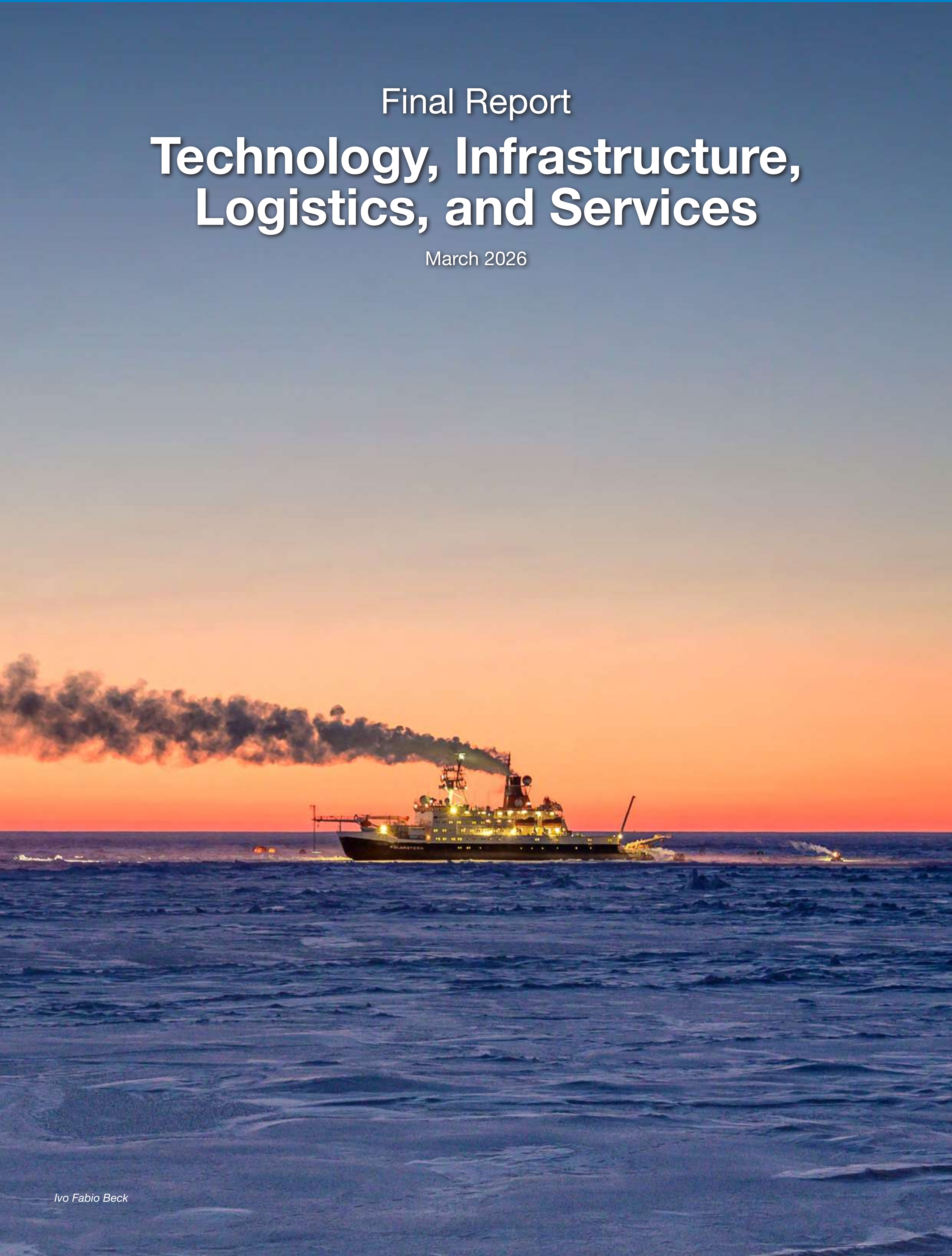
ICARP IV Research Priority Team (RPT) 7

Final Report

Technology, Infrastructure, Logistics, and Services

March 2026



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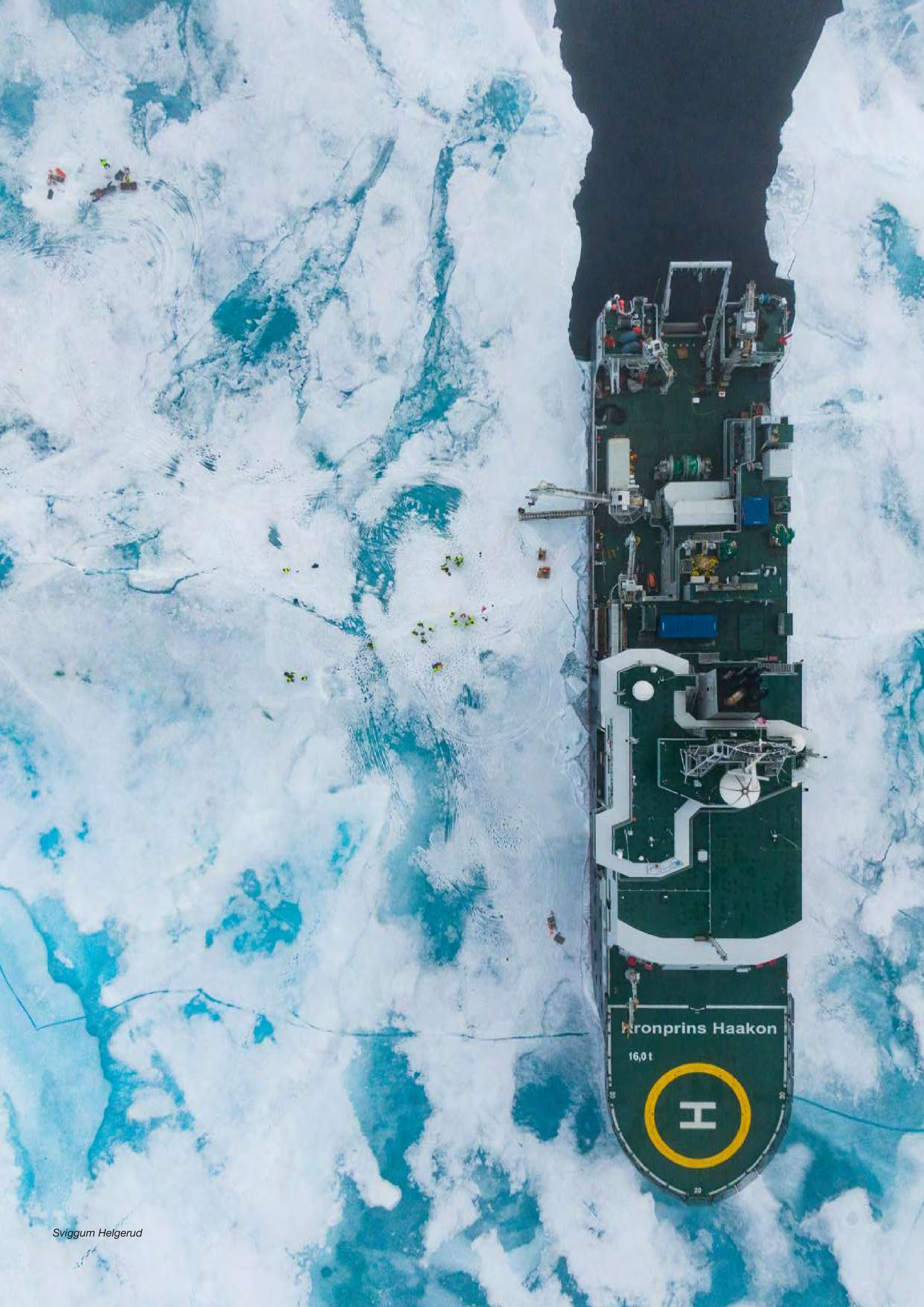

Sviggum Helgerud

1. Executive Summary

Research Priority Team (RPT) 7 addressed key gaps and priorities in technology, infrastructure, logistics, and services which will support Arctic research in the coming decade. These gaps and priorities are presented as research priorities however they may require research or may be issues of focus and implementation. We present this information as a road map for policy makers, funding agencies and scientists, acknowledging the extensive body of thought work which this report is based on.

Arctic research relies on technology, infrastructure, logistics, and services specifically designed to address the unique challenges posed by the Arctic's extreme climatic conditions and fragile ecosystems. **Technology**, understood as the application of scientific knowledge through tools, systems and methods, provides innovations that may enable remote operations and effectively "compress" distance for communication and information transfer between remote locations, operations, and communities. In this report, technology is used as a broad, cross-cutting term that includes advances in energy and power systems, transportation, water and waste management (including reduce–reuse–recycle approaches), and other solutions that enhance the sustainability, efficiency and safety of infrastructure and fieldwork logistics.

Research **Infrastructure** encompasses essential facilities such as research stations (both year-round and seasonal), vessels, aircraft, vehicles, autonomous vehicles and is closely linked to general infrastructure, such as roadways, ports, satellites, energy, compute and communication networks. **Logistics** are built around the procurement, maintenance, utilization of these assets. **Services** can support the on-site or remote needs for fieldwork including lodging, meals, communications and data hosting, safety, remote access, and science support.

Many of the requirements for Arctic research are also critical to the sustainability of Arctic communities. This report seeks to point out the intersection of research and community needs. Technology and infrastructure represent significant long-term investments that may benefit scientists, Indigenous Peoples, and local communities while logistics and services provide essential research support and may contribute to northern economies. We acknowledge that infrastructure and technology also have the potential to harm northern communities; it is critical that communities are involved in making decisions about technology, infrastructure, logistics and services that impact them.

Ted Karlsson

Key Takeaways

1. **Sustainability must guide all investments.** Diesel dependency remains the norm for Arctic research operations, yet it is costly, carbon-intensive, and increases particulate matter emissions, which impacts health and can compromise the accuracy of climate data collection. Research priorities must encourage transparent documentation of environmental impacts and accelerate the development of more sustainable science, including renewable energy systems, effective water and waste management systems, advanced batteries, low-emission transport, logistics sharing platforms, and resilient communications. These systems can benefit both researchers and communities, lowering costs, reducing health risks, and enabling sustainable Arctic living.
2. **Distributed observing systems are critical.** The Arctic is changing faster than any other region on Earth. To capture these changes, research requires spatially distributed, long-term, and year-round observations across land, ocean, and atmosphere. International networking of research stations, vessels, and aircraft and the development of the next-generation of remote sensing, highly elliptical orbit satellites, and cabled or autonomous ocean observatories is essential for providing an efficient platform for implementation of arctic science priorities. These investments provide the backbone for improved process understanding and observing power that may yield more robust assessments, predictive climate/ ecosystem models, and informed decision-making at arctic, national and community scales. Reliable infrastructure, with redundancy, and proper logistical support, are essential to avoid data gaps and for proper functioning observing systems.
3. **Remote and virtual access is a necessary innovation.** Reducing the environmental and economic costs of Arctic research will require advanced remote and virtual access systems. Automated instrumentation, intuitive virtual platforms, and expanded broadband capacity will allow more researchers to participate without extensive travel. Remote and virtual access can be developed to enhance research infrastructure platforms; within Arctic communities it can be applied to capture human observations, provide economic input, and to increase community digital access, hence supporting education, telemedicine, local monitoring, and emergency preparedness.
4. **Indigenous participation strengthens Arctic science**. Indigenous Peoples are leaders in observing, interpreting, and responding to Arctic change. Formalizing Indigenous governance roles in research—including formulating research questions, making observations, participating in research review boards, adopting data sovereignty protocols and Indigenous-led or co-managed repositories—ensures that knowledge is protected, respected, and mobilized appropriately. Co-designing infrastructure, logistics, and data systems with Indigenous Nations creates solutions that are both scientifically rigorous and socially equitable.
5. **Cross-cutting priorities require systemic attention.** Sustained funding for infrastructure operations, field safety, data preservation and access, data harmonization, and cybersecurity are essential foundations for Arctic science. Without stable, predictable investment, long-term observing systems and skilled technical workforce development cannot be maintained. Without safety planning—including multi-use infrastructure for evacuation and disaster response—neither researchers nor communities can thrive. Without harmonized, secure, and sovereignty-compliant data practices, Arctic knowledge risks fragmentation or misuse, particularly in the context of Artificial Intelligence (AI).


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2. Definition of the Focus of RPT 7

RPT 7 is a globe-spanning group of 25 Arctic researchers, logisticians, northern community members and practitioners. We have distilled a wide body of literature on Arctic research, focusing on the technology, infrastructure, logistics, and services that support science. Using the expertise of the team members, the pre-existing knowledge in relevant literature, and community input, we worked in subteams focused on the four topic areas. Each subteam drafted gaps and priorities which were iteratively consolidated. Significant progress was made in advance of and during the ICARP summit in Boulder, Colorado, USA (March 2025), where RPT7 presented on our draft gaps and priorities. The combination of being able to work together in-person, as well as to receive feedback directly from the research community, was invaluable in honing our focus.

Over the course of the 20 months of work, a wide range of topics were suggested for inclusion in RPT7, to the extent that it, at times, became a catch-all for issues not noted within the other RPTs. We were not able to address all suggestions in this report. Several consistent, recurring themes were moved to the cross cutting priorities, while other topics such as cybersecurity and AI impacts are noted in this report but not addressed despite being foundational issues for research in the coming decade.

Following are the definitions used in this report:

Technology refers to the specialized tools, systems, and methods designed or adapted to operate effectively in the Arctic's extreme environmental conditions. Technology innovation encompasses several approaches: modifying existing technologies to withstand the region's severe cold, ice, and isolation, adapting traditional technologies for new applications, or developing new, specialized technologies specifically for Arctic use. Successful Arctic technology emphasizes durability, reliability, ease of deployment and maintenance, and the ability to function autonomously or with limited human intervention in remote, challenging settings. It includes areas such as remote sensing, energy solutions, environmental monitoring, and infrastructure designed to endure the unique challenges of the Arctic environment.

Research **infrastructure** is composed of the facilities and installations needed for the support of Arctic research. Arctic research infrastructure includes a variety of platforms that accommodate people and instruments, including research stations (year-round and seasonal), research vessels, aviation assets, satellites, underwater autonomous vehicles, and infrastructure to support power supply and connectivity, such as submarine cables, internet access systems (cellular, cabled, satellite, …), and underwater GPS systems. Infrastructure also includes social and cultural infrastructure. This infrastructure represents a significant and long-term investment to cope with the challenges and harness the opportunities of working and collecting data in extreme climatic conditions.

Scientific work in the Arctic also depends heavily on logistical support. **Logistics** are the means to access the Arctic and to perform scientific studies within it. Logistics for work in high latitudes are especially extensive, and may require special technology and infrastructure, and hence, are costly in both financial and temporal terms. Historically, logistics costs claim approximately one-third of Arctic Science funds (data from 1997[1]). Many areas of the Arctic are not accessible to researchers on a year-round basis. Currently, investigators and facilities managers have limited abilities to predict and plan for research opportunities. Supporting research in the Arctic requires coordinated efforts by governments and industry to develop new technologies and improve methods for organizing logistics in remote areas, including the movement of vehicles, while minimizing environmental impacts. A well-planned transport and logistics infrastructure will facilitate scientific initiatives and strengthen Arctic communities, thereby enhancing the region's contributions to knowledge and innovation while supporting local resilience.

[1] Schlosser P., Tucker W., Flanders N., and W. Warnick (eds.). Logistics Recommendations for an Improved U.S. Arctic Research Capability. In The Arctic Research Consortium of the U.S., Fairbanks, AK. June 1997. 88 pp. https://www.arctic.gov/uploads/assets/usarc_logistics_report.pdf

Services for Arctic research provide essential operational and scientific support, enabling the effective use of technology, infrastructure, and logistics in extreme environments. They ensure efficient and safe fieldwork through support, operational planning, risk management, real-time communication, weather forecasting, and emergency response. Building on these functions, services also encompass advanced applications such as remote sensing, which bridges operational support with scientific observation. Remote sensing services utilize satellite imagery, aerial surveys, and drones to monitor environmental changes such as ice dynamics, land deformation, and ecosystem health. These services offer broad coverage and real-time data, enhancing research while reducing the need for extensive on-site presence. Services also support data management, ensuring that information from various sources, including remote sensing, is accessible, interoperable, and aligned with data stewardship standards and practices, while at the same time respecting Indigenous rights for data collected in their territory. Access to infrastructure, field sites, data or observations, whether in-person or remotely, can also be considered as a key service provided by research infrastructure. Additionally, services promote collaboration with local and Indigenous communities by supporting co-designed projects, incorporating Indigenous traditional and place-based knowledge in field planning and decision-making, and ensuring that research practices reflect community priorities and expertise. Finally, services may contribute to sustainability by supporting energy-efficient operations, waste management, and environmentally responsible practices helping minimize the ecological footprint of Arctic research.

Innovative technology, sustainable infrastructure, as well as robust logistics and services are integral to implementing Arctic research priorities. Automation and remote operations, the development of new large-scale research equipment and monitoring systems, and the necessity of sharing of national infrastructure and services will advance Arctic research over the next decade and beyond.

Igor Vasilevich

3. Priorities and Needs in Arctic Research for the Next Decade

3.1. Needs and Priorities specific to the RPT 7 topic area

3.1.1. Research Needs for the RPT 7 topic area

Research need	Description of the research need	Rationale why included in this report
Improved technologies	Existing technologies such as batteries and power supply systems or Remotely Operated Vehicles (ROVs) and Autonomous Underwater Vehicles (AUVs) need to be further developed for Arctic environments.	Current technology doesn't fully meet scientific needs for remote deployment and communications, nor is it able to accommodate the need to decarbonize infrastructure. Technology is needed to enhance research capabilities while also decreasing emissions. Advancing renewable energy, developing reliable batteries, improving communication resources, and improving arctic-capable ROVs/AUVs can support both research and community applications such as fisheries monitoring, sea-ice safety, and search-and-rescue.
Sustainable Arctic technology, infrastructure, and logistics	Environmental impacts need to be minimized while advancing technology, infrastructure, and logistics. Research is required in some instances, while other solutions require knowledge sharing or political commitments. Energy is a prime example: technologies that reduce carbon emissions are needed to decrease reliance on diesel fuel, which remains the dominant energy source in most Arctic communities.	The growing scientific, economic, and political interest in the Arctic requires coordinated solutions that ensure responsible development while reducing ecological footprints. When infrastructure and logistics are improved for research purposes—such as renewable energy systems, resilient housing for field staff and researchers, reliable communications, and safe transport—these same investments can also meet pressing needs of Indigenous and Arctic communities, including affordable energy, efficient housing, broadband access, and secure supply chains.
Securing observational data and integration of observing systems	Inconsistent data collection hinders the comprehensive monitoring of the Arctic's rapidly changing environment. A unified and collaborative observing system is necessary to ensure the best possible coverage and quality of observational data, including real-time measurements.	Data inconsistencies hinder environmental monitoring and real-time decision-making. Data gaps due to geopolitical changes, changes in financing and staffing pose challenges to research. An integrated data observation system would enhance environmental monitoring accuracy, support predictive modeling, and enable better-informed decisions regarding climate adaptation strategies as well as real-time decision making. Coordinated efforts will lead to more reliable and comprehensive Arctic data collection, including their description through standards-abiding metadata, which is critical for understanding and managing climate-related changes and provides communities with the information they need for planning, safety, and resource management.
Indigenous Knowledges in research and ethical human dimensions of infrastructure	Sustainable Arctic research requires governance structures that promote Indigenous leadership and equitable partnerships. Ethical field practices—such as community consultation, local workforce development related to research activities, and safe operational standards—are essential to ensure that research infrastructure (field stations, vessels, observation sites) reflects both scientific and community priorities. While human "infrastructure" is not traditionally categorized alongside physical assets, the contributions of local residents, trained staff, and remote access technicians are a vital component of effective research support.	Incorporating Indigenous Knowledges strengthens the socio-cultural and ecological relevance of Arctic research while ensuring equitable and ethical collaboration. Recognizing the human dimension of research infrastructure helps guarantee that activities do more than "cause no harm"—they actively benefit Arctic communities, uphold polar research codes of conduct, and support long-term, sustainable research practices. Addressing the economic and temporal costs of Arctic research is also critical: collaboration with communities can reduce inefficiencies, increase safety, and ensure more timely data collection, while Indigenous Knowledges provides rigorous, place-based scientific practices and observations that strengthen research outcomes.

Research need	Description of the research need	Rationale why included in this report
Expansion and development of remote and virtual access services to Research Infrastructure	Challenges such as logistical barriers, lack of standardization, and cybersecurity risks limit effective remote and virtual access to Research Infrastructure (RIs). Improved systems for remote access and user-friendly virtual platforms as well as the services provided through these modalities are necessary to foster collaboration and reduce the environmental footprint of Arctic fieldwork. Service design and co-design approaches and the identification of user needs in service design are needed to innovate and develop services that benefit both scientific users and local communities. Development of effective Quality Assurance methods and their implementation in remote and virtual access are needed to ensure high quality and efficiency of the services provided. These systems can also function as training environments, allowing Arctic residents to develop transferable skills in data analysis, digital monitoring, and research coordination, all of which are aligned with STEM and skilled technical workforce development priorities.	Enhancing remote and virtual access will democratize scientific research by enabling broader participation and collaboration across institutions, nations, and communities. It reduces the need for physical presence, lowering environmental impacts from Arctic fieldwork, while also increasing the efficiency and sustainability of research operations. At the same time, these systems provide complementary benefits for workforce development: they open pathways for Arctic residents to participate in research activities without requiring costly travel, build experience in digital and technical roles, and connect community-based expertise with broader research networks. In doing so, they expand the Arctic research workforce, support long-term skill development, and strengthen both scientific and community readiness.

3.1.2. Priorities for Arctic Research for the RPT 7 topic area

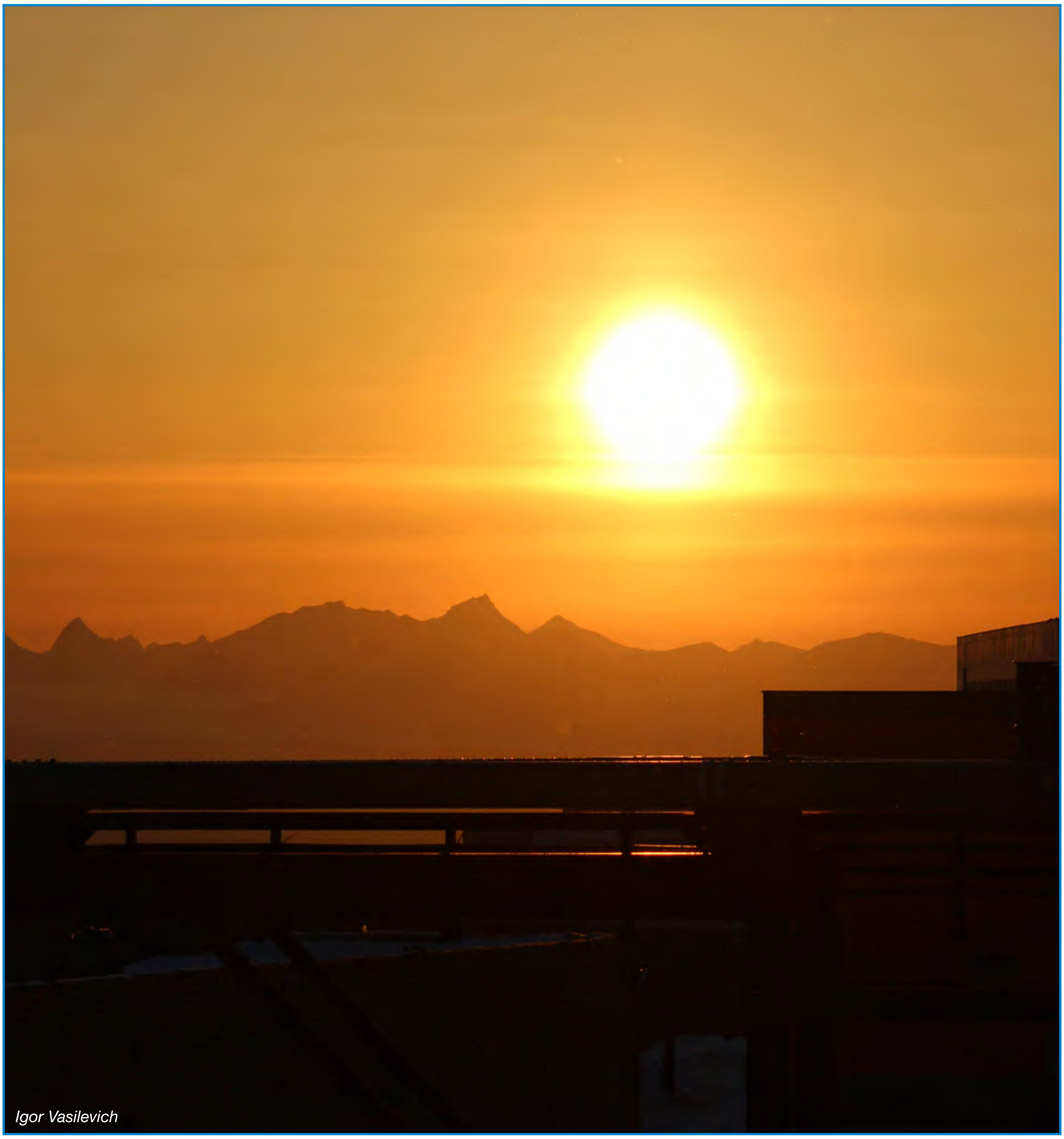
Priorities for research	Reason why this should be an ICARP IV Priority
1. Develop and deploy environmentally and socially sustainable Arctic infrastructure and logistics	It is critical to continue to develop and deploy infrastructure and logistic systems that are environmentally appropriate and suited to the unique challenges of the Arctic. Research should focus on enhancing appropriate technologies for vessel and land-based infrastructure in order to reduce emissions and minimize environmental impact. Feasible areas of focus include pilot projects in renewable energy systems, effective waste and water management systems, advanced batteries, automation for remote data gathering, and improved systems for remote access at field stations. Sustainability needs to be extended to the human sphere as well through collaboration between governments, funding agencies, private companies, and Indigenous communities and entities. Research partnerships that co-design infrastructure solutions can ensure that innovations meet the needs of both researchers and Arctic residents. For example, energy innovations that reduce diesel dependence for field stations may lower household energy costs; improved transport systems for research supplies can support community resupply and emergency response; expanded broadband for virtual research access can also benefit schools and local businesses; and innovations in waste management and water systems can improve the safety, health, and sustainability of both research facilities and remote Arctic settlements. AI-driven autonomous systems need investment and development, for real-time monitoring, predictive maintenance, and adaptive management of Arctic infrastructure. While AI has a significant climate impact through the high energy consumption of data centers for training and running models, the technology should be mined for how it might benefit Arctic research and support. Leveraging emerging AI technologies—such as edge AI, reinforcement learning, and digital twins— may enhance resilience, energy efficiency, and safety of stations in extreme and remote polar environments, while anticipating infrastructure challenges under future climate change.
2. Maintain and develop distributed research infrastructure to provide sustainable observing platforms in support of societal and scientific needs	We need observations that provide: 1) spatial coverage across ecosystem gradients on the land, in the ocean and atmosphere (representative sampling) 2) in-depth, process-based measurements and experiments (land-based flagship observatories and icebreakers), and 3) continuous, long-term, year-round observations to capture spatial changes, understand underlying mechanisms, and to capture both long-term trends and short-term variability. Innovations in technology, such as pan-Arctic submarine cable systems and land-based autonomous measurements, will allow more real-time data collection from remote locales. Linking societal challenges, science needs, and infrastructure development is key for optimal investment in Arctic science. Maintaining and expanding distributed research infrastructure is feasible through upgrading existing observation infrastructure, supporting autonomous monitoring platforms, and ensuring continuity of long-term datasets. These systems not only advance scientific understanding but also serve societal needs. For example, year-round ice, weather, and ocean observations improve maritime safety, support subsistence harvest planning, and strengthen early warning systems for hazards such as coastal erosion or flooding. Investments in distributed infrastructure can also create opportunities for workforce development by training Arctic residents as technicians and data stewards who maintain instruments, manage local research stations, and contribute to community-based observing networks.

Priorities for research	Reason why this should be an ICARP IV Priority
3. Enhance remote and virtual access to Research Infrastructure (RI) and their services	Remote and virtual access are important strategies to reduce the environmental impact of Arctic research which may reduce the costs and carbon necessary to transport researchers into the field. Automated technologies and local logistic support from Arctic communities may provide employment and services necessary for Arctic communities. There are specific challenges associated with remote and virtual access. Remote access may increase demands on staff, energy, and instrumentation compared to traditional access methods. However, the reduction in access costs and carbon expenditure is beneficial, while improving the resilience of research by addressing challenges including pandemics, regime change, and funding instability. Intuitive user interfaces and virtualization solutions need to be developed for remote instrumentation. Prioritizing investments in cybersecurity measures to protect sensitive data and infrastructure is also critical for remote and virtual access. **Expand access to Research Infrastructures (RI) and their remote and virtual access services to complement field-based research and minimize environmental footprints.** It is essential to simultaneously develop solutions to the specific challenges associated with remote and virtual access provision (e.g. increased demand for staff, power, connectivity, and instrumentation at research infrastructure compared to traditional in-person access) with strong efforts to harmonize RI facilities, services, and observational data by using standards-based metadata descriptions that respect the CARE principles of Indigenous data ownership, Persistent Identifiers (PIDs), and ISO certificates to ensure interoperability and high quality services and data across distributed RIs, and to help users to identify suitable RIs, services, and data for their research. **Cultivate innovation in developing new methods and services for remote and virtual access provision.** Enhanced remote and virtual access to RIs such as through digital twins and automated/ advanced controls must be paralleled with the development of new methods and services, preferably based on user need assessment and in co-design with the users and can include e.g. intuitive user interfaces and virtualization solutions. Investments and developments in cybersecurity, as well as remote instrumentation and automated data collection, are also needed to protect sensitive data and infrastructure, and to facilitate remote and virtual access. **Ensure seamless, economic and sustainable access and services through integration.** More efficient, streamlined and environmentally friendly modalities of access and related services are needed to complement the traditional in-person access. This requires better integration of services, observations, as well as metadata and data across the RIs. **Stronger international collaboration, multi-national agreements and new funding instruments** are needed to secure the enhancement of international and trans-national remote and virtual access and related service provision to research infrastructure. **Strengthen local and Indigenous communities involvement in research activities.** Rural residents and Indigenous communities can provide remote access support and observations, such as operating local sensor networks, maintaining field stations, and contributing place-based expertise that enhances data interpretation. To make this feasible, funding agencies must create flexible mechanisms that compensate community members for technical and observational work, while educational programs at all levels should invest in workforce development programs that prepare Arctic residents for STEM and skilled technical worker roles as research technicians, energy, network, cybersecurity, and other technical system operators and maintenance, data stewards, and co-investigators.
4. Development and deployment of next-generation remote sensing technologies to strengthen Arctic climate, environmental, and ecosystem monitoring	The deployment of next-generation remote sensing technologies is essential to ensure the accuracy and continuity of monitoring in the Arctic. The Arctic's rapidly changing climate demands enhanced real-time monitoring to better predict and mitigate environmental shifts, and for better informed decision-making on climate adaptation strategies. This monitoring includes the introduction of additional reliable, long-term instruments such as upgraded microwave sensors, cost-effective and environmentally-friendly unoccupied aerial vehicle (UAV) technologies, enhanced spatial observations in high-latitude regions through highly elliptical orbit (HEO) satellites, as well as improved on-site technologies. Marine environments will also benefit from innovations to improve deep sea operations from research vessels and to advance intelligent robot exploration to improve Autonomous Underwater Vehicle (AUV) technologies. In addition to the above, and specifically for the Arctic ocean, real-time in-situ, year-round observations from the seabed and the water column using cabled observatories or SMART cables will provide under-the-ice essential and complementary information to surface data. These advancements will improve the precision of real-time and long-term data on climate, environment, and ecosystems, enhancing our ability to predict and respond to changes in these critical areas. Strengthening international collaboration between space agencies and Arctic research institutions will ensure data harmonization and sharing, improving the overall understanding of Arctic climate dynamics. Indigenous and local knowledge can also add substantial benefit to observing activities. At the same time, these systems can provide complementary benefits to Indigenous and Arctic communities, for example by supplying more accurate local weather, sea ice, and ecosystem information to support travel safety, subsistence activities, and community adaptation planning. Ground systems investments at a significant level are a necessity to realize these benefits.
5. Improve renewable energy production and advance new technologies to support sustainable research, and living, in the Arctic.	The high cost of energy in the north impacts both research and residents. Optimizing energy efficiency in all infrastructure and technology projects is a fundamental starting point. Development and deployment of sustainable energy systems will benefit research and northern communities. Examples for Arctic research include "power kiosks" that combine wind turbines designed for low temperatures, hybrid solar systems that can operate efficiently in low-light conditions, and energy storage systems that maintain performance in cold climates, such as thermal batteries or supercapacitors that are less affected by low temperatures. Utilizing cleaner fuels or green technologies on a small scale such as fuel cells is an excellent test-bed for larger systems to support lower-latitude energy demands.. Additionally, development of innovative technologies for CO2 sequestration, wastewater treatment, and food production in Arctic environments can support local communities and businesses, as well as research efforts. These systems, when piloted at research stations, can demonstrate both scientific value and Arctic community benefit—for example, reducing the cost of field operations while also lowering household energy bills, improving water and food security, and creating opportunities for local economic development.

3.2. Cross-Cutting Needs and Priorities

Cross-cutting needs and priorities are defined as not only relevant for one of the RPT topic areas specifically, but instead cutting across several of the seven topic areas:

- RPT 1: The Role of the Arctic in the Global Earth System
- RPT 2: Observing, Reconstructing, and Predicting Future Climate Dynamics and Ecosystem Responses
- RPT 3: Understanding the Dynamics and Resilience of Arctic Social-Ecological Systems to Foster Sustainable Futures
- RPT 4: Arctic Research Cooperation and Diplomacy
- RPT 5: Co-Production and Indigenous-led Arctic Research
- RPT 6: Education and Knowledge-Sharing In and About the Arctic: Research and Practice
- RPT 7: Technology, Infrastructure, Logistics, and Services



Igor Vasilevich

3.2.1. Cross-Cutting Research Needs

Research need	Description of the research need	Rationale why included in this report
1. Data Integration, Harmonization and Cybersecurity	Where ethically appropriate, data collected in the Arctic should be made available to a broad range of scientists and stakeholders, as well as the public. To encourage inclusiveness, data should be available in an open way, enabling M2M (Machine-to-Machine) integration without human intervention, using a network of sensors, software, and connectivity. A key element determining data usability is harmonisation in terms of quality (including quality control) and the consistency of metadata and formats. Data repositories used for long-term preservation of collected data should be duly certified (e.g. CoreTrustSeal) and should receive special attention from a cybersecurity perspective. This includes ensuring long-term data deposition and restricting access to sensitive and strategic data from a defence, personal, and economic perspective. Importantly, data practices must also respect Indigenous data sovereignty (IDsov), ensuring that Tribal and community-based protocols guide how Indigenous Knowledges and community-derived data are stored, accessed, and shared. Principles such as FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) provide a framework for ensuring that Arctic data systems are both technically robust and socially responsible. Data repositories must also be able to parse collected datasets to distinguish those approved for public, secondary use from those that are not to be made public, in accordance with the direction of Indigenous communities, as outlined in the CARE data maturity model. As Artificial Intelligence (AI) systems become increasingly integrated into Arctic data management and analysis, additional safeguards are needed to prevent the misuse or misrepresentation of all data, and particularly of Indigenous Knowledges. There is a lack of understanding how AI functions and interacts with Indigenous data, and what may be the consequences of its utilization for communities. AI systems trained on community-derived datasets without consent risk violating Indigenous sovereignty and producing misleading outputs. Therefore, repositories and research infrastructures must develop and implement clear policies for AI use, including requirements for transparency, consent, and Indigenous oversight in how AI systems access, process, or apply community data. Flagging synthetic data and model output that are byproducts of AI analysis is also essential. Building Indigenous capacity to understand, evaluate and direct AI-driven research is essential to ensure that these technologies are used ethically and in alignment with community priorities.	The huge amount of data currently acquired requires its harmonisation and standardisation in order to build services based on it. In times of growing political tensions, access to data that may be of strategic importance should be appropriately secured without harming scientific research. Cybersecurity measures are therefore essential to protect sensitive information while maintaining open scientific exchange. For Indigenous communities, data must be stewarded in ways that protect cultural knowledge, safeguard subsistence resources, and support community decision-making. Co-designed approaches to metadata standards, repository governance, and access policies will ensure that data systems respect both FAIR and CARE principles, while implementing IDSov practices to separate datasets intended for public use from those that must remain protected. The availability of data for future generations is crucial for understanding the changes taking place in the Arctic and for making knowledge-based strategic decisions for the environment, economy and sustainable development of communities. Feasible actions include the development of standardized metadata protocols that complement Indigenous Knowledges incorporation, investment in long-term Arctic data repositories, and partnership with Indigenous and Arctic communities to define access frameworks that balance openness with the protection of sensitive and culturally significant knowledge.
2. Indigenous engagement	Institutional science can benefit from Indigenous Knowledge and long-term observations, which provide unique insights into environmental and ecosystem change. Engagement must extend across all dimensions of Arctic research, including logistics, services, infrastructure, and technology. This means supporting Indigenous participation in research planning, including the selection of sites, the timing of fieldwork, and the design of field safety protocols; ensuring that services such as communication platforms and data repositories are responsive to community priorities; co-developing infrastructure that supports both research operations and community well-being (e.g., energy systems, housing, and waste management); and creating technology pathways that value Indigenous expertise in monitoring, navigation, and environmental stewardship; and building programs that expand STEM education and Skilled Technical Workforce (STW) training for Indigenous residents, enabling career pathways in research support, data stewardship, and field operations. Recognition of Indigenous rights to work done and data collected in their territories is essential to building equitable and sustainable Arctic research systems. This includes not only respecting Indigenous Knowledges systems but also ensuring that communities are active partners in the design, conduct, and outcomes of research.	Recognition of Indigenous rights and knowledge is essential to building equitable and sustainable Arctic research systems. Co-designed approaches improve the relevance, accuracy, and impact of science, while also ensuring that research investments create lasting value for communities. Indigenous engagement in logistics planning can reduce costs, improve safety, and ensure that fieldwork aligns with local conditions and practices. Service design that incorporates Indigenous needs makes data platforms and observing systems more inclusive, usable, and ethical. Infrastructure investments co-developed with Indigenous communities address both research requirements and local challenges such as energy costs, safe housing, and transportation. Technology development that incorporates Indigenous Knowledges produces monitoring systems, decision-support tools, and innovations that are more robust and context-appropriate. Finally, investments in STEM and STW development expand the Arctic research workforce by creating accessible training opportunities and career pathways for Indigenous residents, ensuring that capacity built through research remains in the region.

Research need	Description of the research need	Rationale why included in this report
3. Continuity of Funding	Future-proofing Arctic research means establishing sustained, predictable investment that enables Arctic research systems to remain resilient, adaptive, and effective over time. Continuous funding supports the long-term data collection, infrastructure maintenance, and technological innovation necessary to respond to environmental change. Further, sustained predictable funding allows for the technology, infrastructure, logistics and services necessary to support Arctic research.	Arctic research needs stable, long-term investment to be feasible at scale. Sustained funding is necessary to train and retain skilled personnel, maintain long-term monitoring, maintain facilities, and ensure the flexibility to adapt methods, logistics, and priorities as environmental, operational, and community needs evolve.
4. Field Safety	Arctic research needs to protect researchers in the field, both from objective concerns in the environment (weather, cold, wildlife) but also to assure that field experiences are accessible, safe, and harassment-free for all participants. Field safety requires investment in appropriate gear and infrastructure (e.g., shelters, communication systems), reliable logistics (e.g., transportation planning, evacuation options), and services such as training, mentorship, support resources, policies, and cross-cultural orientation. Research institutes and organizations should include resources for mental and emotional health in field safety planning including development or adoption of existing codes of conduct. Institutes and teams must establish and provide reporting structures, and protocols for following up on reported violations of the code of conduct. Institutes should provide equal access to fieldwork and equitable support for diverse groups participating in field operations. Partnerships with Indigenous and Arctic communities can strengthen safety protocols by incorporating local expertise in navigation, weather assessment, and wildlife interactions. Importantly, many of these same safety investments are also critical for Arctic and Indigenous communities, who need access to evacuation options, disaster planning, and reliable emergency communication systems to respond to environmental hazards and climate-driven risks.	Managing risk in the field includes the physical, and objective risks of the environment, but also the interpersonal challenges carried by working with small teams in isolated places. Without safe access for all participants, Arctic research loses valuable voices and perspectives. What is unsafe for researchers—such as inadequate evacuation options, poor communication systems, harmful interpersonal relationships, or lack of disaster planning—is also unsafe for communities. Shared investments in safety infrastructure therefore serve both scientific and community needs. Ensuring field safety broadens participation by empowering women, early-career researchers, Indigenous experts, and other underrepresented groups to engage fully in Arctic science. Feasible actions include standardized, whole-person safety training, investment in communications and remote monitoring technologies, co-developed protocols with Arctic residents who hold generations of knowledge about safe travel and survival in extreme conditions, and shared investments in evacuation and disaster response infrastructure that serve both research and community needs. Field safety is not only an ethical obligation but also a research necessity: it reduces risk, increases efficiency, and ensures that Arctic science benefits from the widest possible range of expertise and perspectives.
5. Effective policymaking and governance	Governance is the scaffolding on which all human decision-making and implementation occurs. Without effective and inclusive decision-making processes, including collaboration and negotiation across diverse stake- and rights - holders, few of the goals of the ICARP process will be effectively implemented.	Actors beyond the state increasingly wield power in Arctic decision-making, inclusive of sovereign Indigenous communities and nations, industry, and non-profit organizations. The challenge of documenting and communicating change in the Arctic is increasingly complex, and the stakes for Arctic peoples and ecosystems have never been higher. Progress on critical Arctic challenges, such as climate change and adaptation, human well-being, energy transformation, prediction and observation of change, as well as ecosystem health and human security are all predicated on effective policy making and governance. The shifting geopolitical landscape of nation states has led to an erosion of collaboration and severe declines in funding for Arctic science. The goal is to connect governance questions across scales and realize forms of interconnected decision-making that work with - or despite - rapid change in state-driven power dynamics. Governance is multi-level, requiring engagement with decision-making bodies across jurisdictional boundaries, from local communities, regions, to states, nations, and global entities.

3.2.2. Cross-Cutting Priorities for Arctic Research

Priorities for research	Reason why this should be an ICARP IV Priority
1. Strengthen Data Integration, Harmonization and Cybersecurity	Collaboration with international agencies and research institutions is critically important to harmonize Arctic environmental data, ensuring consistent data standards and methodologies. This can be done by: • Assessing data gaps in Arctic observing systems, and how can they be addressed through integrated monitoring technologies • Sensitivity studies on what new, additional data creates highest impact and best fill in current data gaps • Development of technologies and infrastructure that support data sharing • Update modeling frameworks and technologies to accept a broad range of observations Development of robust cybersecurity measures is essential to protect sensitive information while maintaining open scientific exchange. As Artificial Intelligence (AI) systems become increasingly integrated into Arctic data management and analysis, development of additional safeguards are needed to prevent the misuse or misrepresentation of all data.
2. Engage and support equitable Indigenous participation	Indigenous communities hold crucial knowledge about Arctic social-ecological systems, yet their participation in decision-making and research is often limited. These are also often the communities on the forefront of environmental change. A key cross-cutting priority is implementing governance frameworks that include Indigenous leadership and that integrate traditional knowledge into scientific studies. Development of new Arctic research infrastructure needs to be co-conceived with Indigenous leadership. Research should prioritize capacity-building initiatives that support the continued prioritization of Indigenous voices in decisions that will affect their livelihoods, especially related to large-scale infrastructure projects such as ports, shipping-routes, or airports. Governance decisions also apply to data collected, in following the OCAP (ownership, control, access, and possession) and CARE (Collective Benefit, Authority to Control, Responsibility, and Ethics) principles. Promoting equitable, long-term partnerships with Indigenous Peoples in Arctic research will benefit northern communities and contribute to sustained monitoring of environmental change. Community-based monitoring programmes can a) highlight changes to the environment that necessitate documentation or adaptation, b) maintain observational records especially during periods of challenged and insecure research funding for logistics of southern scientists and c) innovate research practice through co-production of knowledge.
3. Continuity of Funding	Continuity of funding is a critical factor in future-proofing Arctic research infrastructure and in obtaining the long-term data necessary to understand the future of the changing environment. Without continuity in funding, it is challenging to maintain and develop environmentally responsible technologies and energy solutions that serve not only research but also the local and Indigenous communities of the Arctic, as well as society as a whole.
4. Prioritize a holistic approach to field safety	Fieldwork constitutes an essential component of Arctic research. To ensure that these operations are done in a safe and sustainable way, the polar and Arctic research community needs to jointly identify, improve and implement, existing guidelines and monitor their efficiency. Aspects that still require more effort are related to intersectional problems, especially with increasingly interdisciplinary research work.
5. Integrated planning - linking the development of Research Infrastructures, long-term monitoring and data sharing with scientific priorities.	Establishing a clear and coordinated connection between research infrastructure development, long-term monitoring, and data sharing is fundamental for advancing Arctic research and responsible development. The Arctic is undergoing rapid environmental, climatic, and socio-economic transformations, and addressing these complex challenges requires a strategic, collaborative, and data-driven approach. Linking these elements ensures that research investments are efficient, purposeful, and scientifically relevant. By aligning infrastructure development—such as research stations, observing systems, and data platforms—with well-defined scientific priorities, researchers can maximize the value of every resource deployed. This alignment supports the collection of consistent, high-quality data that directly informs ongoing studies and addresses critical issues such as sea ice dynamics, permafrost thaw, biodiversity loss, extreme events, natural resource availability and community resilience. A key benefit of this linkage is the promotion of integrated and interdisciplinary science. The Arctic system is interconnected—changes in one component, such as ocean circulation, can affect atmospheric processes, ecosystems, and human livelihoods. Coordinating data collection and infrastructure planning across disciplines enables a holistic understanding of these relationships. Such integration fosters collaboration among oceanographers, climatologists, ecologists, engineers, and social scientists, resulting in comprehensive research outcomes that are greater than the sum of individual efforts.

Sarah Evans

4. Recommendations to Implement the identified Priorities for Arctic Research

4.1. Implementation of the RPT 7-specific Priorities

Priority 1: Develop and deploy environmentally and socially sustainable Arctic infrastructure and logistics.		
Spatial scale:	pan-Arctic	
Time scale:	relevant now and for the next 10 years	
Funding requirements and potential sources:	Governments, private sector, industry, Indigenous communities	
Infrastructure needs and requirements:	Strengthening international collaboration, identifying observational needs, investing in advanced monitoring technologies, and integrating Indigenous knowledge will be crucial for future Arctic research and operations.	
Data needs and requirements:	Developing efficient, safe, and sustainable Arctic logistics and infrastructure requires preserving and sharing high-quality, interoperable, and real-time data and knowledge to ensure environmental protection, operational efficiency, and resilience to climate change.	
Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
Develop renewable energy technologies	Learn from existing projects and initiate pilot projects to explore scalability and appropriate regional systems for renewable energy solutions for Arctic logistics including solar-powered or hybrid icebreakers, and low-emission transport vehicles. Implement sustainable energy solutions at or for existing infrastructure. For new research infrastructure, apply passive energy design in constructions and renewable energy systems.	(i) Governments (ii) Private sector and industry (iii) Indigenous communities (iv) Research Infrastructures: National RI operators and universities
Automation and remote operations	Invest in research and development of automated systems for logistics operations in remote areas to reduce human intervention and environmental impacts.	(i) Research Infrastructures: National RI operators and universities (ii) Funding bodies: European Commission, National Research Councils, Private Foundations
Collaborative Planning	Establish partnerships between governments, the private sector, and Indigenous communities to co-create infrastructure projects that respect ecological sensitivities and minimize disruption.	(i) Governments (ii) Private sector and industry (iii) Indigenous communities (iv) Research Infrastructures: National RI operators and universities
Collaborative Planning	International coordination is key for efficient and sustainable arctic science. Research communities, infrastructure operators, and funding agencies need to work together to develop infrastructure platforms which are aligned with science priorities and which efficiently share logistical support. This is especially important for high emission activities such as the icebreakers and long distance transport of people and goods. Distributed international infrastructure networks such as European Research Infrastructure Consortiums (ERIC) for terrestrial and marine research maximizes observational capacity and yields coordinated data products.	(i) Governments (ii) Research Infrastructures: National RI operators and universities (iii) International organisations, networks and consortiums (e.g. IASC, FARO, SAON)
Reduce expired installations	Removal of research-associated waste or expired sites and infrastructure is also appropriate. Development of field sites should include plans and funds to demobilize all temporary installations.	
Social sustainability	Coordination and engagement with Indigenous and northern communities is necessary to provide long-term investments in logistical and infrastructure needs. Social sustainability extends to the physical, mental and emotional health of individuals involved in field research (see Cross Cutting Priority, following).	(i) Governments (ii) Private sector and industry (iii) Indigenous communities (iv) Research Infrastructures: National RI operators and universities

Priority 2: Maintain and develop distributed research infrastructure to provide sustainable observing platforms in support of societal and scientific needs.		
Spatial scale:	Local at RI level, regional/pan-Arctic on the level of distributed RI	
Time scale:	for next 10 years	
Funding requirements and potential sources:	Governments, private sector and industry	
Infrastructure needs and requirements:	Societal challenges, scientific priorities and observational gaps should guide the development of future infrastructure platforms and networks.	
Data needs and requirements:	Knowledge of societal challenges, science priorities and observational gaps will support maintenance and development of appropriate research infrastructure.	
Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
1. Maintain and improve the existing long-term observation platforms and develop new spatially distributed RI and observation platforms	• Develop distributed RIs with sufficient spatial coverage to avoid gaps and ensure representative sampling and in-depth, process-based measurements, particularly on land. • Develop flagship observatories for continuous, long-term, year-round observations to study long-term trends and short-term variability, ideally providing real-time data. • Involve local observers to extend both the geographical range and the temporal coverage of observations • Develop and utilize mobile observatories to ensure representative sampling and close observational gaps. • Integrate national research infrastructures better with global observation platforms • User needs assessment for RI development, including need for services, transport, accommodation, data collection, instrumentation, and remote and virtual access.	(i) Governments (ii) Private sector and industry (iii) Research Infrastructures: National RI operators and universities (iv) Funding Bodies: European Commission, National Research Councils, Private Foundations (v) Indigenous Peoples
2. Develop and implement societally and environmentally responsible practices for building and operating infrastructure jointly with local / Indigenous communities	• Assessment of Arctic communities' infrastructure and research needs • Community data collection using new technologies in collaboration with the local communities, and enhancing capabilities, training and funding for that.	(i) Governments (ii) Indigenous communities (iii) Research Infrastructures: National RI operators and universities
3. Minimize the environmental impact of infrastructure through sustainable facilities and capabilities	• Develop and refine sustainable operational practices, including renewable energy sources, automating both monitoring instrumentation and remote vehicles. • Work in close communication with scientific and local communities. • Support research on green technologies for shipping, icebreakers, and land-based infrastructure.	(i) Private sector and industry (ii) Indigenous communities (iii) Research Infrastructures: National RI operators and universities

Lionel Favre

Priority 3:
Enhance Remote and Virtual Access to Research Infrastructure

Spatial scale:	Scalable from local to global
Time scale:	Relevant now and over the next 10 years.
Funding requirements and potential sources:	€25-30 million over 10 years; Potential sources: EU Horizon Europe, national research councils, private foundations, Arctic Council grants, and public-private partnerships.
Infrastructure needs and requirements:	Immediate needs within 5 years for foundational infrastructure, followed by optimization and scaling in the following 5 years.
Data needs and requirements:	• High-speed, secure data transmission networks • Ideally, standardized data formats and metadata protocols - alternatively, and perhaps more realistically, systems should be developed that support multiple standards (e.g., ISO 19115 AND FGDC CSDGM AND EML and DarwinCore). • Real-time data streaming capabilities • Compliance with FAIR and CARE principles

Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
Enhance international collaboration and establish agreements for Remote and Virtual Access	• Develop international agreements, funding instruments and access programs. • Develop standardized and compatible systems for access and logistical management of RI access. • Optimize national RI use and logistics by offering trans-national access, expanding from in-person access to remote and virtual access, and by joining international bartering efforts where relevant. • Ensure equitable access to RIs and their services and facilitation of knowledge sharing by involving local and Indigenous communities.	(i) Research Infrastructures: National RI operators and universities (ii) Private sector and industry (iii) Funding Bodies: European Commission, National Research Councils, Private Foundations (iv) International organisations, networks and consortiums (e.g. IASC, FARO, SAON) (v) Indigenous communities (vi) Authorities and policy makers on various levels
Expanding access to RIs and their Remote and Virtual Access Services to complement field-based research	• Ensuring proper registration of infrastructure information and data in relevant catalogues and data portals. • Enhancement the use of ISO standards in validating and quality assuring RI services • Use of Persistent Unique Identifiers (PIDs) in cataloguing RIs, and their services and observing assets to facilitate their discovery and widen their user base. • Making data resulting from observing and monitoring efforts openly available by Virtual Access • Re-directing human resources and funding to support infrastructure staff (field staff, technical support staff, data managers) providing remote and virtual access services to end-users.	(i) Research Infrastructures: National RI operators and universities (ii) International organisations - networks and consortia (e.g. IASC, FARO, SAON) (iii) Organisations maintaining data management systems (repositories, databases)
Cultivating innovation and developing new methods and services for Remote and Virtual Access provision.	• Implementing Quality Assurance methods and programs in Remote and Virtual Access provision. • Utilizing service design and assessment of user needs in development of Remote and Virtual Access services. • Co-design of the services with their end-users, and local and Indigenous communities. • Sharing of expertise and staff in Remote and Virtual Access service development.	(i) Research Infrastructures: National RI operators and universities (ii) Private sector and industries (ii) End users of RI services (iv) Indigenous Communities
Ensuring seamless, economic and sustainable services through integration	• Integration of the Remote and Virtual Access service provision with the development of infrastructure, logistics, and technology to ensure services that are economic and sustainable and benefit the end-users and society at large. • Improvement of in-situ observations, tools and their spatial coverage by integration with remote and virtual access data. • Development of solutions for remote use of instrumentation to reduce the environmental footprint of field work, paralleled with development of intuitive user interfaces and virtualization solutions. • Harmonization of access provision across nations, regions and user communities by e.g. multistakeholder consortia, harmonising of measurements, and better connecting data centers, databases and priorities. • Integration of diverse knowledge systems and research techniques into Remote and Virtual Access service provision.	(i) Research Infrastructures: National RI operators and universities (ii) Private Sector and Industries (ii) End users of RI services (iv) Indigenous Communities

Priority 4: Development and deployment of next-generation remote sensing technologies to strengthen Arctic climate, environmental, and ecosystem monitoring	
Spatial scale:	Pan-Arctic with global collaboration and local community engagement.
Time scale:	Relevant now, with phased implementation over the next 10 years: • 0-3 years: Pilot projects and infrastructure development • 3-7 years: Full-scale deployment of remote sensing technologies • 7-10 years: Optimisation, maintenance, and capacity building
Funding requirements and potential sources:	Space agencies (e.g. NASA, ESA, JAXA, ISRO), Horizon Europe, Arctic Council, national research councils, private sector (e.g., satellite and drone companies), philanthropic foundations, and public-private partnerships.
Data needs and requirements:	• High-resolution, multi-sensor data from: satellites (optical, SAR, LiDAR), drones surveys, surface radars; underwater (and under-ice) sensing with autonomous underwater vehicles, cabled observatories, full water column moorings, … • Preferred Real-time data streaming • Compliance with FAIR and CARE principles (most data should be open except when Indigenous rights to them prevail, interoperable and ease of access by all should be ensured) • Integration of in-situ data with remote sensing outputs for validation and enhanced accuracy • International collaborations for expansion of remotely sensed data

Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**	**Spatial Scale**	**Time Scale**
Arctic surface (land, water & ice) observations AND associated DATA access				
Deployment and data release of advanced active microwave (SAR) data for permafrost monitoring	• Open data sharing within the research community to accelerate the development of improved algorithms for environmental monitoring. • Coordinate with space agencies (e.g., ESA, NASA, NOAA, JAXA) for the launch of SAR satellites with enhanced permafrost monitoring capabilities.	(i) Space Agencies and Environmental Organisations	Land and Ice	Short-medium-long term
Drone systems for mapping and monitoring environmental changes in the Arctic	Train local community members to operate drones and other devices, and process data, enabling informed decision-making and local involvement in research efforts	(i) Research Infrastructures: National RI operators and universities (ii) Private Sector and Industries (iii) Indigenous Communities (iv) Organisations maintaining data management systems (repositories, databases)	Land (mostly), some ice	Short-medium term
Continuous, long-term, year around observations in the deep Arctic Ocean	Deploy seabed telecommunication cables with sensing capabilities (e.g., SMART cables). At the national and international levels (EU-Asia-North America) support the funding of submarine cables with sensing capabilities.	(i) Governments (ii) Research Infrastructures: National RI operators and universities (iii) Private Sector and Industries (iv) Indigenous Communities (v) Organisations maintaining data management systems (repositories, databases)	Ocean	Medium-long term
Autonomous observations, also extending coverage of observations to otherwise inaccessible regions	Organize autonomous underwater (and under-ice) vehicle (AUV) observing campaigns, can use docking stations connected to a submarine cable (see previous row).	(i) Funding Bodies: European Commission, National Research Councils, Private Foundations (ii) Research funding organisations (iii) Defence organisations	Ocean, Ice	Medium-long term
Icebreaker access	Many new icebreakers are currently being built (US, Canada, Scandinavia, Japan, Korea, Germany, China) - develop programs to ensure access opportunities for the international user community.	(i) Defence organisations (ii) Research Infrastructures: National RI operators and universities (iii) Governments	Ocean	Short-medium term

Priority 4 *continued*:
Development and deployment of next-generation remote sensing technologies to strengthen Arctic climate, environmental, and ecosystem monitoring

Implementation: Implementation actions:	How to implement the actions:	Who to address the actions:	Spatial Scale	Time Scale
Data Management				
Ensure all data collected in the North are stored in curated in well-managed repositories and are public without delay, while respecting Indigenous ownership and rights	Establish and communicate best practices for data management in the North, recommending data and meta-data standards, as per the Research Data Alliance, the World Data System, etc. Encourage data deposits in recognized data centres. Investigate the potential use of green energy in the Scandinavian North for local data centres.	(i) Organisations maintaining data management systems (repositories, databases) (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations	Land & Ocean	Short term
Ensure Indigenous rights to data collected on their territories are respected	Standards exist to assign Indigenous ownership to data through meta data keywords. Follow the CARE principles	(i) Governments (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations (iii) Organisations maintaining data management systems (repositories, databases) (iv) Indigenous Communities	Land & Ocean	Short term
Support the development of Digital Twins (or multi-layer portals offering data and predictive model results for an entire region). The layers cover the natural and social sciences.	Funded, multi-party efforts to assemble data sources into a single (or a few) portals delivering societal benefits and the community or industry levels.	(i) Space Agencies and Environmental Organisations (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations		Medium term


Marin Kuizenga

Priority 5: Improve renewable energy production and advance new technologies to support sustainable living in the Arctic.		
Spatial scale:	local, regional	
Time scale:	relevant now and in the future	
Funding requirements and potential sources:	Universal needs that could include any number of partnering organizations including defense, Native corporations and communities, local and Indigenous communities, local governments, and business.	
Infrastructure needs and requirements:	Development and **maintenance** of the new energy infrastructure based on renewable energy production and new technologies.	
Data needs and requirements:	Monitoring of the built environment	
Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
Clean Power – Clean Transport		
Expansion of wind, solar, and alternative fuels	Small scale pilot projects to develop locally-produced energy technologies appropriate for renewable power in Arctic environments. Many implementation challenges exist, particularly to scale at meaningful levels and in a changing climate.	(i) Research Infrastructures: National RI operators and universities (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations (iii) Governments (iv) Private Sector and Industries
SMR (small modular nuclear reactors)	Small scale pilot projects. Actively research community sentiment and community energy planning and decisions making methodologies.	(i) Governments (ii) Private Sector and Industries
Continued innovation in clean transportation	Expanded testing and development of electric vehicles (EVs) to address year-round use, temperature and range, and battery issues.	(i) Governments (ii) Private Sector and Industries
Telecommunications		
Deployment of highly elliptical orbit (HEO) satellites for telecommunication and environmental monitoring in the Arctic. Low earth orbit (LEO) satellite constellations are needed to provide high-bandwidth, low-power communication capabilities from anywhere	Maintenance of the constellations by continuous satellite launches funded by public institutions and the private sector	(i) Governments (ii) Private Sector and Industries
Fibre optic cables (both land and submarine)	Lobby governments, companies (hyperscalars), and National research and education networks (NRENs) to connect the North to the rest of the world	(i) Governments (ii) Private Sector and Industries
Improving telecommunications capabilities and capacity in the North	Lobby governments, industry	(i) Governments (ii) Private Sector and Industries

4.2. Implementation of the Cross-Cutting Priorities

Priority 1: Strengthen Data Integration, Harmonization and Cybersecurity		
Spatial scale:	global, pan-Arctic	
Time scale:	continuously, persistently	
Funding requirements and potential sources:	Data management will have dedicated funding. Research Infrastructures: National RI operators and universities; Organisations maintaining data management systems (repositories, databases); Funding Bodies: European Commission, National Research Councils, Private Foundations.	
Data needs and requirements:	Data and its supporting systems infrastructure will follow and support multiple community standards. Refer to existing and established initiatives such as the Alignment of the Polar Data Principles (Tronstad et al. 2021, https://doi.org/10.5281/zenodo.5734900), Mapping the Polar Data Ecosystem (MPDE), Arctic Data Standards Initiatives, etc. See 'Implementation Actions' column for specifics.	
Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
Adopt Open Standards	Use common metadata standards (e.g., ISO 19115, CF conventions for NetCDF) so datasets from satellites, ships, and communities can "speak the same language." FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) principles should be baked into data design.	(i) Research Infrastructures: National RI operators and universities (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations (iii) Organisations maintaining data management systems (repositories, databases)
Strengthen Community-Based Data Integration	Indigenous Knowledges and local observations need to sit side-by-side with scientific data.	(i) Organisations maintaining data management systems (repositories, databases) (ii) Indigenous Communities
Invest in Shared Infrastructure	Cloud-based platforms (like Pangaea or Arctic Data Center), or other certified research data repositories allow massive datasets—satellite imagery, environmental measurements, ice models, biodiversity records—to be integrated without everyone duplicating storage. Application Programming Interfaces (API) and federated systems can connect national repositories rather than silo them.	(i) Research Infrastructures: National RI operators and universities (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations (iii)Organisations maintaining data management systems (repositories, databases)
Enhance Cross-Disciplinary Interoperability	Climate scientists, marine biologists, and social scientists often have totally different data formats and standards. Middleware and data fusion tools (like OPeNDAP, THREDDS, or semantic web tech) can help bridge those gaps, often referred to as mediation infrastructure or data mediators	(i) Research Infrastructures: National RI operators and universities (ii) Organisations maintaining data management systems (repositories, databases)
Build Strong Governance & Data Policy	Agreements across Arctic Council nations on data sharing can smooth legal/political roadblocks. Clear licensing (Creative Commons, Open Data licenses) avoids the mess of "who owns what."	(i) Governments (ii) Organisations maintaining data management systems (repositories, databases)
Ensure all data collected in the North are stored in curated in well-managed repositories and are public without delay, while respecting Indigenous ownership and rights	Establish and communicate best practices for data management in the North, recommending data and meta-data standards, as per the Research Data Alliance, the World Data System, etc. Encourage data deposits in recognized data centres. Investigate the potential use of green energy in the Scandinavian North for local data centres.	(i) Organisations maintaining data management systems (repositories, databases) (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations

Priority 2: Engage and support equitable Indigenous participation in research.		
Spatial scale:	pan-Arctic	
Time scale:	relevant now and for the next 10 years	
Funding requirements and potential sources:	• Sustainable funding to support Indigenous research offices and centers, research review boards, and data governance committees. • Investment in digital and communication infrastructure in rural and remote Arctic communities to enable participation in virtual research, monitoring, and decision-making. • Support for training and workforce development programs (STEM and Skilled Technical Workforce) that prepare Indigenous residents for roles as technicians, data stewards, safety officers, and co-investigators.	
Data needs and requirements:	• Data that align with both FAIR (Findable, Accessible, Interoperable, Reusable) and CARE (Collective Benefit, Authority to Control, Responsibility, Ethics) principles. • Mechanisms to implement Indigenous Data Sovereignty (IDSov), including the ability for repositories to distinguish datasets approved for public/secondary use from those restricted by Indigenous communities. • Protocols for the ethical use of Artificial Intelligence (AI) in handling Indigenous and community-derived data, including requirements for consent, transparency, and community oversight of how AI systems are trained and applied. • Capacity within Arctic Indigenous communities to evaluate, manage, and direct AI-driven analysis, ensuring that outputs do not misrepresent or extract from Indigenous Knowledge. • Co-created data protocols that support mutual trust and usability for both science and communities.	
Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
Formalize Indigenous governance roles in research	• Establish Indigenous-led research review boards and ensure their recognition in national and international research funding processes. • Protect Indigenous Knowledges and data by requiring repositories to implement IDSov protocols, including metadata standards, access controls, and governance mechanisms that distinguish between datasets approved for public use and those restricted by Indigenous Nations. • Develop AI and emerging technology safeguards to ensure community consent before AI/ML systems access or train on Indigenous data. Implement auditing tools to prevent unauthorized scraping or secondary use of Indigenous Knowledges.	(i) Research Infrastructures: National RI operators and universities (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations (iii) Governments, including Indigenous Nations (iv) Private Sector and Industries
Provide dedicated funding for Indigenous participation	Create grant lines and budget categories that fund Indigenous partners as co-leads, scientific knowledge holders, and technical staff.	(i) Research Infrastructures: National RI operators and universities (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations (iii) Governments, including Indigenous Nations (iv) Private Sector and Industries
Invest in workforce development	Support training programs for Indigenous residents in STEM and skilled technical roles related to Arctic research activities (e.g., drone operators, field technicians, data analysis).	(i) Research Infrastructures: National RI operators and universities (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations (iii) Governments, including Indigenous Nations (iv) Private Sector and Industries
Strengthen digital access	• Fund training programs that prepare Indigenous residents for Skilled Technical Workforce (STW) roles such as broadband technicians, cybersecurity specialists, and data managers. • Create community-based digital service hubs that provide both research support and essential services (e.g., telehealth, remote learning). • Expand broadband access and virtual collaboration platforms in remote communities to enable equitable remote and hybrid participation.	(i) Research Infrastructures: National RI operators and universities (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations (iii) Governments, including Indigenous Nations (iv) Private Sector and Industries

Priority 2 *continued*: Engage and support equitable Indigenous participation in research.		
Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
Protect Indigenous Knowledges and data	• Ensure data repositories are equipped to implement IDsov by parsing datasets into those available for public/secondary use and those restricted by Indigenous governance. • Fund Indigenous training programs in data management, cybersecurity, and AI/ML so communities can directly oversee and manage their own data. • Develop pathways for Indigenous residents into Skilled Technical Workforce (STW) roles such as data stewards, technicians, and repository managers.	(i) Research Infrastructures: National RI operators and universities (ii) Funding Bodies: European Commission, National Research Councils, Private Foundations (iii) Governments, including Indigenous Nations (iv) Private Sector and Industries

Priority 3: Continuity of Funding		
Spatial scale:	regional, global, pan-Arctic	
Time scale:	relevant now and for the next 10 years and beyond	
Funding requirements and potential sources:	national governments; national and international funding organizations	
Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
Re-organizing and re-directing current funding mechanisms to align with needs and priorities identified in ICARP IV	• Arrange joint assessment and evaluation of the currently available funding instruments for re-shaping, re-targeting and re-structuring them to align with current needs and priorities. • Create a strategic overview of the current pan-Arctic research funding landscape to map current gaps in the funding (against the ICARP IV priorities) and plan funding instruments to address science priorities and infrastructure needs. • Include Indigenous people and institutions into planning of research policies and grant development.	(i) Funding Bodies: European Commission, National Research Councils, Private Foundations (ii) Governments
Development of new, international, targeted funding instruments to match the needs and priorities identified in ICARP IV	• Create new targeted funding instruments to support implementation of science priorities and required infrastructure, including continuity and development of e.g. basic and applied research, RI (services, access, instrumentation), technology, observations, integration of local and traditional knowledge and their holders. • Organise pilot funding calls of a smaller scale to test the new funding instruments before their full-scale implementation • Strengthen connections between research and funding agencies, governments and research community to jointly develop funding instruments that meet scientific needs.	(i) Funding Bodies: European Commission, National Research Councils, Private Foundations (ii) International organisations - networks and consortia (e.g. IASC, FARO, SAON)
Involvement of actors and organisations across levels in funding of arctic research	• Prioritise sustainable national and regional funding from countries/regions with long-term interest in polar research to enhance polar collaboration. • Establish a funding action group to identify funding sources, engage the private sector, set joint business-research priorities, and facilitate dialogue between researchers and funding agencies. • Advocate for a portion of profits from private companies extracting natural resources in polar regions to be allocated to public polar observation, through voluntary sponsorship or mandated legal requirements. • Develop a political transnational agreement among national funding agencies to ensure a stable and sustainable funding structure, particularly for underrepresented cross-national initiatives. Allow nations to contribute to the collaborative observing system based on their economic situation, national interests, and priorities.	(i) Funding Bodies: European Commission, National Research Councils, Private Foundations (ii) International organisations - networks and consortia (e.g. IASC, FARO, SAON) (iii) Governments

Priority 3 *continued*: Continuity of Funding		
Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
Re-organizing and re-directing current funding mechanisms to align with needs and priorities identified in ICARP IV	• Arrange joint assessment and evaluation of the currently available funding instruments for re-shaping, re-targeting and re-structuring them to align with current needs and priorities. • Create a strategic overview of the current pan-Arctic research funding landscape to map current gaps in the funding (against the ICARP IV priorities) and plan funding instruments to fill them. • Include Indigenous people and institutions into planning research policies and grant development.	(i) Funding Bodies: European Commission, National Research Councils, Private Foundations (ii) Governments
Development of new, international, targeted funding instruments to match the needs and priorities identified in ICARP IV	• Create new targeted funding instruments to support the continuity and development of e.g. basic and applied research, RI (services, access, instrumentation), technology, observations, integration of local and traditional knowledge and their holders. • Organise pilot funding calls of a smaller scale to test the new funding instruments before their full-scale implementation • Strengthen connections between research and funding agencies, governments and research community to jointly develop funding instruments that meet scientific needs.	(i) Funding Bodies: European Commission, National Research Councils, Private Foundations (ii) International organisations - networks and consortia (e.g. IASC, FARO, SAON)


Wenkai Guo

Priority 4: Prioritize a holistic approach to field safety		
Spatial scale:	pan-Arctic	
Time scale:	relevant now and for next 10 years	
Funding requirements and potential sources:	Funding needed for pre-deployment training, development and facilitation; required gear for field safety; workshops to share best practices in field safety and to develop international standards of field safety; and research on effective field safety training.	
Infrastructure needs and requirements:	Online training courses and portals to share resources in field safety	
Data needs and requirements:	Reports and studies, as well as e-learning materials on field safety.	
Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
Ensure a healthy and inclusive work environment	Research institutes and organizations should include resources for mental and emotional health in field safety planning. Each team should create and implement a code of conduct that contains common standards within Arctic and field research (i.e., explicitly prohibiting harassment and assault) and yet remains adaptable to each team's unique circumstances. Institutes and teams must also establish and provide reporting structures, and protocols for following up on reported violations of the code of conduct. Team leads, PIs, and supervisors should be trained in inclusive mentorship. Institutes should provide equal access to fieldwork and equitable support for diverse groups participating in field operations. All team members should be provided access to protective clothing, gear, and emergency communication devices that suit a diverse group of participants.	(i) Research Infrastructures: National RI operators and universities (ii) International organisations - networks and consortia (e.g. IASC, FARO)
Train and prepare all staff in field safety	Teams should receive training in Arctic field safety before deploying to the field. The training should include interactive, scenario-based lessons and cover physical and objective hazards as well as nonviolent communication strategies, trauma sensitivity, decision-making strategies, bystander intervention, and emergency response. Training must address ways to identify and mitigate risks to individuals with varied identities. Training should also include Indigenous methodologies and tools for early career researchers, such as those from Polar Science Early Career Community Office in USA, Assoc. of Polar Early Career Scientists in Norway.	(i) Research organisations and universities
International collaboration for coordination and exchange in field safety training and standards	Various centres have been developed to tailor to regional needs in safe Arctic operations (e.g., Arctic Safety Centre at UNIS Svalbard, Polar Continental Shelf Programme in Canada) as well as programs focused on holistic field safety (e.g., ADVANCEing Field Safety in USA). These organizations, networks, and consortia should hold international workshops and exchanges between institutes, field sites, and organizations who are excelling in field safety to develop a set of standards.	(i) Research Infrastructures: National RI operators and universities (ii) International organisations - networks and consortia (e.g. IASC, FARO, SAON)
Identify effective and evidence-backed strategies in field safety	Conduct research on field safety trainings to better understand effective strategies and remaining gaps in trainings	(i) Research organisations and universities
Local support and connection between citizens and scientists	Foster equitable, sustainable and relationship-centered engagement with local communities and Indigenous Peoples.	(i) Research Infrastructures: National RI operators and universities (ii) Indigenous Communities

Priority 5: Integrated planning - link the development of Research Infrastructures, long-term monitoring and data sharing with scientific priorities.		
Spatial scale:	pan-Arctic	
Time scale:	relevant now and for next 10 years	
Funding requirements and potential sources:	Research Infrastructures: National RI operators and universities; Organisations maintaining data management systems (repositories, databases); Funding Bodies: European Commission, National Research Councils.	
Infrastructure needs and requirements:	Data management and storage systems, research infrastructures, long-term monitoring systems, research funding organizations.	
Data needs and requirements:	Data collected throughout the Arctic.	
Implementation: **Implementation actions:**	**How to implement the actions:**	**Who to address the actions:**
Creation of a catalogue of key long-term monitoring systems based on scientific priorities.	For specific scientific priorities, a catalogue of key variables should be defined for long-term monitoring. This should leverage existing standards and best practices, such as Essential Climatic Variables (ECVs), Shared Arctic Variables (SAON ROADS), and SIOS Core Data.	(i) Research Infrastructures: National RI operators and universities (ii) International organisations - networks and consortia (e.g. IASC, FARO, SAON, ENVRI)
Development of research infrastructures and long-term monitoring in line with scientific priorities.	Research funding organisations should incorporate the priorities developed by ICARP IV into their scientific criteria. To this end, it is essential to conduct informed science diplomacy in cooperation with governments.	(i) Funding Bodies: European Commission, National Research Councils, Private Foundations (ii) Governments
Based on scientific priorities, identify gaps in observations and infrastructure.	Based on scientific priorities and a catalogue of key long-term monitoring, geographic areas requiring specific observations, as well as the development of research infrastructures, should be identified. This task should be coordinated by international networks/consortia in cooperation with research infrastructures.	(i) Research Infrastructures: National RI operators and universities (ii) International organisations - networks and consortia (e.g. IASC, FARO, SAON, ENVRI)
Ensure access to collected data in accordance with FAIR data principles.	Research infrastructures that conduct long-term monitoring with public funding should be required to share data in accordance with the FAIR data principles. Research funding organisations should require grantees to share data collected during the research process.	(i) Research Infrastructures: National RI operators and universities (ii)Organisations maintaining data management systems (repositories, databases) (iii) Funding Bodies: European Commission, National Research Councils, Private Foundations
Integrate Arctic observing	• Integrate data products • Connect data systems • FAIR information sharing about observing activities and infrastructures • Promote inventories of observing assets (through US AON, SAON, and more) • Sustained and coordinated funding (avoiding funding stovepipes) • Improved communication and coordination of logistics and infrastructures through FARO, IARPC FO, the Arctic Funders Forum, SAON, etc.	(i) Research Infrastructures: National RI operators and universities (ii) International organisations - networks and consortia (e.g. IASC, FARO, SAON, ENVRI)

5. Recommendations on how to track the Implementation of the ICARP IV Outcomes over the next decade?

Implementation Action	How to track?	Who to track?	How to include in the IPY-5 planning?
Collaborative Planning	Monitor number of co-designed workshops, joint projects and community agreements produced under ICARP IV.	Governments, Research Infrastructures, International organisations, networks and consortiums (e.g. IASC, FARO, SAON).	Make collaboration a core evaluation criterion for IPY projects.
Maintain and improve the existing long-term observation platforms and develop new spatially distributed RI and observation platforms	Existing data management networks (e.g. SAON Arctic Data Committee, SIOS) and Research Infrastructure Networks should be used to track the development of monitoring and data sharing.	Research Infrastructures, Funding Bodies: European Commission, National Research Councils.	Encourage thematic funding calls. Use IPY to support international networks.
Develop and implement societally and environmentally responsible practices for building and operating infrastructure jointly with local / Indigenous communities	Through international networks of research infrastructures (ENVRI, SIOS, RoPON, ICRI).	Governments, Indigenous communities, Research Infrastructures.	Identify in relevant communications. Workshops.
Enhance international collaboration and establish agreements for Remote and Virtual Access. Expanding access to RIs and their Remote and Virtual Access Services to complement field-based research	Within networks and activities such as INTERACT, POLARIN, SIOS.	International organisations, networks and consortiums (e.g. IASC, FARO, SAON).	Encourage thematic funding calls. Use IPY to support international networks.
Ensure all data collected in the North are stored in curated, well-managed repositories, and are made public without delay	Existing data management networks (e.g. SIOS, SAON Arctic Data Centre) and Research Infrastructure Networks should be used to track the development of monitoring and data sharing.	Organisations maintaining data management systems and data repositories.	Emphasize mandatory data sharing in line with FAIR, CARE data principles.
Ensure Indigenous rights to data collected on their territories are respected	Implement audits with data repositories	Indigenous communities, Governments.	
Support the development of Digital Twins (or multi-layer portals offering data and predictive model results for an entire region).	Demonstrate the usefulness of successive versions of Digital Twin initiatives with local, regional stakeholders from communities, industry and critical infrastructures such as ports.	Space agencies and Environmental Organisations.	Encourage thematic funding calls.
Deployment of highly elliptical orbit (HEO) satellites for telecommunication and environmental monitoring in the Arctic. LEO satellite constellations are needed to provide high-bandwidth, low-power communication capabilities from anywhere.	Publish the net increase in new observational assets deployed in space, on land and in the ocean/under ice. Similarly gather statistics on the number of communities with access to broadband and on the actual performance improvements of the telecommunication infrastructure.	Governments.	Support for projects developing new technologies and communications (R&D)

Implementation Action	How to track?	Who to track?	How to include in the IPY-5 planning?
Formalize Indigenous governance roles in research	Working with Indigenous communities and organisations that negotiate and cooperate with governments.	Governments, Indigenous communities.	Prioritize Indigenous research themes in IPY science planning.
Provide dedicated funding for Indigenous participation	Cooperation between funding agencies and Indigenous communities. After a few years, publish changes in Indigenous participation.	Funding Bodies	Prioritize Indigenous research themes in IPY science planning.
Development of new, international, targeted funding instruments to match the needs and priorities identified in ICARP IV. Re-organizing and re-directing current funding mechanisms to align with needs and priorities identified in ICARP IV	Through collaboration with funding agencies and the Arctic Science Funders Forum. After a few years, report on funding changes that have occurred.	Funding Bodies	Use IASC and the Arctic Science Funders Forum to coordinate the preparation of the national and international funding agencies for the IPY.

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Appendix: About RPT 7

1.1. Approaches / Methods used to complete the RPT 7 tasks

Multiple approaches and methods were used to complete the RPT 7 tasks.

The work of RPT 7 started by dividing the larger group consisting of 25 members into ***four sub-teams*** (Infrastructure, Logistics, Services and Technology), based on the field of expertise of the RPT members.

The whole RPT and the sub-teams had ***regular on-line meetings*** to ensure continuous progress of the priorities, and the members worked on a ***shared main document*** in-between the meetings.

To begin their work, each sub-team conducted a ***literature review*** on identified key reports and publications on Arctic research (43 reports and publications) related to the topic of each sub-team. After that, the ***sub-teams drafted the related gaps and priorities*** which were ***iteratively consolidated*** into the main document and reviewed in the joint meetings of the whole RPT.

After several rounds of ***drafting, discussions and iterations***, the originally 23 identified priorities were reduced to 11 by the time of ICARP-IV planning retreat in Akureyri, Iceland, in 21-23.10.2024. Several consistent, recurring themes were moved to ***cross-cutting priorities***, and the work was structured into the common template provided by IASC, including 5 gaps, 5 priorities and their implementation.

After the planning retreat, the priorities were further ***reduced*** to 5 main priorities that were presented at the RPT7 townhall at the ASSW2025 in Boulder, Colorado, in March 2025.

Following the ASSW2025, the ***community feedback***, including from the ICARP website submissions and RPT 7 survey, were incorporated into the priorities and their implementation. Furthermore, key aspects of the ***meeting notes and reports from other RPT Townhalls*** were integrated into the RPT7 report to align the work.

The final work focused on sharpening the priorities and their implementation plan and completing the draft final template. Some feedback was received from the other RPTs in the two open comment periods of the draft final template, during the fall of 2025.

1.2. Overlaps and Synergies with other RPTs

RPT7 is highly interdisciplinary in nature, and its topics are linked to the priorities and needs of other RPTs. Therefore, discussions and exchange of the best practices with members of other teams were held throughout the process, primarily based on:

1. ICARP IV Research Priority Teams Workshop: Arctic Science Summit Week (ASSW) 2024, Edinburgh, Scotland, UK (21 - 29 March 2024).
2. ICARP IV Webinar Series: September – October 2024.
3. ICARP IV Planning Retreat 2024 in Akureyri, Iceland: 21-23.10.2024.
4. ICARP IV Summit 2025 – RPTs Town Hall Sessions: During the ICARP IV Summit 2025 in Boulder, Colorado, USA (25 - 28 March 2025) as part of the Arctic Science Summit Week.
5. Co-chair RPT2 Syndonia Bret Harte is a member of RPT7.
6. Participation in meetings and workshops, e.g.:
   a. Svalbard Integrated Arctic Earth Observing System (SIOS) Polar Night Week ICARP IV Workshop, Longyearbyen, Svalbard: 23-26.01.2024.
   b. Arctic Circle Berlin Forum 2024 - Defining Priorities for Arctic Research and International Cooperation for the Next Decade: From ICARP IV to IPY 5, Berlin, Germany: 07.05.2024.
7. Personal contacts.
8. Through the first and second round of draft report reviews.

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